On the Role of GNSS Receivers for Antenna Patterns and Parameter Estimations

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Introduction

Challenge and scope of study

- Transition function and metrics necessary to assess impact of Phase Center Corrections (PCCs) on geodetic parameters
- Cause (and effect) of differences in PCC patterns remains unknown
- New GNSS signals, frequencies and tracking philosophies affect the propagation of unknown systematic effects - resulting in different uncertainties on geodetic estimates (offsets & coloured noise)

Research Question and Focus

- Previous studies confirm dependencies [Kersten and Schön, 2010]
- Assessing the impact of different receivers on PCC estimation
- Evaluating both, relative positioning (DD) and PPP strategy

Set-Up for assessing quality measures

- Reference network: short baseline between geodetic pillars, common clock

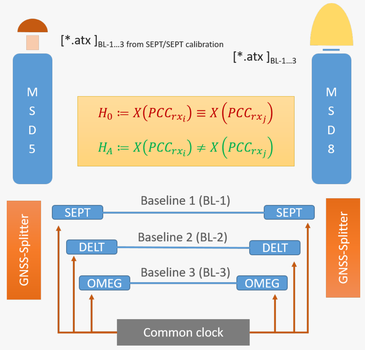


Figure 1: Concept of validation set-up

Figure 2: Combined zero / short baseline set-up with common clock for validation of the IfE-PCC patterns

General processing scheme

- PCC obtained by in-house processing [Kröger et al., 2021], variable receiver combination (cf. #EGU21-8507, Session G1.3)
- Study for 12 days GNSS data in 2020 for each combination
  - DOY162-173: NOV703GGG.R2 (relative (DD) strategy)
  - DOY184-195: NAX3G+C (relative (DD) & PPP strategy)

Approaches and processors

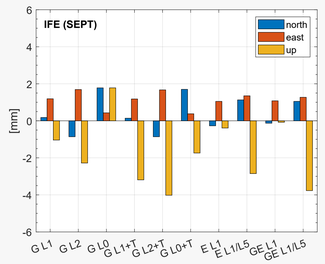
- Elimination: Bernese 5.2 GNSS incl. CODE products [Dach et al., 2015]
- Estimation: PPP-Algorithm in-house implementation (Kalman Filter)

Table 1: Processing parameters

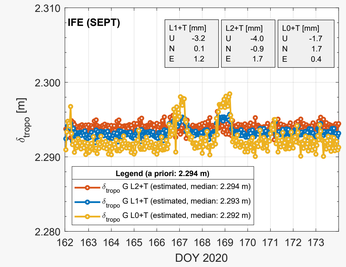
Approach	Weighting	cutt-off	ZTD	Ambiguity res.
Bernese 5.2	$\cos z$	6°	Dry/wet GMF	SIGMA
PPP (IfE)	$\cos z$	6°	VMF3	-

Results for elimination approach (double difference)

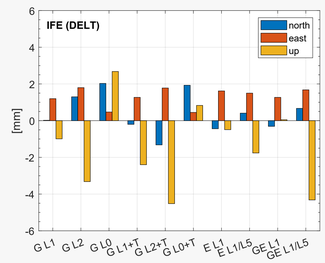
Baseline: NOV703GGG.R2 NONE



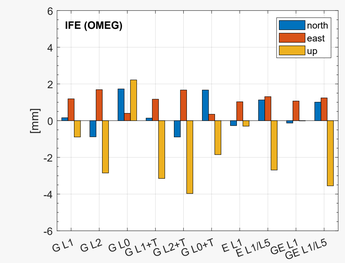
(a) BL-1 (SEPT/SEPT)



(b) BL-1 (SEPT/SEPT)



(c) BL-2 (DELT/DELT)



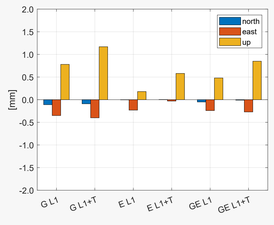
(d) BL-3 (OMEG/OMEG)

Figure 3: Position variations using several GNSS signals and linear combinations with and without tropospheric estimates. Results are shown for NOV703GGG.R2 using identical receiver brands in parallel (a) Septentrio PolaRx5TR, (c) Javad Delta TRE_G3T and (d) Javad OMEGA. The PCC sets have been obtained using Javad Delta TRE_G3T.

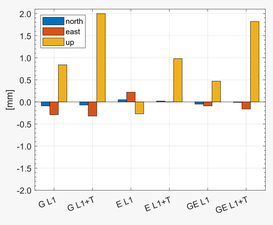
Table 2: Comparison of previous baseline configurations with respect to BL-1 (SEPT/SEPT) solution

No.	Freq.	$\Delta\delta_{tropo}$ DELT/SEPT [mm]	$\Delta\delta_{tropo}$ OMEG/SEPT [mm]	Δh DELT/SEPT [mm]	Δh OMEG/SEPT [mm]
1	GL1+T	0.2	0.2	0.8	≈ 0
2	GL2+T	-0.1	-0.1	0.5	≈ 0
3	GL0+T	0.7	0.1	2.0	0.3

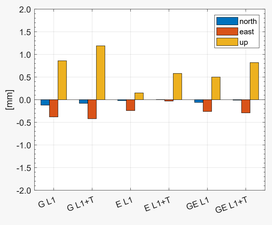
Baseline: NAX3G+C NONE



(a) BL-1 (SEPT/SEPT)



(b) BL-2 (DELT/DELT)



(c) BL-3 (OMEG/OMEG)

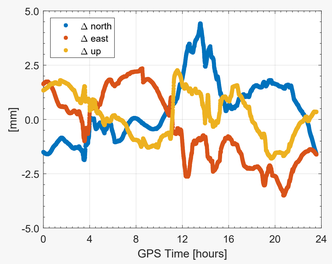
Figure 4: Topocentric position deviations with and without troposphere estimates using NAX3G+C receiver antenna and parallel baselines with various PCCs obtained with SEPT (cf. Fig. 1 and Fig. 2)

Findings

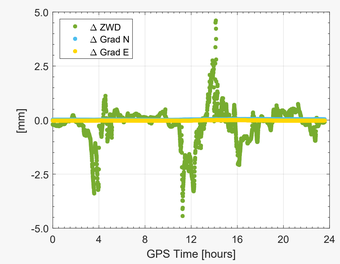
- The Up-component is most affected (cf. Fig. 3–Fig. 4)
- Individual effects noticeable but close to the level of significance

Results for estimation approach (PPP)

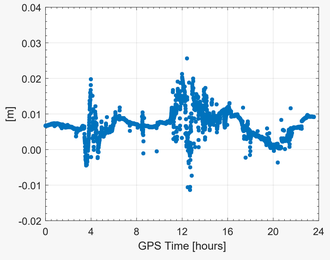
NAX3G+C NONE



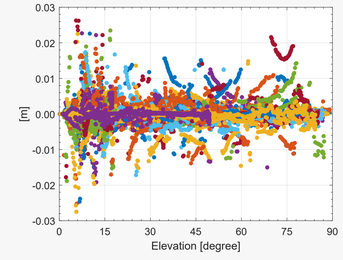
(a) Topocentric



(b) ΔZWD



(c) Δ receiver clock estimates



(d) Δ post fit residuals

Figure 5: Differences of PPP results (DoY186, 2020) obtained for multi-GNSS processing using an identical antenna but with different, individual PCCs that were derived by simultaneous calibrations of Javad Delta TRE_G3T (DELT) and PolaRx5TR (SEPT). PPP results obtained for GPS/Galileo ionosphere-free linear combination L0(GPS) & L15(Galileo)

Conclusions

- Linear combinations increase the effect of the individual signals (cf. Fig. 3) due the corresponding factors [L0(L1/L2): (2.54, -1.54) and L0(L1/L5): (2.26, -1.26)]
- Different signals show individual effects, in elevation higher as in azimuthal range (cf. Fig.4) with up to 2 mm in Up-Component
- PPP affected by position deviations and further effects on ZWD (cf. Fig. 5) and clock offset below 1 cm
- More signals and frequencies demand for decision on corresponding PCC distribution (signal - or rather frequency dependent PCCs)

References

Dach, R., Lutz, S., Walser, P., and Fridez, P., editors (2015). *Bernese GNSS Software Version 5.2*. University of Bern, Bern Open Publishing.

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