Gefördert durch:
Bundesministerium für Wirtschaft und Technologie
aufgrund eines Beschlusses des Deutschen Bundestages

Impact of individual Receiver Antenna Code Phase Variations on the Ambiguity Resolution

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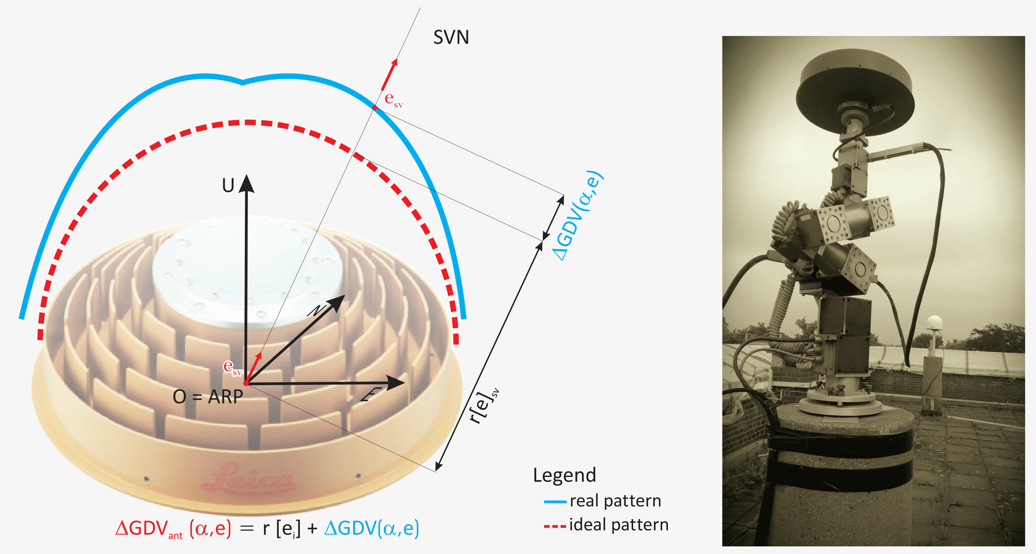
Introduction

This contribution discusses the current investigations at the Institut für Erdmessung (IfE) on Code Phase Variations (GDV) within a combined code and carrier phase processing strategy. An analysis of the GDV impact on the important Melbourne-Wübbena linear combination (MW-LC) - which is widely used for cycle slip detection and ambiguity resolution - is of special interest since effects which origin from GDV are amplified on both code phases (P1 and P2).

GNSS Receiver Antenna Code Phase Variations (GDV)

Variations of the Code Phase Observation at GNSS Antennas?



- **ideal** An isotropic radiator for the reception of code phase observation independent of incident angle.
- **real** Systematic effects occur due to imperfections during the design and production process of the important characteristics of GNSS antennas (sensitivity etc.).

Figure 1: Methodology and principle concept (a) of the Hannover Concept of absolute antenna calibration in the field (b) used in an experimental GDV setup.

The effect of azimuth and elevation dependent GDV is currently known in literature for satellite as well as for receiver antenna, cf. [Murphy et al., 2007], for example.

Review Melbourne-Wübbena Linear Combination (MW-LC)

$$L_w = \frac{f_1}{f_1 - f_2} L_1 - \frac{f_2}{f_1 - f_2} L_2$$

$$P_w = \frac{f_1}{f_1 + f_2} P_1 + \frac{f_2}{f_1 + f_2} P_2$$

$$\boxed{MW = L_w - P_w = \lambda_w (N_1 - N_2)}$$

Code and carrier observations denoted by P_i and L_i resp., f_i is the frequency and λ_w=0.86 m the Widelane wave length.

- GDV amplified by a factor of 0.562 (f_1) and 0.438 (f_2), standard GPS L_1 and L_2 frequencies
- accumulation of GDV for MW-LC and for different frequencies
- degradation of observation precision and additional uncertainties in coordinate domain

Experiment on Laboratory Network

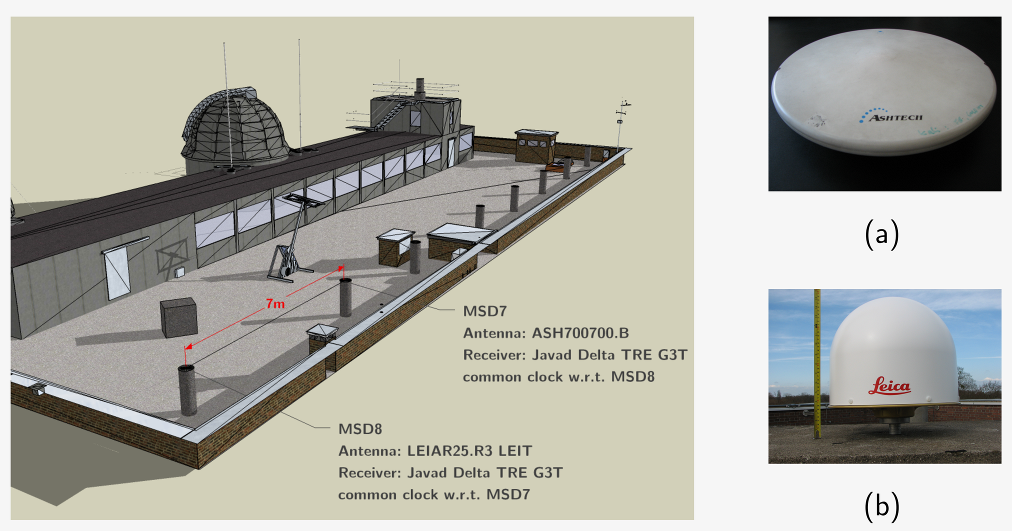


Figure 2: Experimental Setup at the IfE Laboratory network, (a) ASH700700.B NONE and (b) LEIAR25.R3 LEIT.

Experimental Setup

- common clock mode on a short baseline
- long sessions (>5 hours) ensure a good geometry (satellite coverage)
- asymmetrical setup with antennas providing different GDV pattern, determined by IfE, [Kersten et al., 2012]

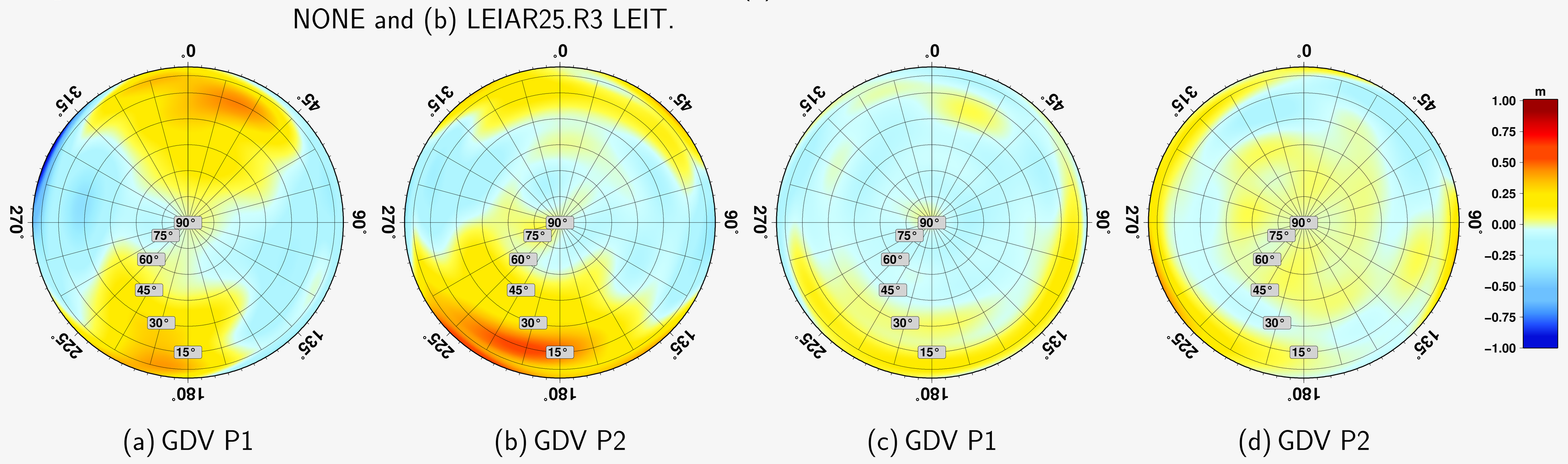


Figure 3: GDV for Ashtech Marine Antenna (ASH700700.B NONE) in (a-b) and for Leica AR25 (LEIAR25.R3 LEIT) in (c-d).

Observation Domain - Double Differences of MW-LC

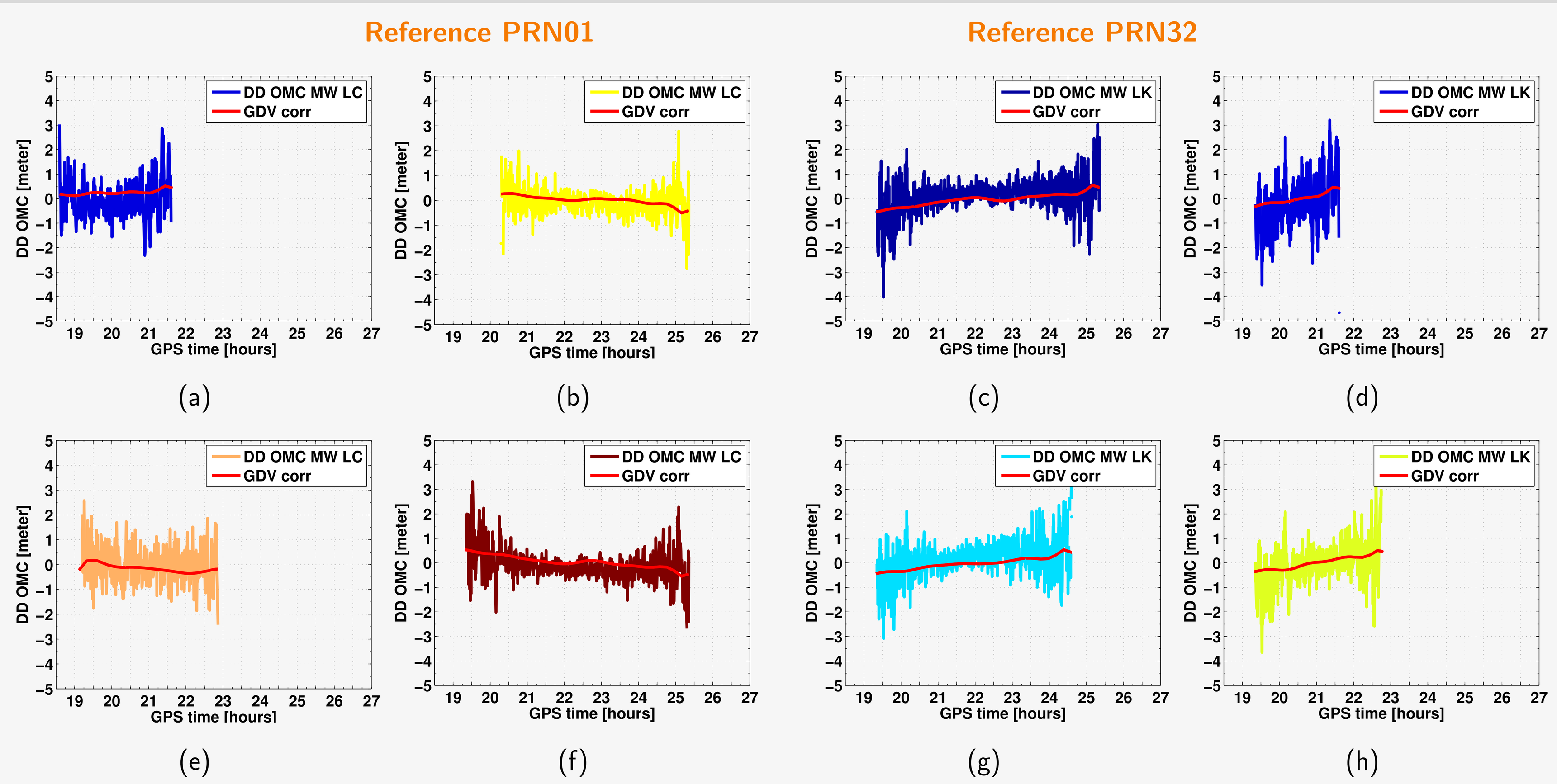


Figure 4: Double Differences of Melbourne Wübbena Linear Combination for two different reference satellites, (a-b) and (e-f) correspond to reference satellite PRN01 whereby (c-d) and (g-h) correspond to reference satellite PRN32; GDV correction is shown by the solid line.

Widelane Ambigutiy Fixing

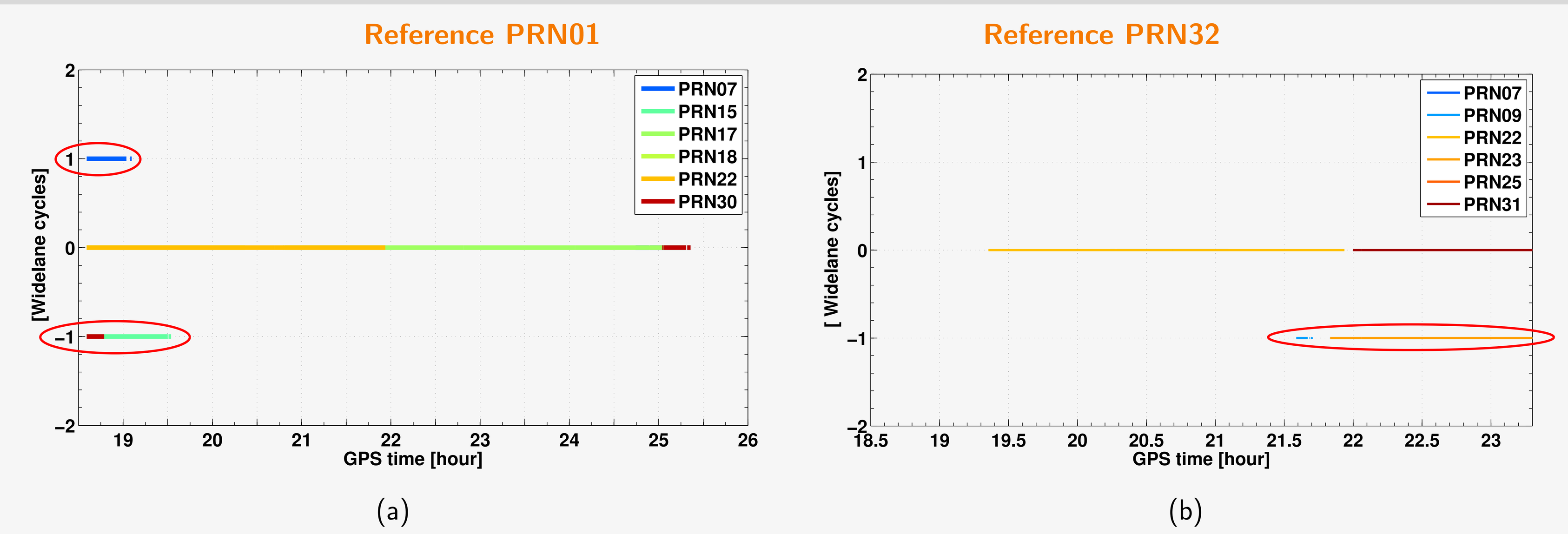


Figure 5: Differences of WL ambiguity fixing induced by GDV corrections for situation of reference satellite PRN01 (a) and PRN32 (b).

Coordinate Domain - DD Lw Solution with reference PRN01 and PRN32

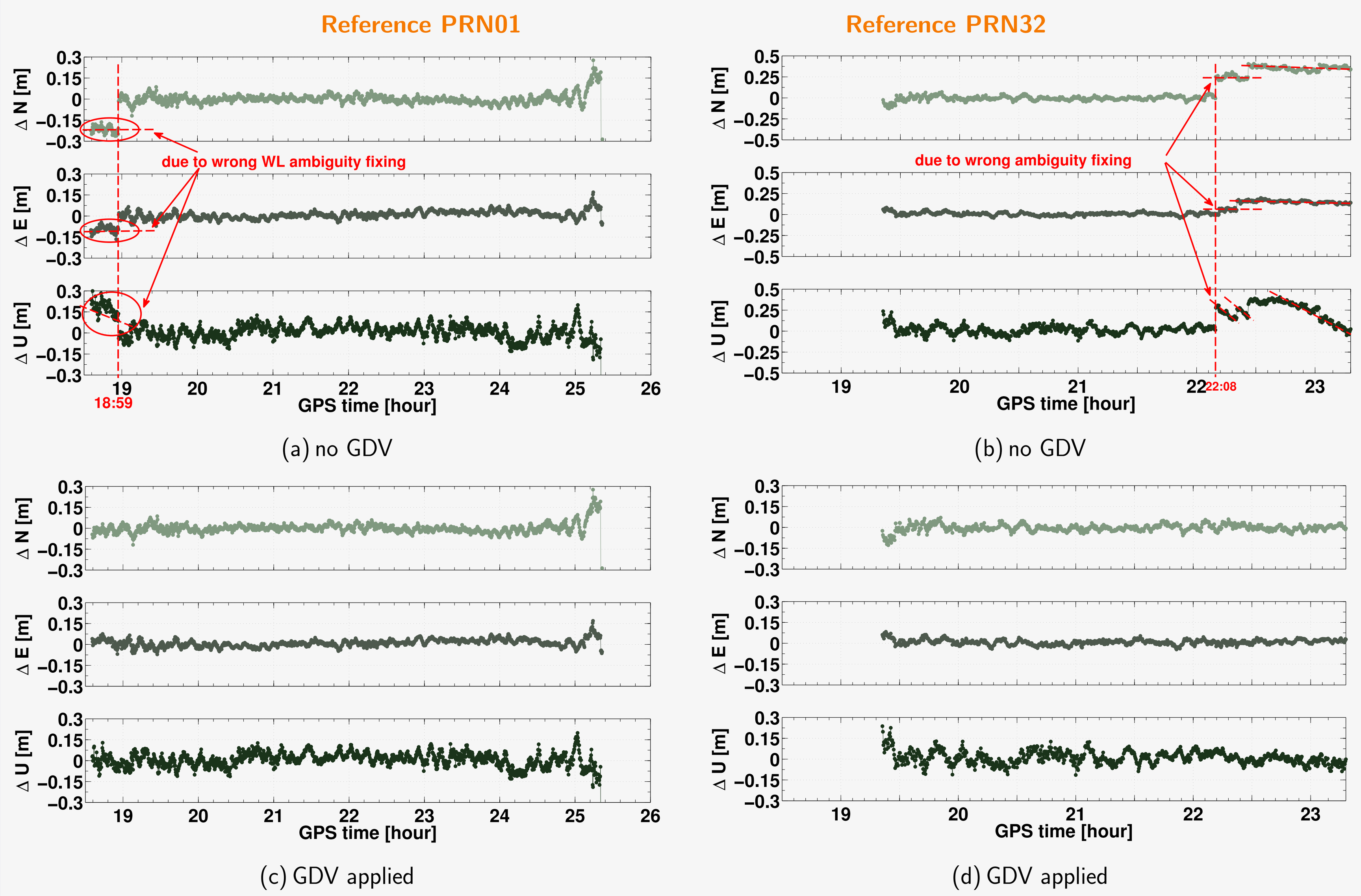


Figure 6: Double Difference Coordinate Solution using Widelane Phase and Ambiguities obtained without GDV correction (a-b) and with GDV correction (c-d) and identical observation weighting.

Narrowlane and N_1 Ambiguity Fixing - Reference PRN32

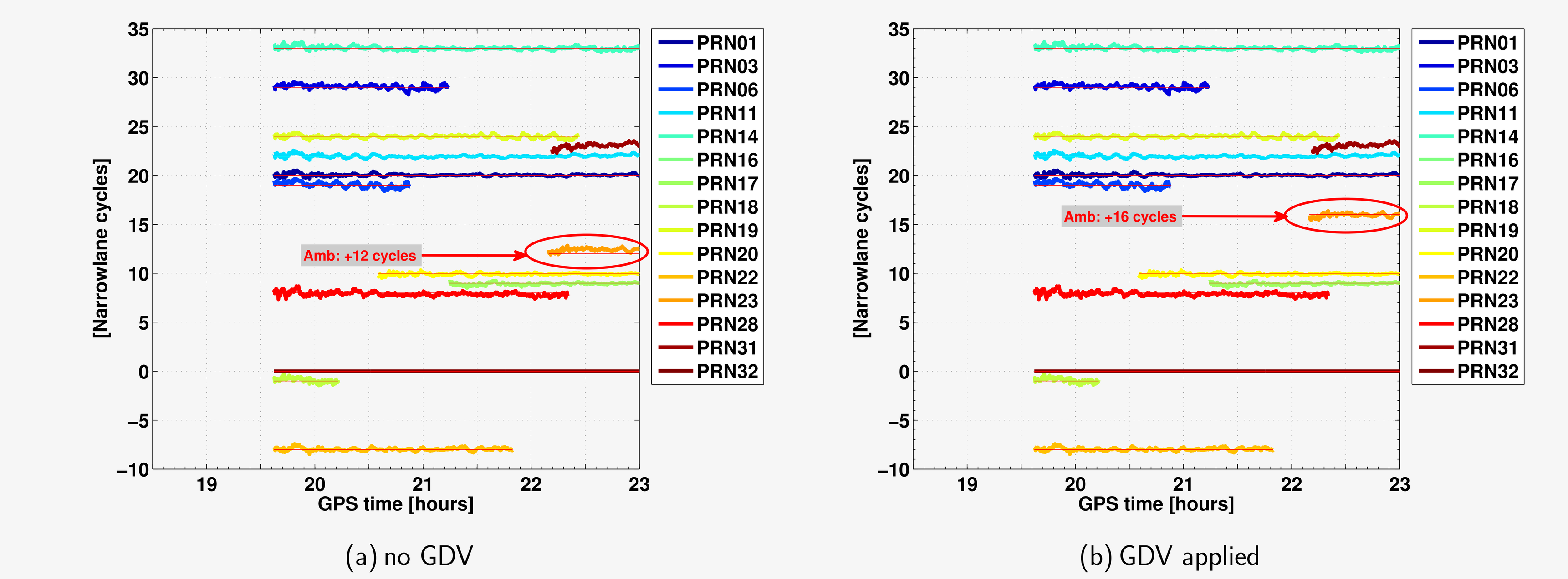


Figure 7: Wrong Widelane ambiguity introduces wrong Narrowlane ambiguity in (a) and can be repaired using GDV corrections (b).

Impact on Coordinate Domain - Reference PRN32

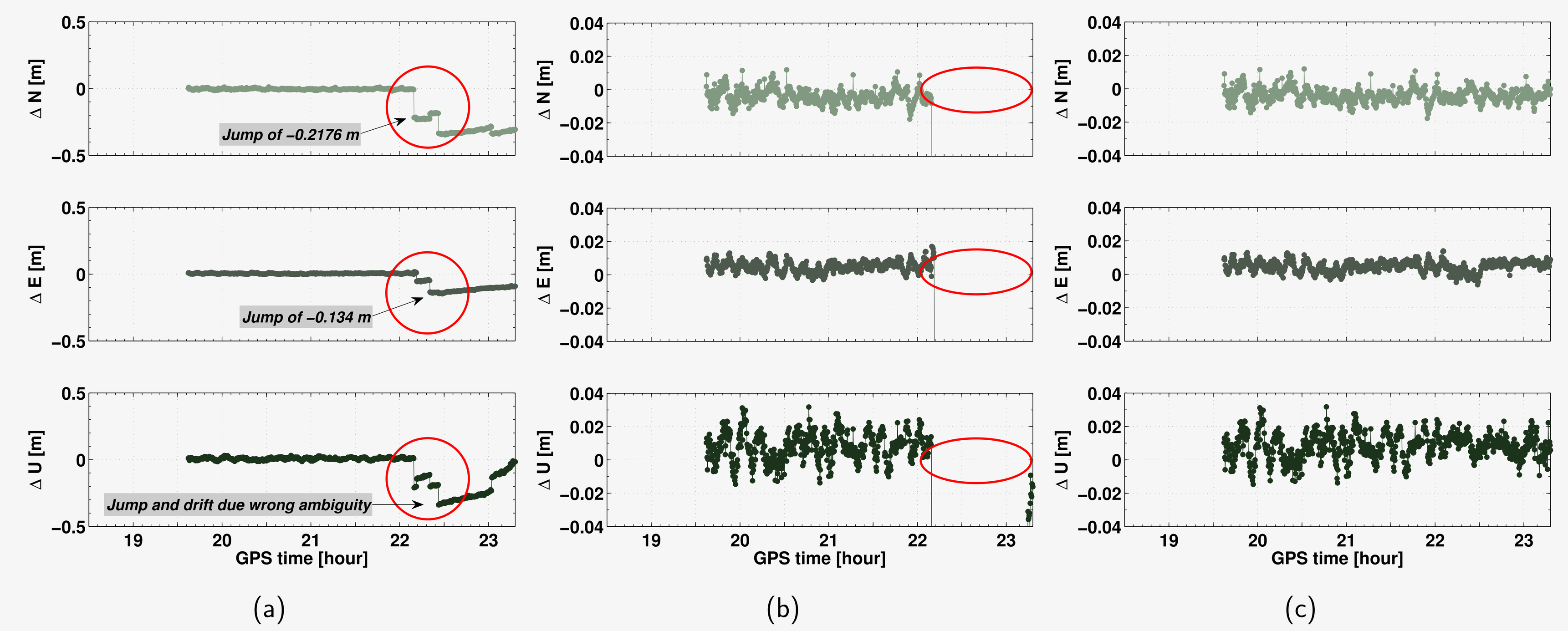


Figure 8: Double Difference L_1 phase solution and original MW-LC ambiguities (a-b) and GDV-repaired MW-LC ambiguities (c).

Conclusions

Code Phase Variations (GDV)

- Significant and repeatable GDV depending on the antenna design are obtainable (Fig. 3).
- GDV can reach magnitudes of $\geq \lambda_i$ per frequency i and the effect on DD of MW-LC depends also on the selected reference satellite and the processing strategy, cf. Fig. 4.

Observation Domain

- GDV induce wrong Widelane ambiguities (up to 1 cycle) as shown in Fig. 5.
- Wrong Widelane ambiguity introduces wrong Narrowlane ambiguity, cf. Fig. 7.

Coordinate Domain

- GDV influence directly and repeatable the coordinate time series via incorrectly fixed WL ambiguities and induce jumps of up to 0.4 m (cf. Figure 8(b) & 8(a)).

Outlook and Challenges

- GDV are interesting for future GNSS signals since a reduced observation noise can be expected and will be an important element in navigation approaches with small antennas.
- GDV degrade code based and code/carrier combined applications.

Acknowledgement

This project is supported by the German Aerospace Center (DLR) with the project label 50 NA 1216, funded by the Federal Ministry of Economics and Technology (BMWI) based on a resolution by the German Bundestag.

References

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