

GLONASS- Signalverzögerungen und Mehrdeutigkeitsfestsetzung bei *Precise Point Positioning*

Nico Reußner, Lambert Wanninger

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Faculty of Forest, Geo and Hydro Sciences Department of Geosciences, Geodetic Institute

GLONASS inter-frequency code biases and PPP carrier-phase ambiguity resolution

Nico Reußner, Lambert Wanninger

Introduction

The two fully operational GNSS GPS and GLONASS use different methods to make their signals distinguishable. GPS satellites broadcast their signals on the same frequencies but with different PRN codes (code division multiple access, CDMA). On the other hand, GLONASS satellites transmit their signals with the same PRN code but on slightly different frequencies in

the two parts of the L-band (frequency division multiple access, FDMA).

Due to FDMA, GLONASS signals experience different code delays in the receiving equipment which affect both, the code positioning solutions and those ambiguity resolution techniques which rely on the code measurements. Although, the carrier-phase is also affected, but modeling and correction of the carrier-phase inter-frequency bias (IFB) seems to be easier

than the modeling and the correction of the code IFB or of a combined carrier-phase/code IFB.

As a consequence, difficulties occur in Precise Point Positioning (PPP) ambiguity resolution (AR) where the Melbourne-Widebana (MW) linear combination (LC) is used for fixing the wideband (WL) ambiguities. We have tested pure carrier-phase WL AR as an alternative technique.

Precise Point Positioning (PPP) Ambiguity Resolution (AR)

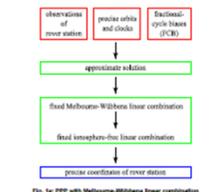


Fig. 1a: PPP with Melbourne-Widebana linear combination

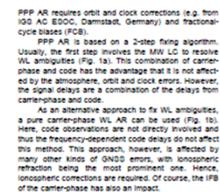


Fig. 1b: PPP with wideband linear combination

GLONASS Code Delays

One of the reasons for the introduction of code observations into PPP is the use of the MW AR technique. As shown by mean code residuals of the ionosphere-free LC PD of 2 weeks of observations from 2010 and from GREP (Integrated Geodetic Reference Network of Germany) and EUREF stations, a dependence on frequency is obvious. Moreover, these delays are receiver- and antenna-individual (Fig. 2a). In addition, the code delays can behave completely different after an antenna exchange as shown by the mean PD code delays from station ERLA with each part of Fig. 2b being based on 1 week of observations from 2010.

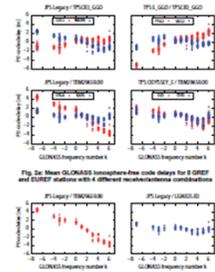


Fig. 2a: Mean GLONASS ionosphere-free code delays for 6 GREP and EUREF stations with 4 different receiver/antenna combinations

Fig. 2b: Mean GLONASS ionosphere-free code delays for station ERLA before (left) and after (right) an antenna exchange

Summary

As a consequence of the GLONASS FDMA approach, receiver/antenna hardware biases are not equal for all signals, but they depend on the signal's frequency and they are different for carrier-phase and code. Furthermore, code delays are receiver- and antenna-individual so that antenna exchanges can cause shifts of the MW IFB. GLONASS code delays are often so large that they

GLONASS MW Ambiguity Resolution

As shown in Fig. 2a and 2b, it can be expected that the MW LC is biased by code delays which may be able to prevent a successful MW AR. Therefore we analyzed the fractional parts (FP) of WL ambiguity estimates using the MW LC.

First, we calculated MW FP for station WARIN based on 2 weeks of observations from 2010 (Fig. 3a). The applied FCBs were estimated from observations of station BORJ. Both stations are equipped with iGPS Legacy receivers and antennas of type TPICOR_IGD. The characteristic of the PD code delays of WARIN and BORJ is very similar. Nevertheless, a frequency dependence is visible in the MW FP (left panel of Fig. 3a). The main part of the frequency dependence can be removed by linear modeling. Large residual errors remain for channel number 1 = 7 (R10 and R14) and prevent a successful AR.

Secondly, we calculated MW FP for station ERLA with the same data as used for Fig. 2b (Fig. 3b). The applied FCBs were estimated from observations of station IFB2. It is clearly noticeable, that an antenna exchange can cause a shift of the MW IFB.

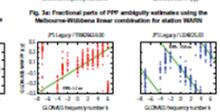


Fig. 3a: Fractional parts of PPP ambiguity estimates using the Melbourne-Widebana linear combination for station WARIN

Fig. 3b: Fractional parts of PPP ambiguity estimates using the Melbourne-Widebana linear combination for station ERLA

GLONASS WL Ambiguity Resolution

The WL AR based on pure carrier-phase is an alternative technique to the MW AR. WL AR is not influenced by code biases, but by other kinds of GNSS errors which may be able to prevent a successful WL AR. Based on observations of 6 consecutive weeks from 2010 and from 11 GREP and EUREF stations, we calculated GPS MW FP, GPS WL FP and GLONASS WL FP after applying MW and WL FCB.

In the case of GLONASS, we distinguished 2 approaches: no application of a prior WL IFB, application of correction values published by Wanninger 2012 (Journal of Geodesy, 86:139-148).

Fig. 4a shows the distribution of GPS MW and WL FP. A fixing efficiency of 86 % and 86 % can be reached for GPS MW and GPS WL ambiguities, respectively (round-off criterion: 0.2 cy).

Fig. 4b shows the distribution of GLONASS WL FP. Without application of WL IFB, they are much larger than the ones of GPS. After applying WL IFB, a fixing efficiency of 82 % for GLONASS WL ambiguities can be reached (round-off criterion: 0.2 cy). The GLONASS WL results are almost as good as the ones of GPS WL.

Fig. 4a: Distribution of the fractional parts of GPS MW and WL PPP ambiguity estimates

Fig. 4b: Distribution of the fractional parts of GLONASS WL PPP ambiguity estimates of the carrier-phase wideband linear combination

Summary

GLONASS WL ambiguities is not as good as the one of GPS MW ambiguities but still acceptable. In conclusion, we propose to use Melbourne-Widebana wideband ambiguity resolution for GPS and pure carrier-phase wideband ambiguity resolution for GLONASS.

Geodetic Institute
 Technische Universität Dresden, Germany
 nico.reu@tu-dresden.de

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Motivation

- GPS: *Code Division Multiple Access* (CDMA)

$$f_1 \quad f_2$$

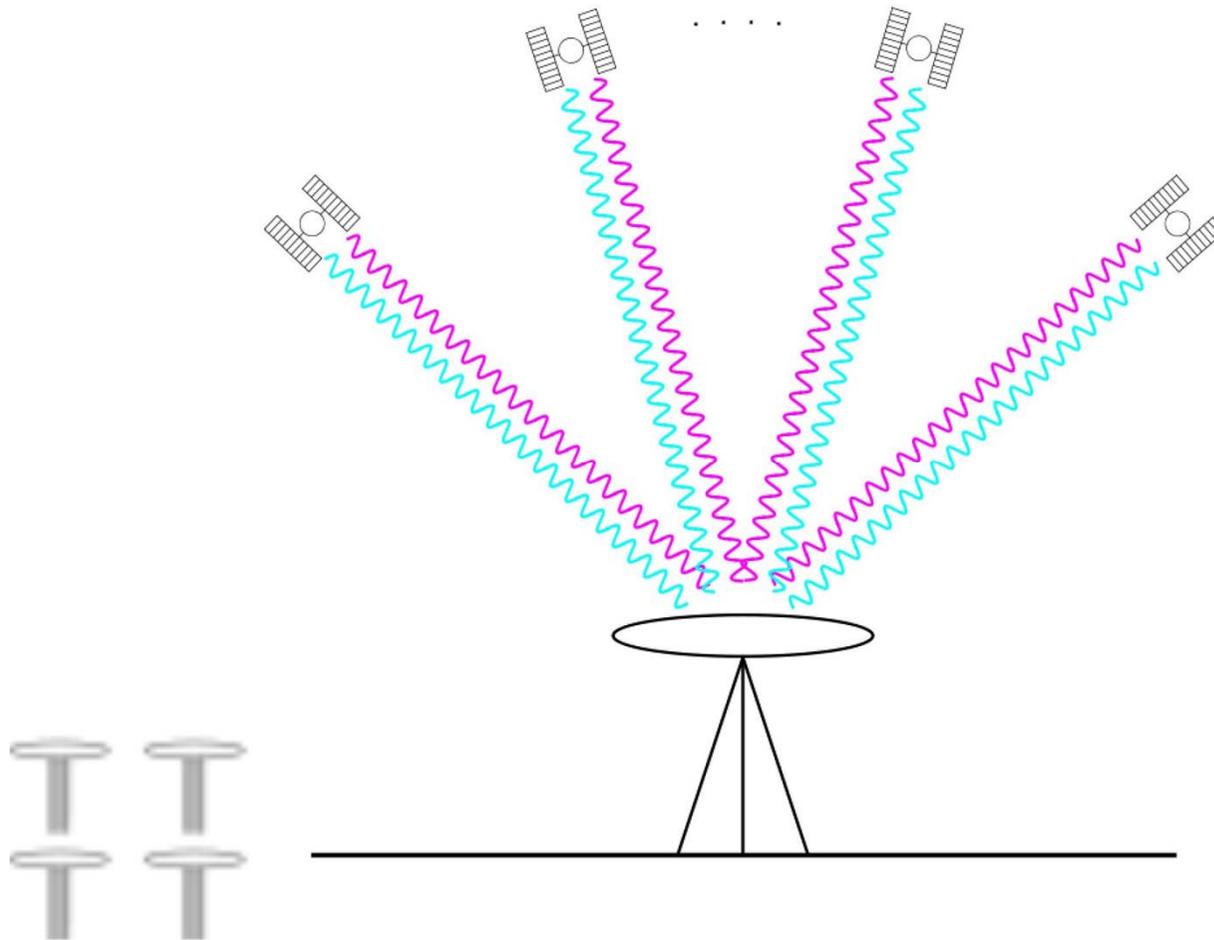
- GLONASS: *Frequency Division Multiple Access* (FDMA)

$$f_{1,k} = f_{0,1} + k \cdot \Delta f_1 \quad f_{2,k} = f_{0,2} + k \cdot \Delta f_2 \quad k = [7;6]$$

→ frequenzabhängige instrumentelle Laufzeitverzögerungen
(*Inter-Frequency Biases*, IFB)

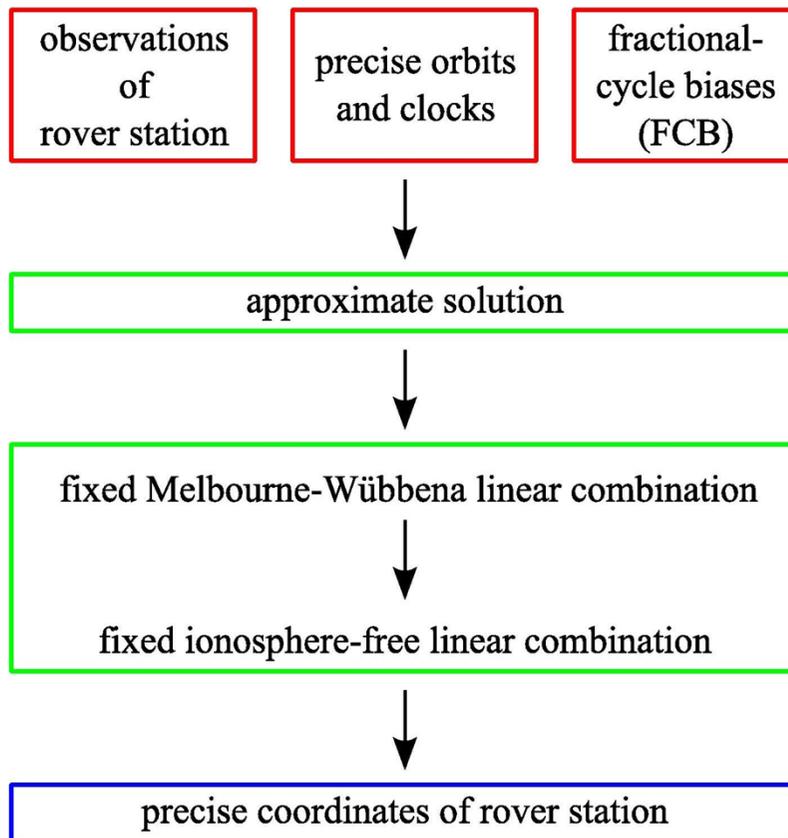
- Ziel: Modellierung des IFB in linear Abhängigkeit der Frequenznummer k

Precise Point Positioning (PPP) - Prinzip

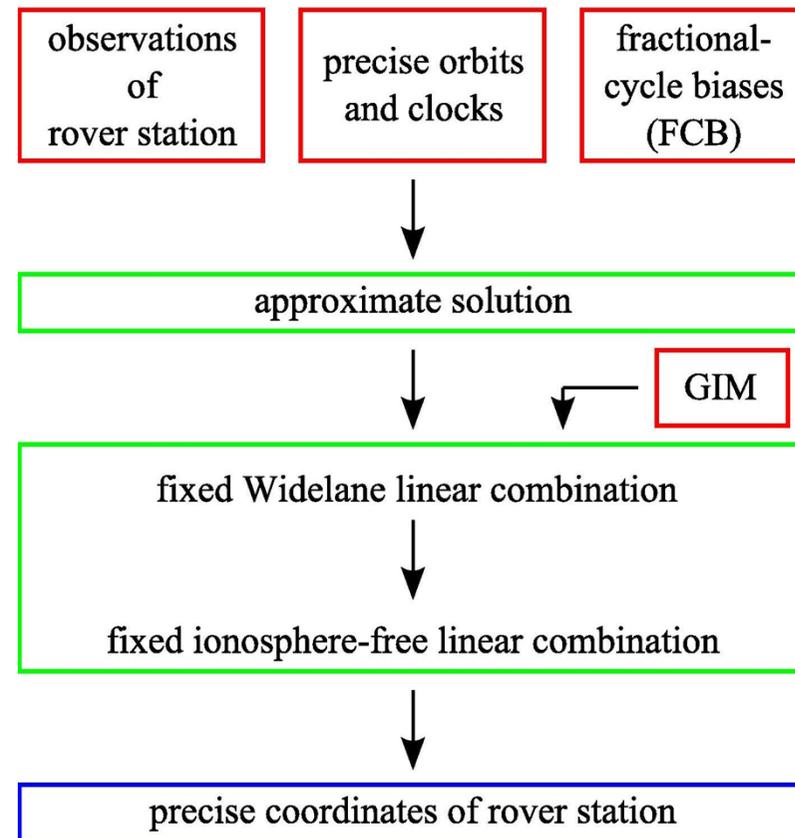


Precise Point Positioning (PPP) - Ablauf

PPP mit Melbourne-Wübbena LC



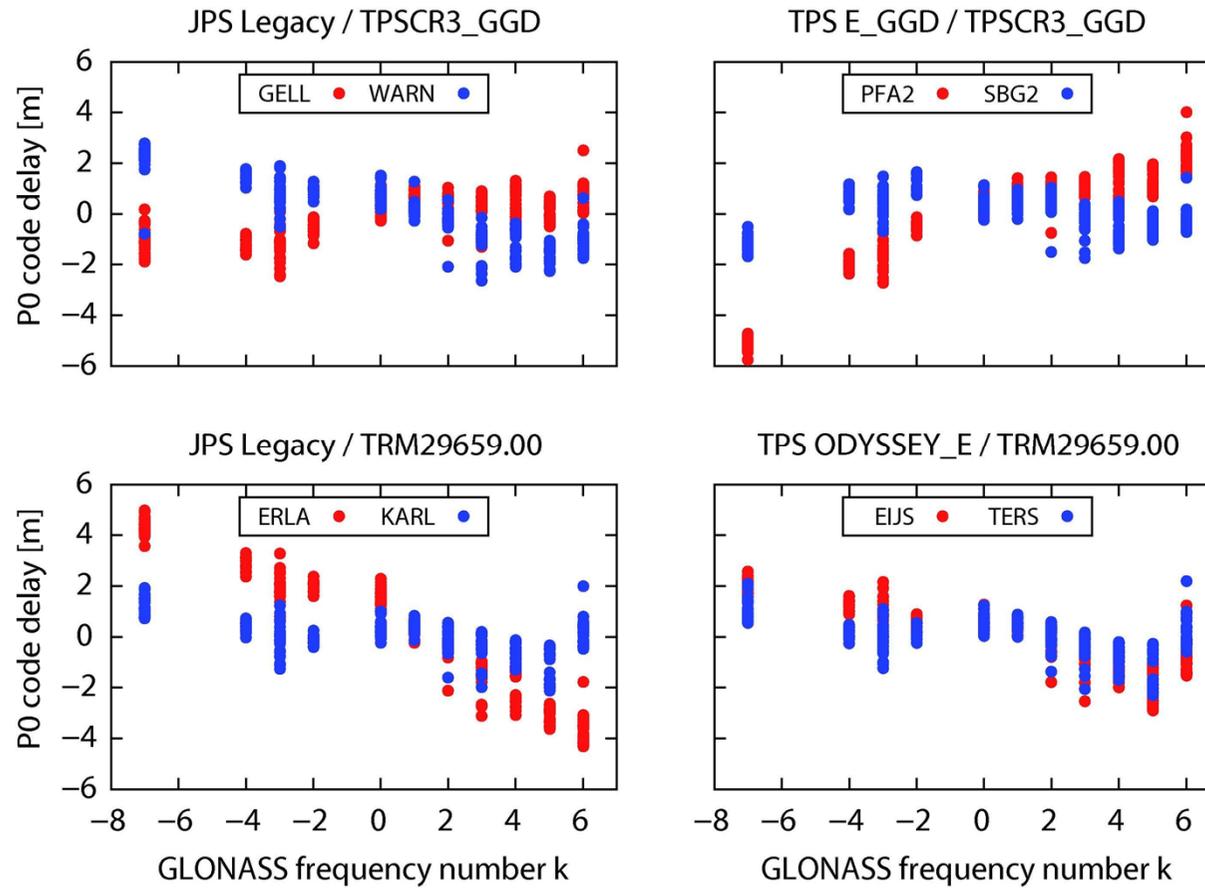
PPP mit Widelane LC



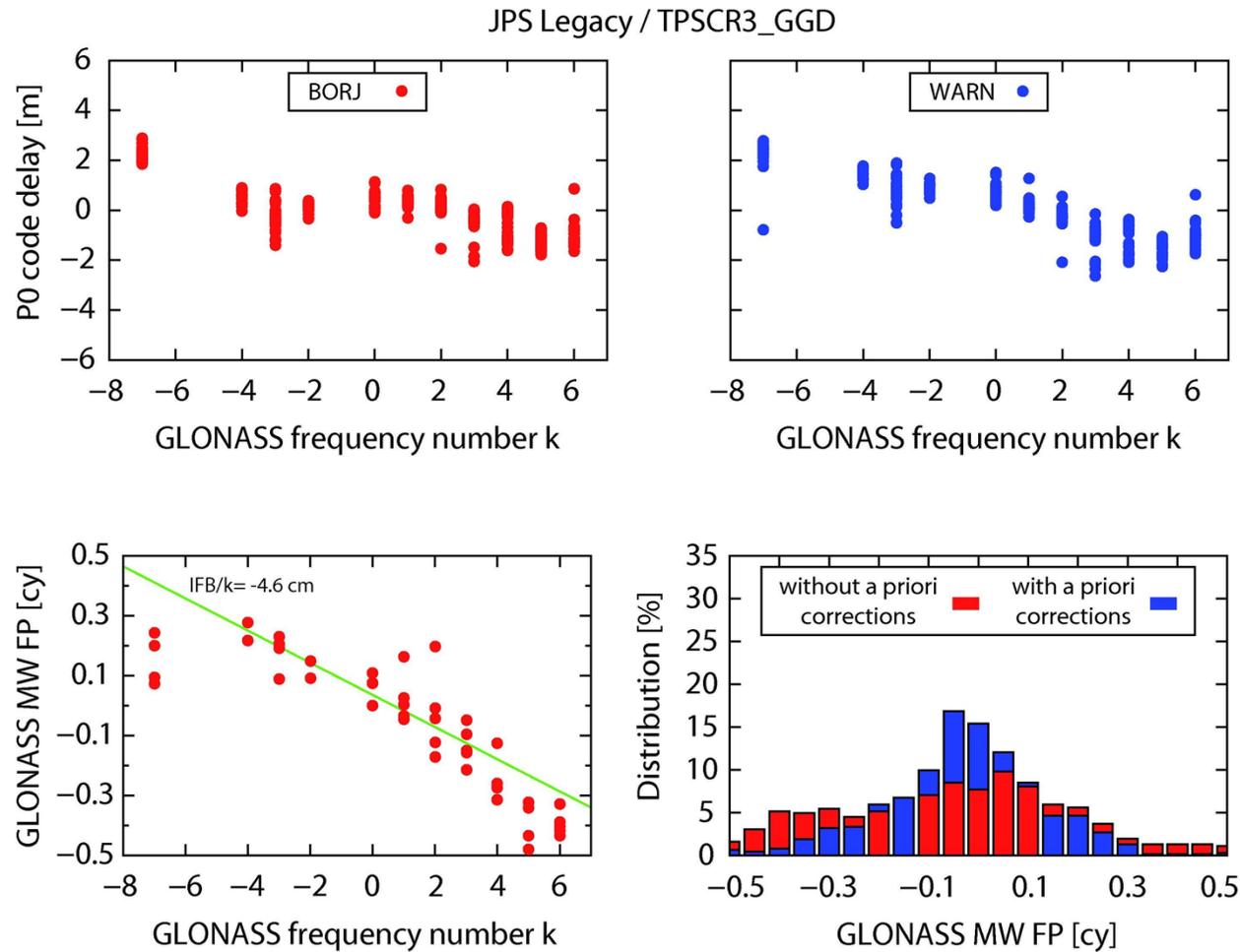
Daten

- Beobachtungsdaten
 - GREF, EPN
 - Code (P1, P2), Phase (L1, L2)
 - GPS-Woche 1596 bis 1602 (Jahr 2010)
 - verschiedene Kombinationen aus Empfänger- und Antennentypen
- präzise Orbit- und Uhrkorrekturen
 - IGS AC ESA/ESOC
 - GPS + GLONASS

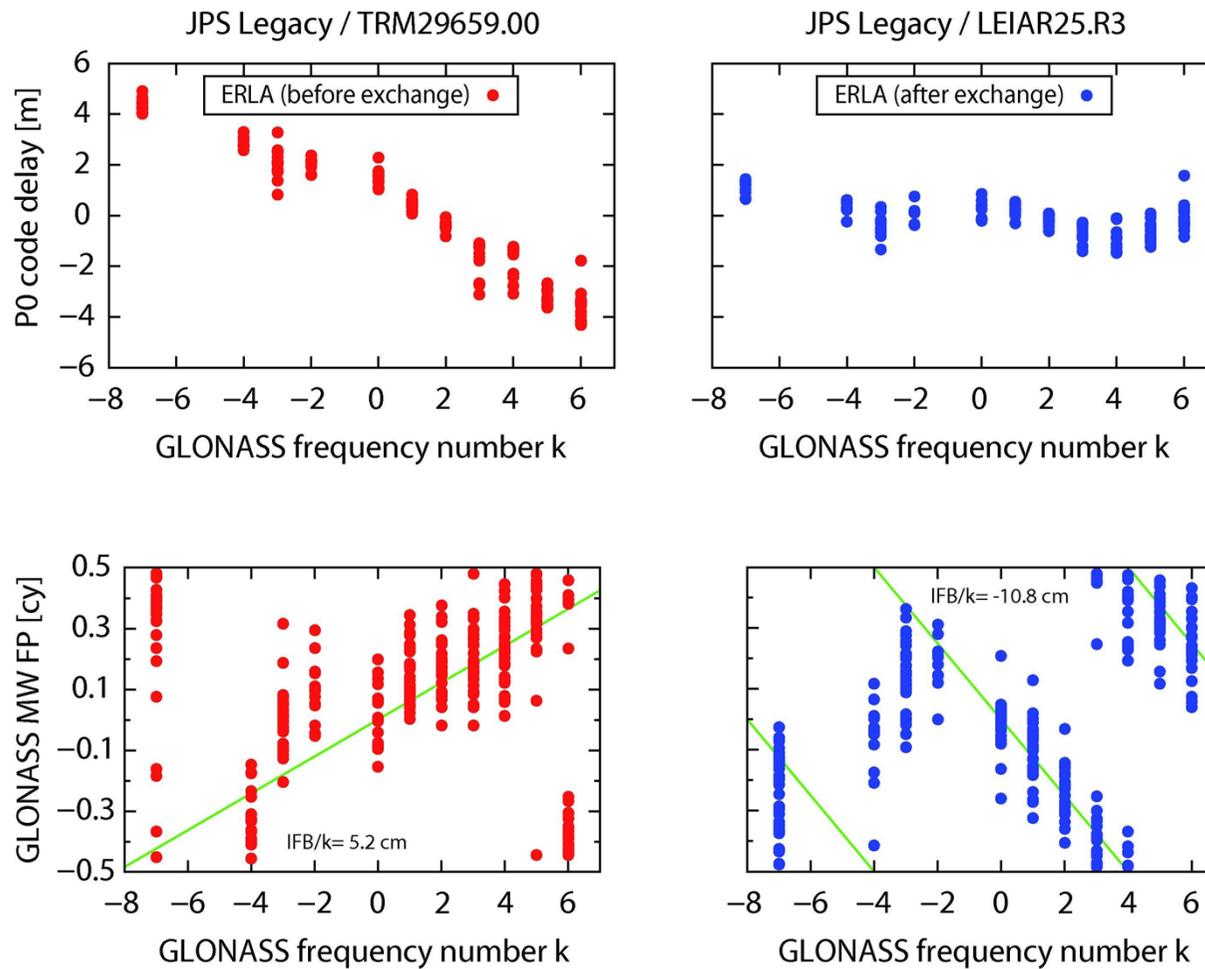
GLONASS P0 Codeverzögerung



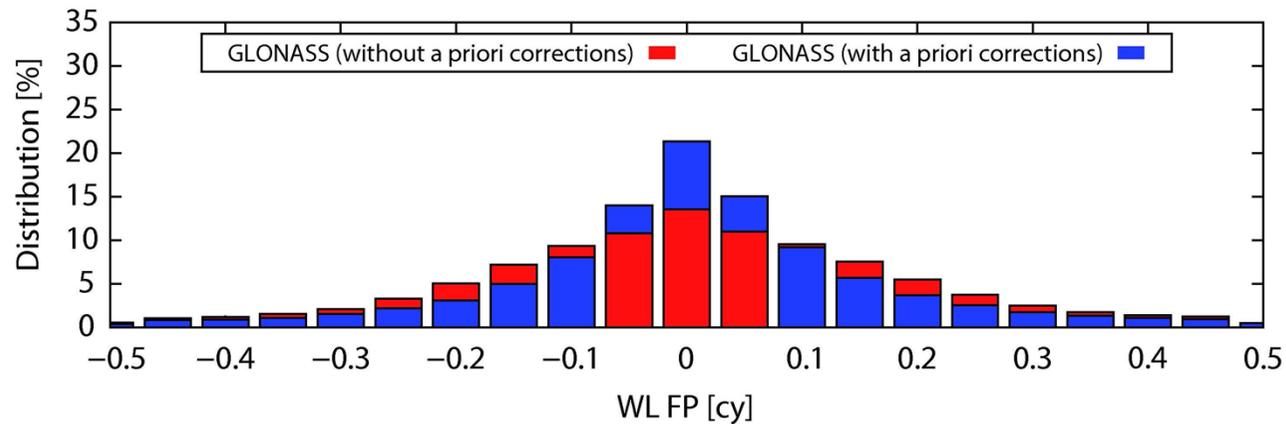
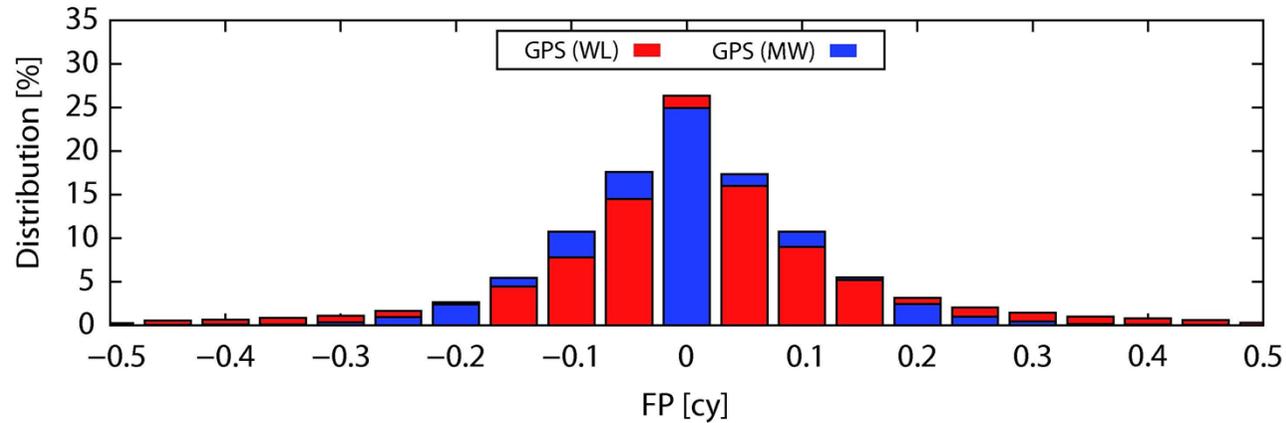
Mehrdeutigkeitslösung mit MW LC (1/2)



Mehrdeutigkeitslösung mit MW LC (2/2)



Mehrdeutigkeitslösung mit Widelane LC



Zusammenfassung

GLONASS Codeverzögerungen:

- empfänger- und antennenabhängig

Mehrdeutigkeitsfestsetzung mit Melbourne-Wübbena LC:

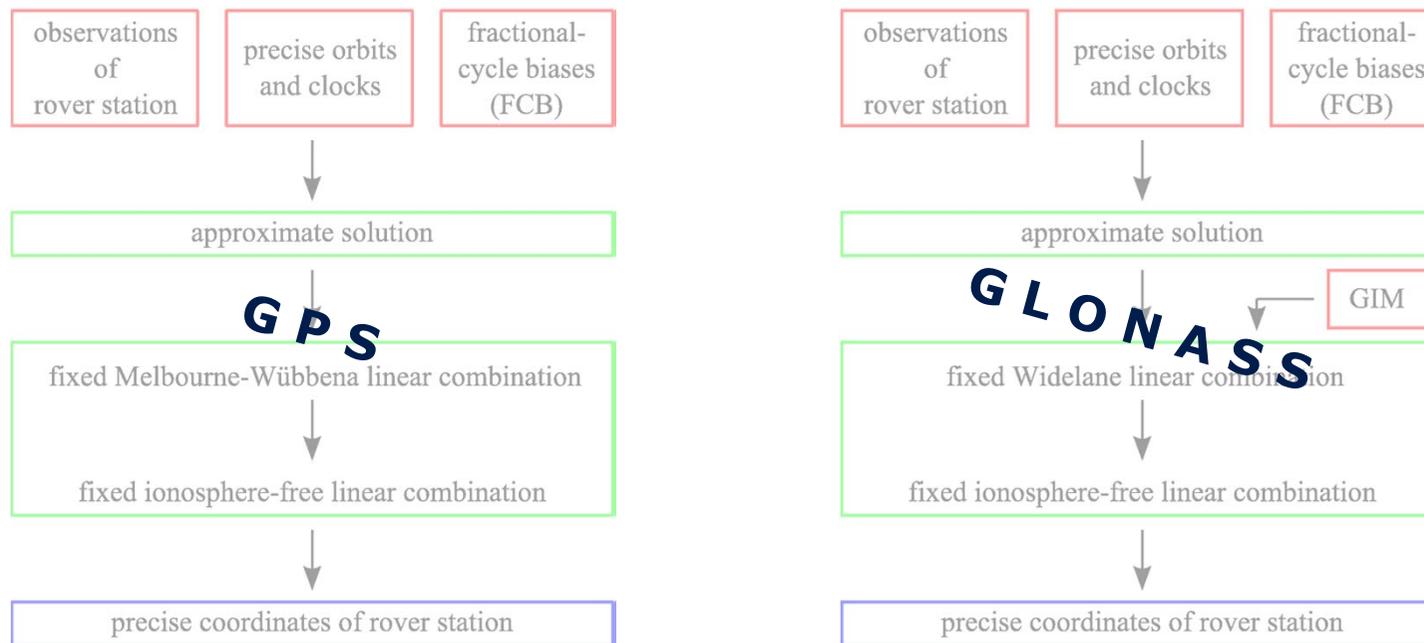
- GPS: 95%
- GLONASS: ---

Mehrdeutigkeitsfestsetzung mit Widelane LC:

- GPS: 86%
- GLONASS: 82%

Zusammenfassung

Fazit:



Ausblick:

- Verwendung präziser Orbit- und Uhrkorrekturen weiterer IGS AC

Danke für Ihre Aufmerksamkeit

Nico Reußner
Geodätisches Institut
Technische Universität Dresden

<http://tu-dresden.de/gi/gg>
nico.reussner@tu-dresden.de

Literatur

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