Antenna Code Phase Variations (GDVs) and the Impact on Ambiguity Resolution

Tobias Kersten and Steffen Schön
Institut für Erdmessung
Leibniz Universität Hannover

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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?

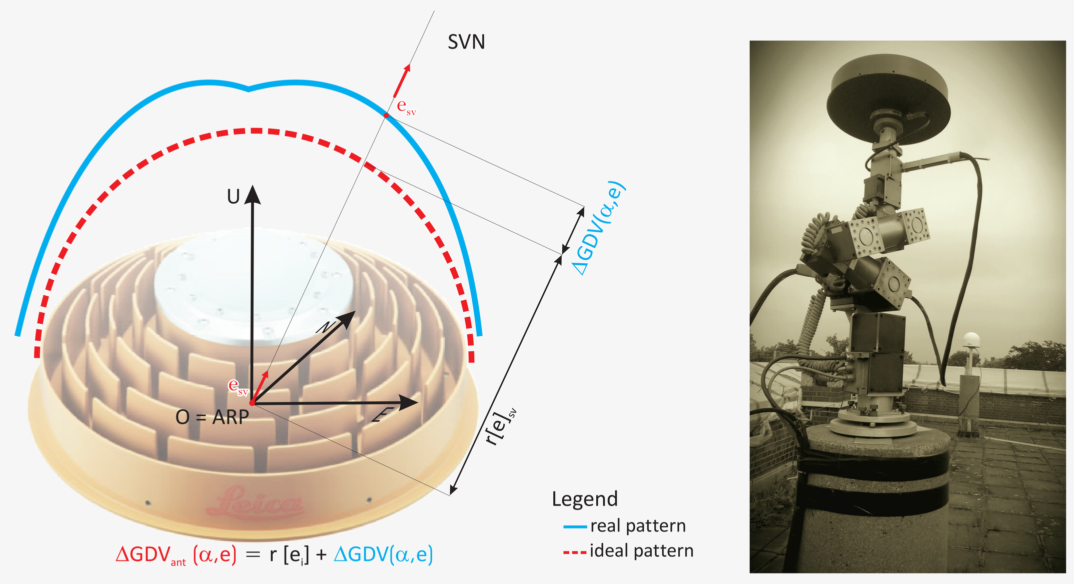

Figure 1: Methodology and principle concept (a) of the Hannover Concept of absolute antenna calibration in the field (b).

- **ideal** Antenna is 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, bandwidth, etc.).

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

Review Melbourne-Wübbena Linear Combination (MW-LC)

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

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

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

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 wavelength.

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

Experiment on Laboratory Network

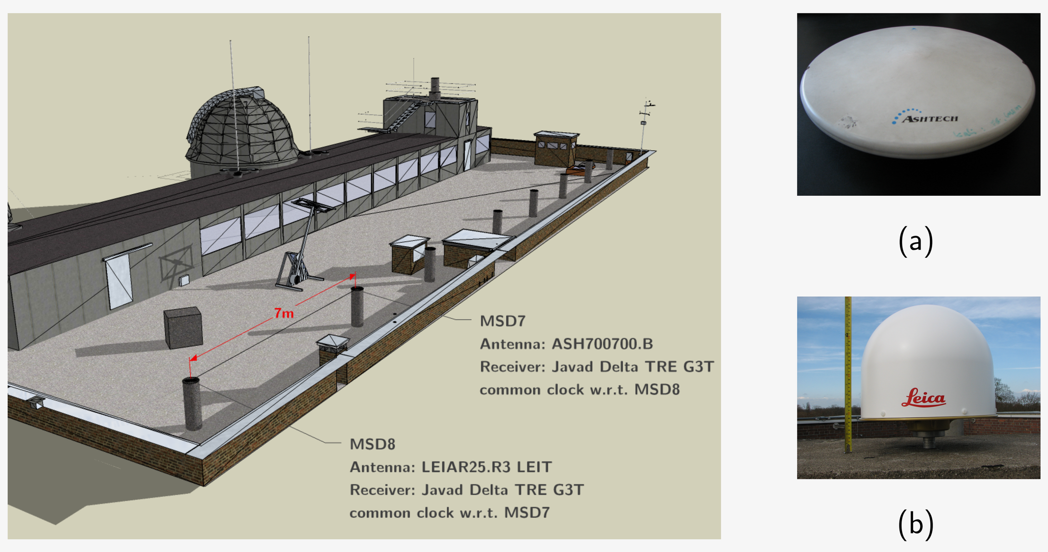

Figure 2: Experimental Setup at the IfE Laboratory network, (a) ASH700700.B NONE and (b) LEIAR25.R3 LEIT.

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]

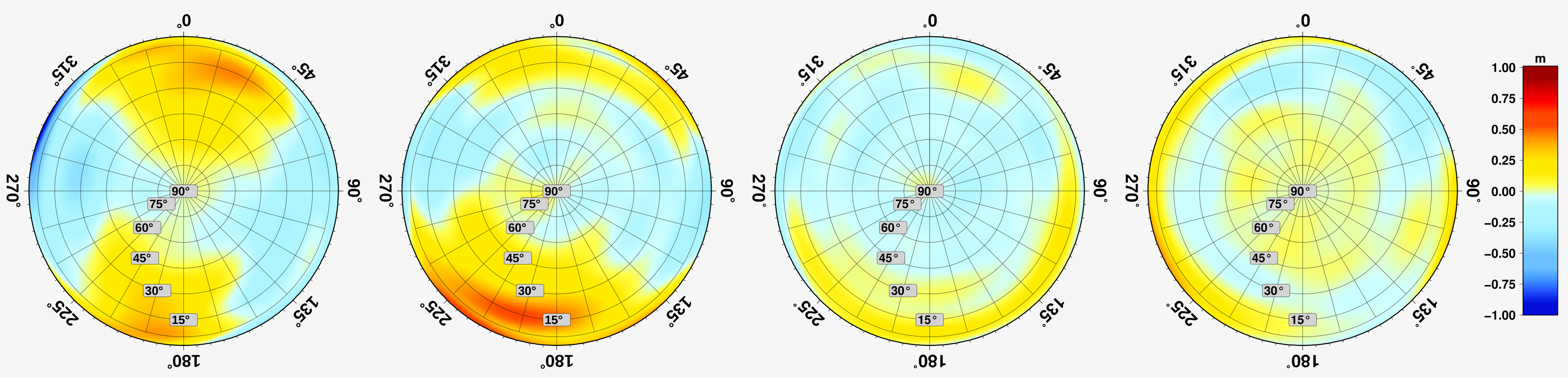

Figure 3: GDV for Ashtech Marine Antenna (ASH700700.B NONE) in (a-b) and for Leica AR25 (LEIAR25.R3 LEIT) in (c-d).

Observation Domain - Double Differences of MW-LC

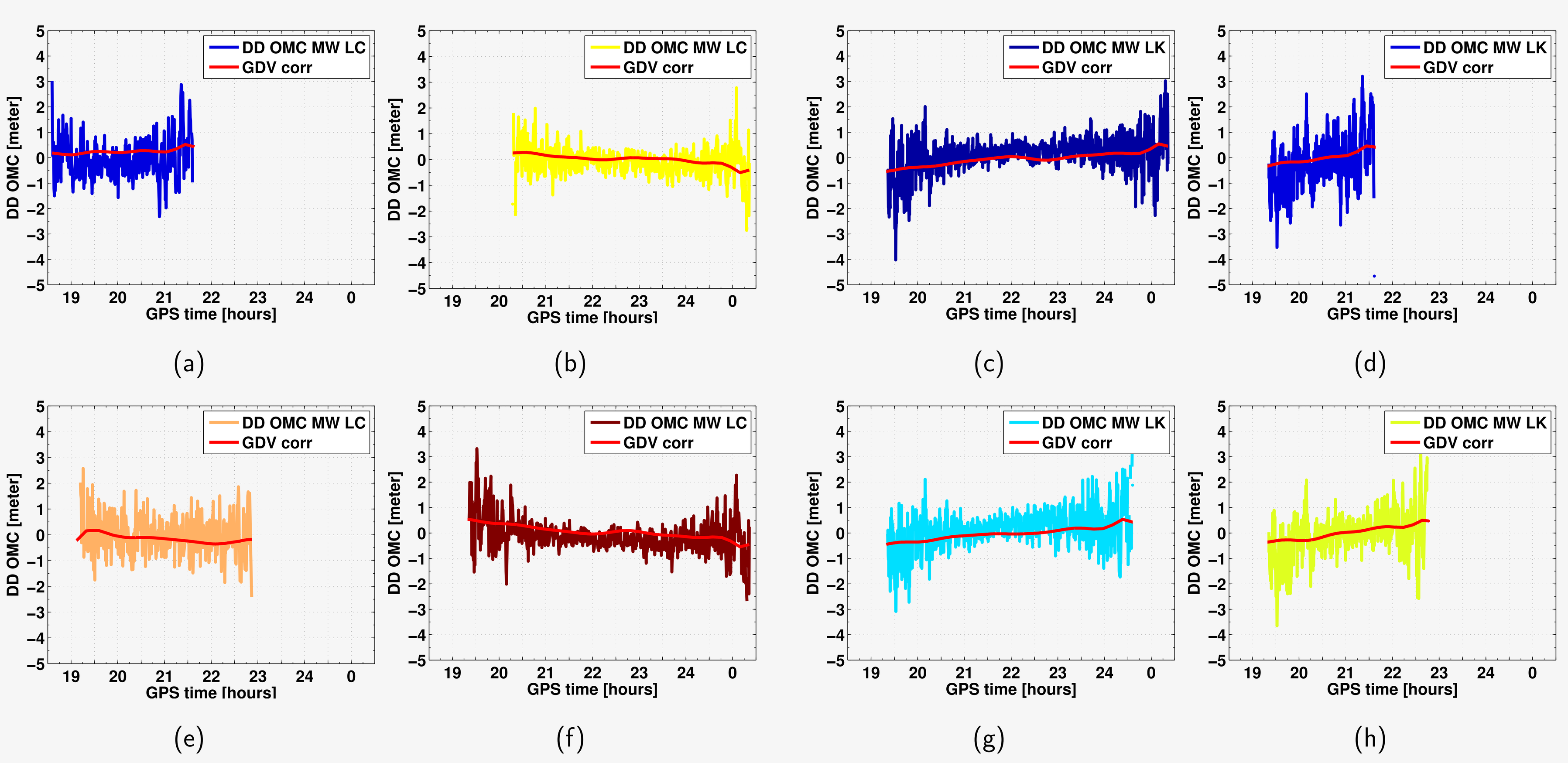

Figure 4: Double Differences of Melbourne-Wübbena linear combination for two different reference satellites, (a-b) and (e-f) correspond to reference satellite PRN01 while (c-d) and (g-h) correspond to reference satellite PRN32. The correction of GDV is indicated by a solid line.

Widelane Ambigutiy Fixing

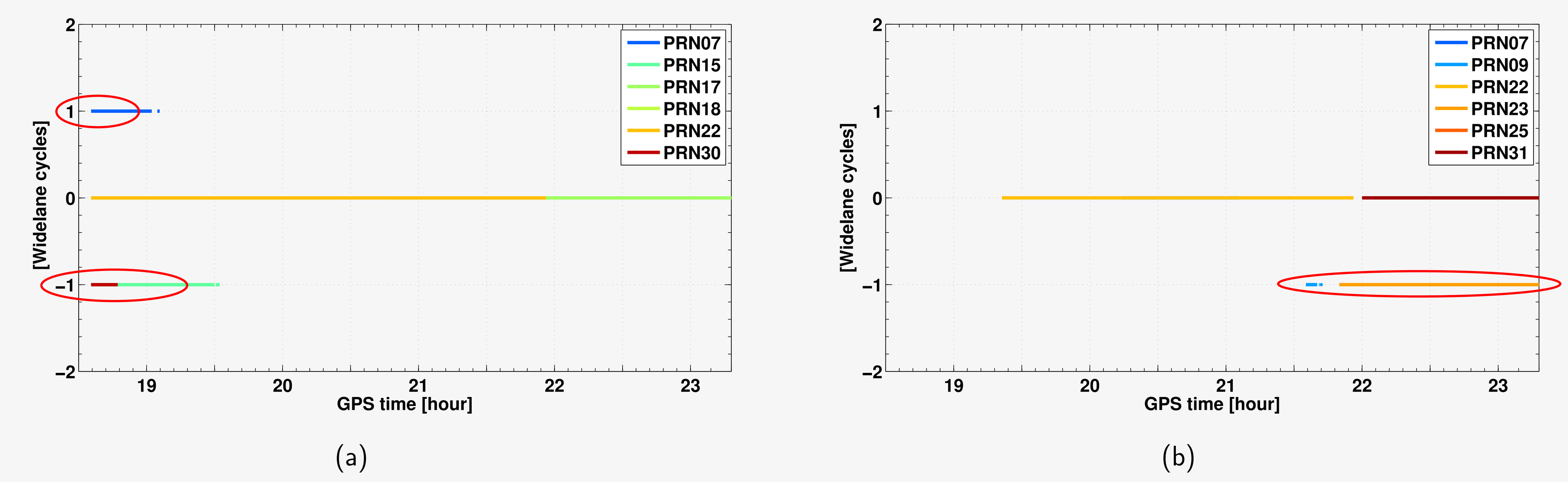

Figure 5: Differences of WL ambiguity fixing induced by GDV corrections for situation of reference satellite PRN01 (a) and PRN32 (b).

Coordinate Domain - DD Lw Solution with reference PRN01 and PRN32

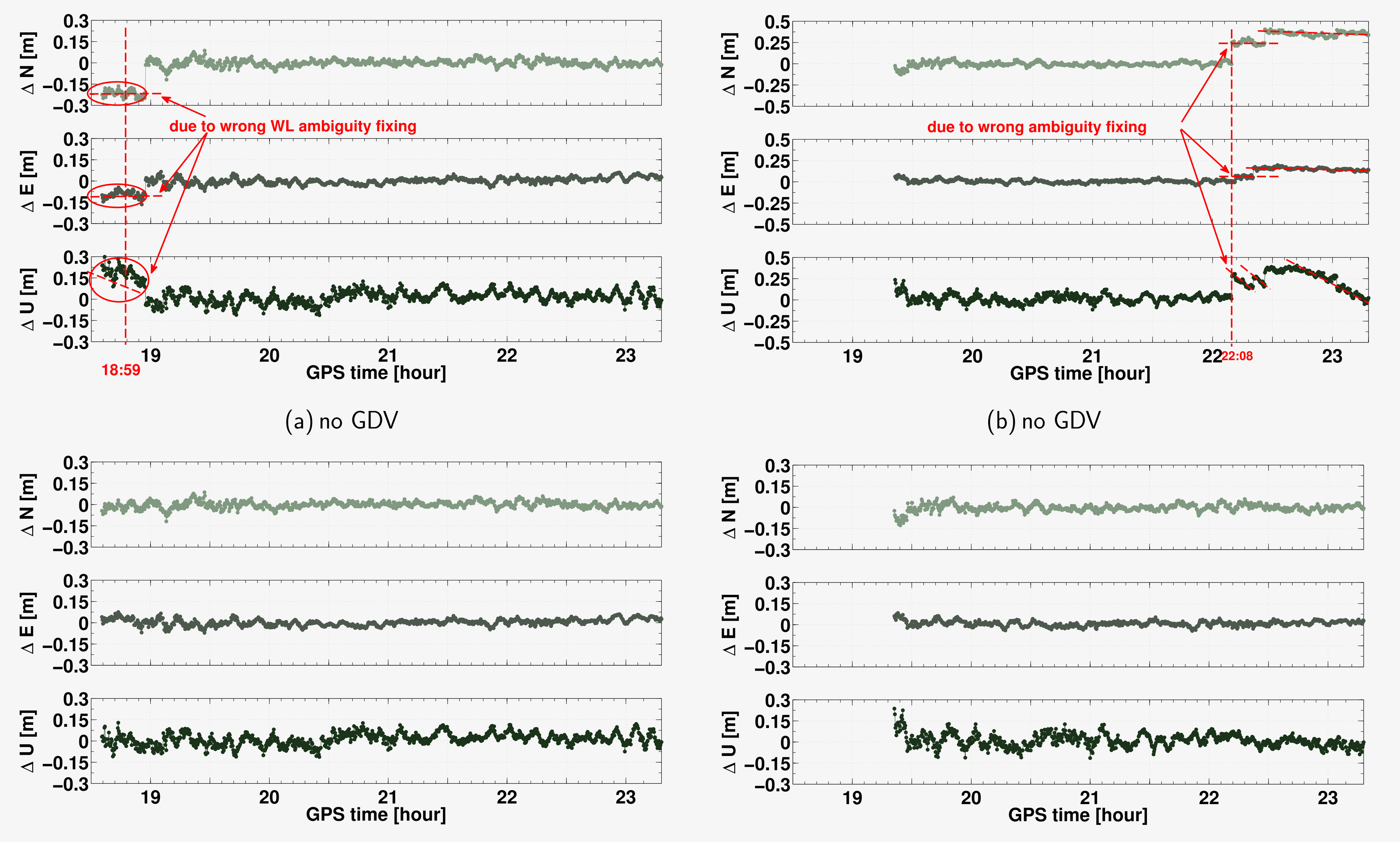

Figure 6: Double Difference coordinate solution using Widelane phase and ambiguities obtained without GDV correction (a-b), with GDV correction (c-d) and identical observation weighting.

Impact on Coordinate Domain - Reference PRN32

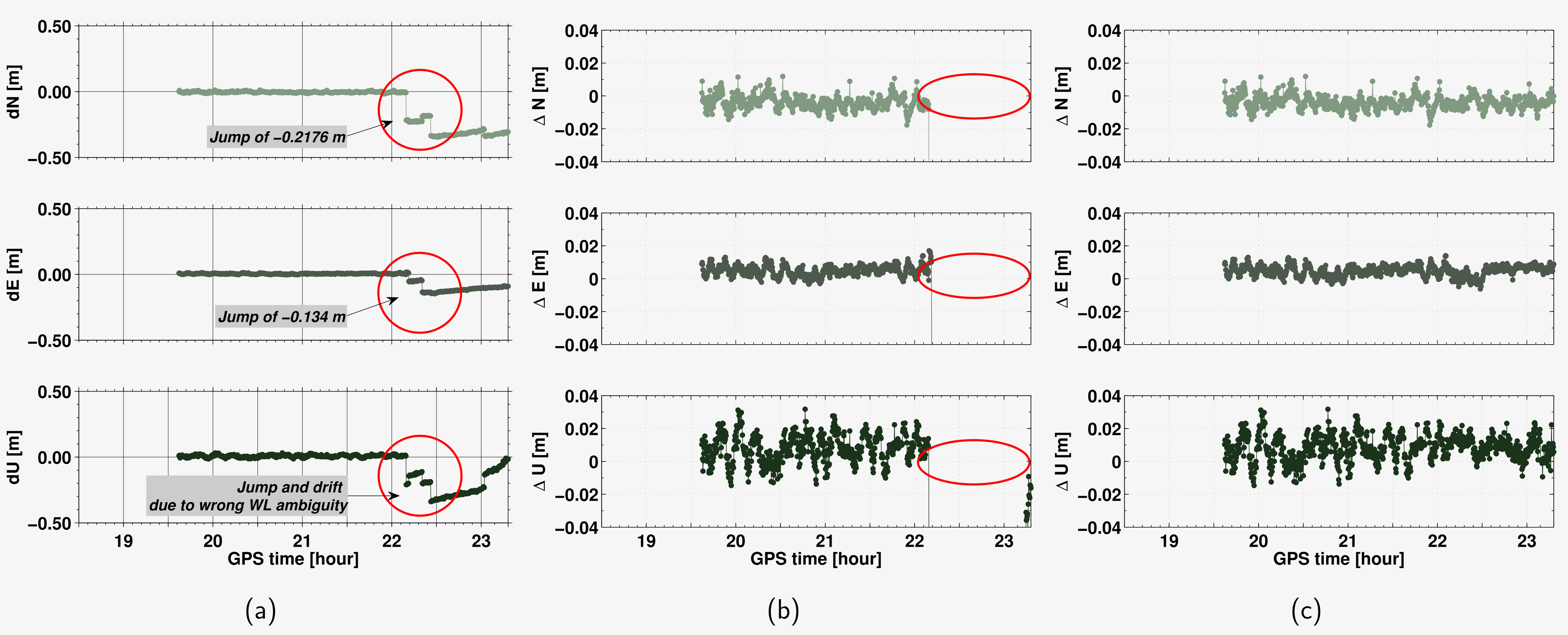

Figure 7: Double Difference L_1 phase solution and original MW-LC ambiguities (a-b) and GDV-repaired MW-LC ambiguities (c).

Conclusions

Code Phase Variations (GDV)

- Significant and repeatable GDV depending on the antenna design are obtained (Fig. 3).
- GDV can reach magnitudes of $\geq$ 1 cycle 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.

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 7(a) & 7(b)).

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.

References

Kersten, T., Schön, S., and Weinbach, U. (2012). On the Impact of Group Delay Variations on GNSS Time and Frequency Transfer. In *Proceedings of the 26th European Frequency and Time Forum (EFTF), 24.-26. April 2012, Gothenburg, Sweden*, pages 514 – 521. DOI: 10.1109/EFTF.2012.6502435.

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