Combining the Observations from Different GNSS

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Motivation

Even if geodetic GNSS receivers contain only one physical clock we can detect more than a simple offset between receiver clock differences computed with the L1 and L2 carrier phase data on short baselines. The magnitude of these deviations from the theoretically expected behaviour clearly exceeds the general noise of the solution for many receiver types. Typical examples are given in Fig. 1.

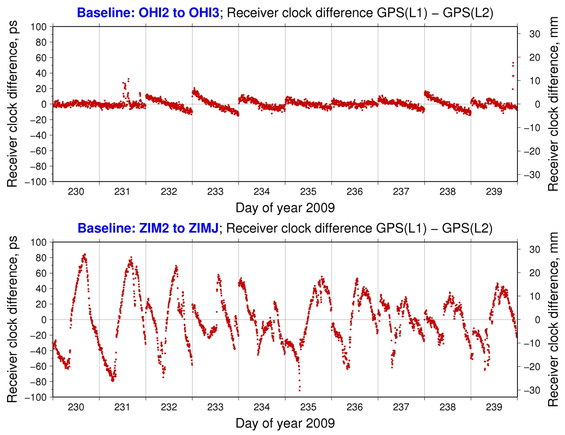

Figure 1: Differences between the estimated receiver clocks using the L1 and L2 carrier phase observations on short baselines.

Technical remarks

Table 1: List of stations

Station	Location	Receiver	Firmware
OHI2	O'Higgins	JPS E_GGD	2.6.1 Jan10,2008
OHI3	Antarctica	TPS E_GGD	2.6.1 Jan10,2008
WTZJ	Wettzell	JPS LEGACY	2.6.0 OCT24,2007
WTZZ	Germany	TPS E_GGD	2.7.0 Mar21,2008
ZIM2	Zimmerwald	TRIMBLE NETR5	Nav 4.03/Boot 3
ZIMJ	Switzerland	JPS LEGACY	2.5.1 Jan10,2008

The baseline in O'Higgins (OHI2/OHI3) provides an example for very stable ISB conditions whereas the baseline in Zimmerwald (ZIM2/ZIMJ) is the worst case scenario. The baseline in Wettzell (WTZJ/WTZZ) represents typical conditions for most stations. The stations and their equipment are listed in Tab. 1. Different assumptions on the variations of inter-system biases (ISB) in time and their implementation in the multi-GNSS processing are compiled in Tab. 2.

Table 2: Assumptions on the time variation of the ISB and their implementation in the zero- or double-difference processing.

Assumption on the behaviour of the ISB	Constant ISB within the processing interval	Completely free running ISB	A certain variation of the ISB is allowed
Realization in a phase zero-difference processing	Absorbed by the real valued ambiguity parameters	Estimation of GNSS-specific receiver clock parameters	Estimation of time-dependent inter-system biases
Realization in a phase double-difference	No ambiguities between the GNSS are resolved to integer	No double-diff. between satellites of different GNSS	Estimation of time-dependent inter-system biases

Stability of the GPS/GLONASS inter-system bias (ISB)

An analogue experiment can be carried out when comparing receiver clock estimates derived only from GPS or GLONASS measurement on multi-GNSS receivers. The ionosphere-free linear combination (L3) is used to get a comparable situation with regional or global multi-GNSS analysis. The results compiled in Fig. 2 indicate significant variations in time for the ISB for some examples.

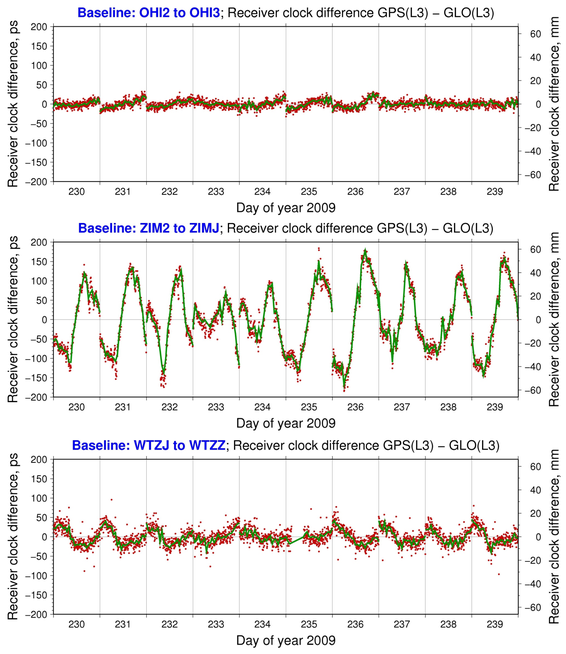

Figure 2: Receiver clock differences computed from GPS or GLONASS observations using the ionosphere-free linear combination (red dots). The hourly estimated ISB are indicated by the green line.

Impact on ambiguity resolution

A part of the variations in the ISB may be compensated by the phase ambiguity parameters. This is not possible to the same extent, if they are introduced with their integer values instead of being freely estimated.

The histograms of the residuals in Fig. 3 illustrate that variations of the ISB in time need to be considered - in particular when introducing the integer values for the ambiguity parameters.

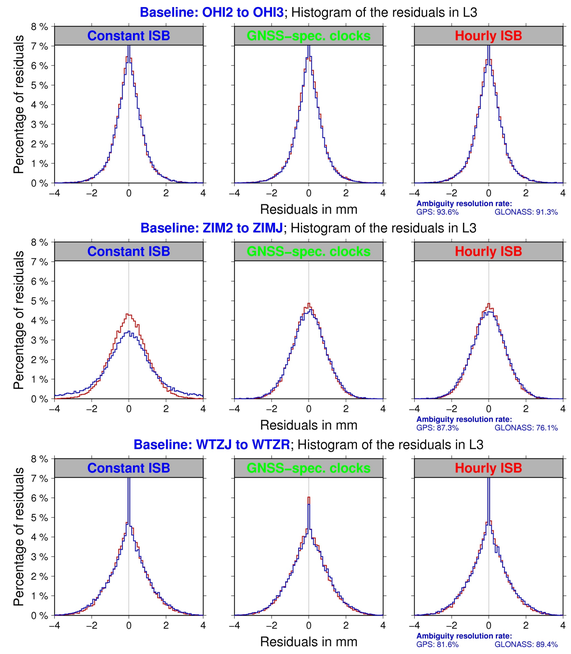

Figure 3: Histogram of the residuals from baseline solutions where the ambiguities are freely estimated or their integer values are introduced. Three strategies to handle variations in the ISB (see Tab. 2) are compared.

Summary

When processing the measurements from different GNSS together it is important to verify the stability of the inter-system bias of the receivers. If necessary it has to be considered in the data analysis by additional parameters. A piece-wise linear ISB parameter with a resolution of one hour seems sufficient for all cases included in this study. In this way the benefit due to the combined processing of the different GNSS is still bigger than assuming fully independent receiver clocks for each GNSS.

Impact on kinematic positioning

A set of kinematic solutions (sampling 5 minutes) are investigated for their sensitivity for time variations of the ISB.

The time series of kinematic positions is divided into intervals. From all positions in each interval a mean coordinate is computed. The standard deviation of the mean may serve as a quality measure for the mean position within an interval. The results for different intervals are shown in Fig. 4.

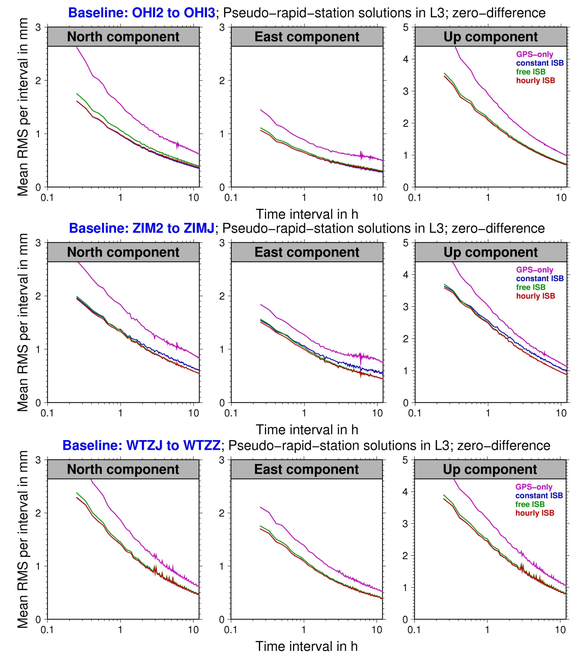

Figure 4: Standard deviation of a mean coordinate computed from a certain time interval (extracted from a kinematic positioning with a sampling of 5 minutes).

When introducing the integer values for the ambiguity parameter ignoring the variations of the ISB may even lead to a degradiation of the solution, see Fig. 5 for an example.

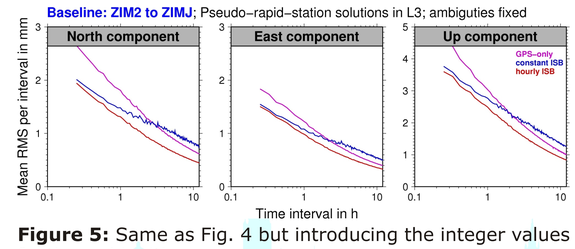

Figure 5: Same as Fig. 4 but introducing the integer values for the ambiguities.

Poster compiled by R. Dach, April 2010
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