Biases and clock modelling in the frame of ambiguity resolution

International GNSS Service
Workshop 2012
23 - 27 July 2012, Olsztyn, Poland

E. Orliac[1], R. Dach[1], K. Wang[2], M. Rothacher[2],
D. Voithenleitner[3], U. Hugentobler[3], M. Heinze[3], and D. Svehla[4]
[1] Astronomical Institute, University of Bern, Switzerland
[2] Institute of Geodesy and Photogrammetry, Swiss Federal Institute of Technology Zurich, Switzerland
[3] Institut für Astronomische und Physikalische Geodäsie, Technische Universität München, Munich, Germany
[4] European Space Operations Centre, European Space Agency, Darmstadt, Germany

OVERVIEW

In the frame of the ESA project "Satellite and Station Clock Modelling for GNSS" we carried out a review of the code and phase biases in and between existing GNSS. The stability of these biases and opportunities for their modeling were investigated and compared to the requirements for successful ambiguity resolution on the zero- and single-difference levels.
Based on both simulated and real data, the track-to-track ambiguity resolution was investigated, with a special focus set on the impact of clock modeling.

INTER-SYSTEM PHASE BIASES

GPS/GLO mixed baselines only as formed in the CODE final 1-day solution are used in this investigation, i.e. GPS only baselines are not considered. Only preprocessed phase ionosphere-free (L3) observations are used. Estimated parameters are daily coordinates and troposphere parameters, plus (float) ambiguities. The mixed baselines are processed 7 times:

1. in GPS-only mode (**G**)
2. in GLO-only mode (**R**)
3. in GPS/GLO mode (**RG00**)
4. in GPS/GLO mode, correcting for station inter-system translation biases (**RG10**)
5. in GPS/GLO mode, correcting for station inter-system troposphere biases (**RG01**)
6. in GPS/GLO mode, correcting for both station inter-system translation and troposphere biases (**RG11**).
7. in GPS/GLO mode, estimating a phase inter-system bias, modelled as a piece-wise linear function with a knot spacing of 1 hour (**RGI**)

Table 1: Statistics on the distribution of the baseline L3 DD phase normalized residuals RMS. Values are given in mm and are based on residuals from DOYs 170-172 of 2012.

Solution	Q00% (min)	Q25%	Q50% (median)	Q75%	Q100% (max)	Size
G	0.16	1.06	1.23	1.42	1.90	566
R	0.13	1.09	1.27	1.43	2.11	566
GG00	0.17	1.06	1.24	1.43	1.89	566
GG10	0.20	1.21	1.42	1.60	2.01	566
GG01	0.17	1.06	1.24	1.43	1.89	566
GG11	0.17	1.06	1.23	1.43	1.89	566
GGI	0.17	1.06	1.24	1.42	1.89	566
RR00	0.14	1.12	1.30	1.47	2.08	566
RR10	0.15	1.11	1.29	1.47	2.05	566
RR01	0.15	1.12	1.30	1.48	2.07	566
RR11	0.14	1.11	1.29	1.47	2.05	566
RRI	0.14	1.10	1.28	1.46	2.05	566
RG00	0.20	1.23	1.42	1.60	2.01	566
RG10	0.20	1.21	1.42	1.60	2.01	566
RG01	0.20	1.23	1.42	1.60	2.01	566
RG11	0.20	1.21	1.42	1.60	2.01	566
RGI	0.20	1.21	1.40	1.57	1.99	566

The main point from Tab. 1 is that the G and R solutions (single-GNSS) show the smallest residuals overall, with, comparable performances.
For mixed solutions (3. to 7.) the DD residuals were analyzed in three groups: GPS/GPS (GG), GLO/GLO (RR), and GPS/GLO (RG). The RMS of the DD residuals between satellites of the same GNSS (GGxx and RRxx) are only slightly higher than the residuals from the single-GNSS solutions (1. and 2.) whereas the residuals accross the systems (RGxx) are significantly higher.
In solutions 4. to 7. attempts were made to identify the potential source of the degradation. Correcting for coordinate and/or troposphere bias (to handle GLO antenna calibration bias from a GPS only based calibration, solutions 4. to 6.) did not help. Only estimating a inter-system time-varying phase bias seems to have a little effect (solution 7.).

We now investigate the role of the receiver type, or more precisely the role fo the receiver type combination. Receivers from a same brand were grouped together. Here we focus on the difference between the residuals RMS from the GG and RG DD in solutions RG00, RG11 and RGI.

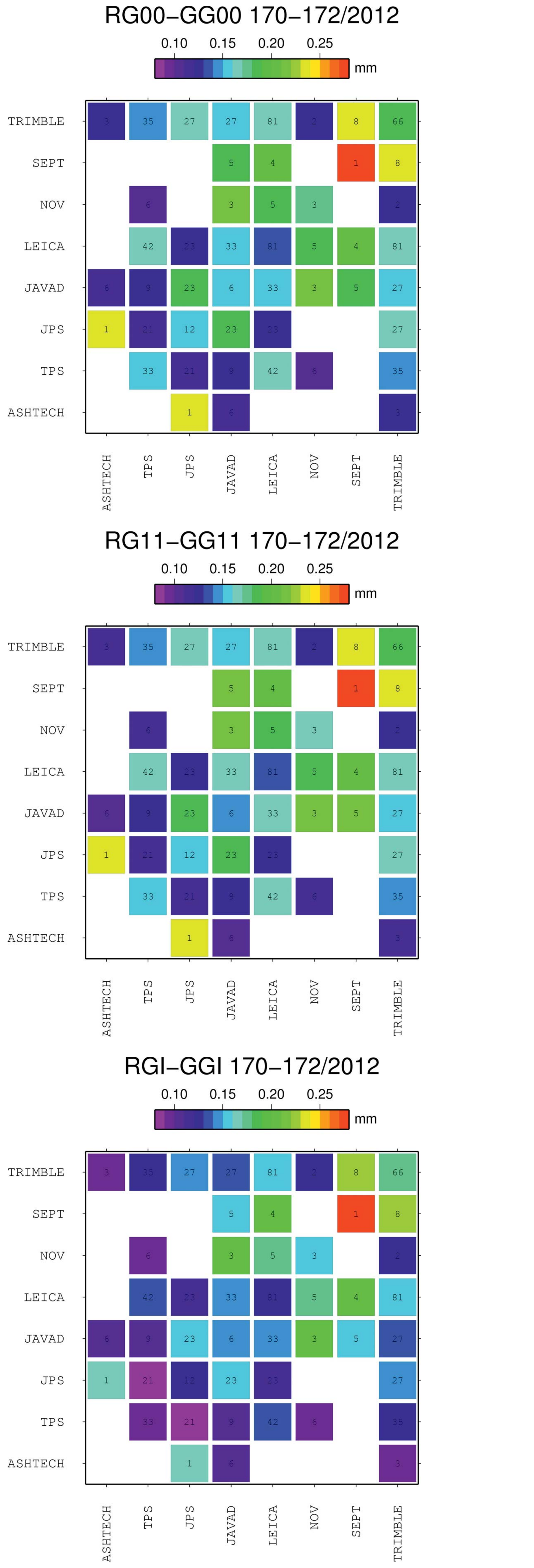

Figure 1: Mean of the difference of baseline residual RMS when grouped by receiver class between the RG and GG residuals for mixed-GNSS solutions RG00 (top), RG11 (middle), and RGI (bottom). Values were computed residuals from baselines from DOY 170-172 of 2012. The numbers in each square indicate the number of contributing baselines to a specific receiver class combination.

Summary on inter-system phase bias

Fig. 1 shows that correcting for station-wise GLONASS translation and troposphere bias does not impact the performances of any receiver class pair. However, when estimating a time-varying inter-system phase bias, the degradation of the RG residuals compared to the GG or RR one is reduced (colder colors in Fig. 1).
This effect is not yet fully understood and needs to be further investigated.

TRACK-TO-TRACK AMBIGUITY RESOLUTION

Fig. 2 shows the histograms of the fractional wide-lane ambiguities (left) and the fractional track-to-track wide-lane ambiguities (right) for station USN3 on February 1st, 2011. We see that most of the receiver- and satellite-related biases, which still remain in the zero-difference wide-lane ambiguities, were significantly reduced by forming track-to-track ambiguities.

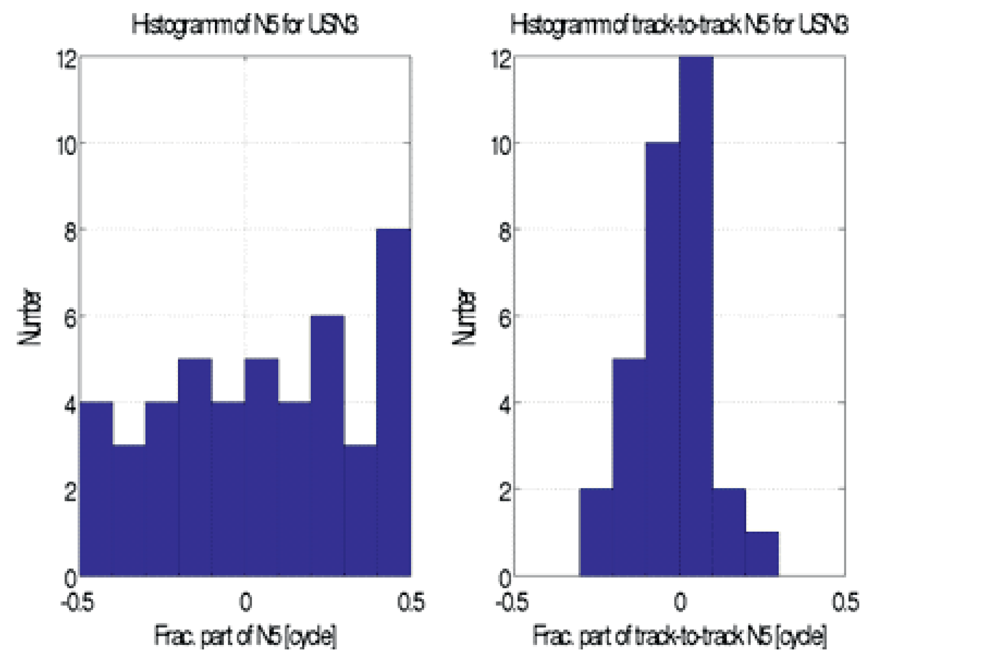

Figure 2: Histograms of the fractional wide-lane ambiguities (left) and the fractional track-to-track wide-lane ambiguities from Melbourne-Wübbena linear combination for station USN3 on February 1st, 2011.

Fig. 3 shows the relationship between the fractional N5 and N1 ambiguities and the weighted track lengths on the zero-difference level. The data for 10 stations in February 2011 was used for plotting. We see that track-to-track ambiguities with small fractional parts are more likely to be generated by the ones with long track lengths.

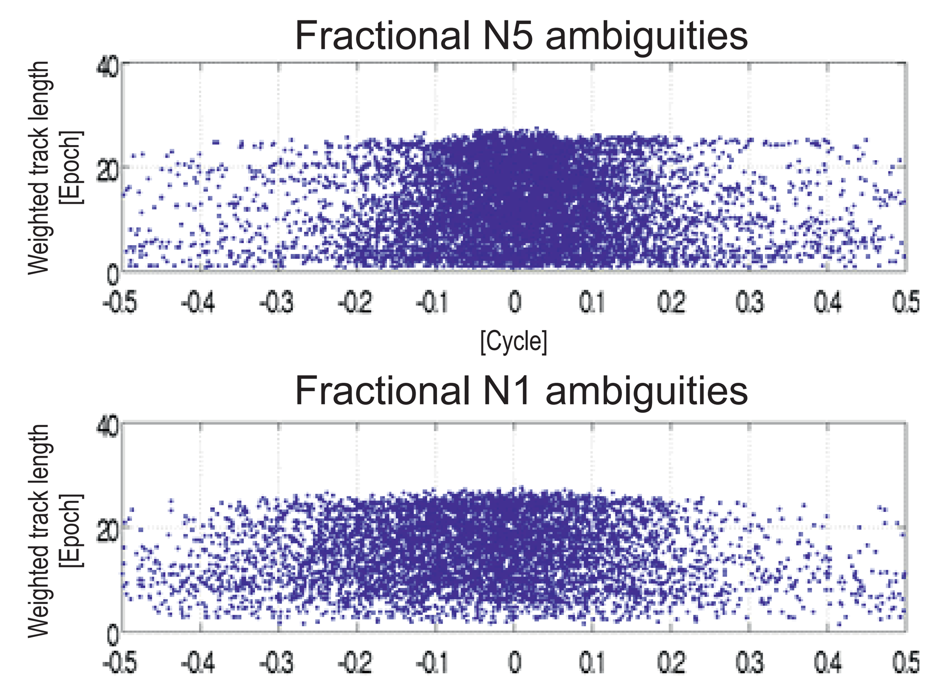

Figure 3: Relationship between the fractional N5 (top) and N1 (bottom) ambiguities and the weighted track lengths on the zero-difference level.

Fig. 4 shows the track-to-track N1 ambiguities with an absolute fractional part below 0.1 cycle. The resolved track-to-track ambiguities were constrained with a strong weight on the normal equation level iteratively. We see that the constraining has increased the number of the good track-to-track ambiguities significantly.

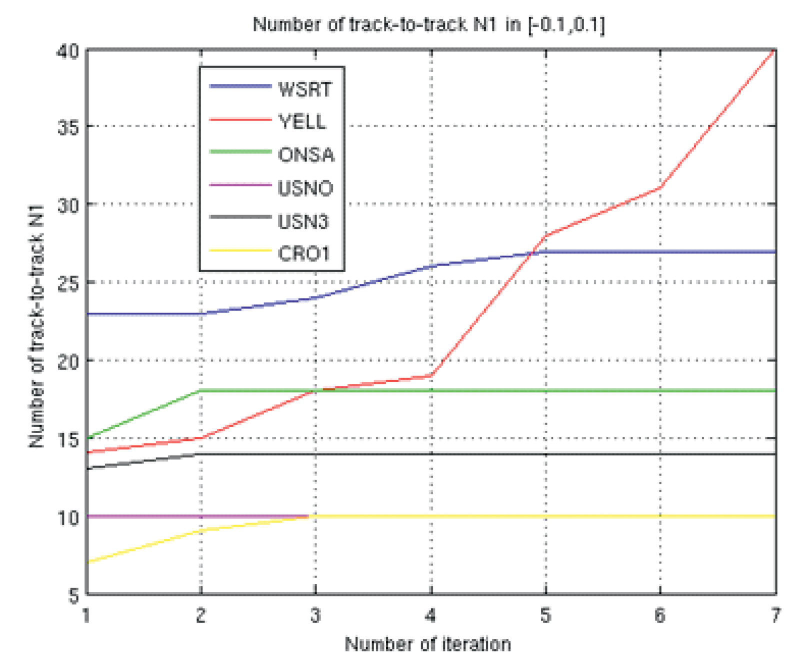

Figure 4: Number of track-to-track N1 ambiguities with a fractional part in [-0.1, 0.1] cycle after seven iterations of constraining the resolved ones on the normal equation level.

ACKNOWLEDGEMENTS

This study was performed in the framework of the ESA Project «Satellite and Station Clock Modelling for GNSS» (Main Contract No. 4000101520/10/D/SR).

AIUB
Poster compiled by E.Orliac, July 2012
Astronomical Institute, University of Bern, Bern
etienne.orliac@aiub.unibe.ch

u[b] UNIVERSITÄT BERN
IAPG
ETH Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich