Vertical Height Errors when Mixing Trimble 4000 SST and Trimble 4000 SSE Observations

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Introduction

Problems when mixing GPS phase observations between Trimble 4000 SST and Trimble 4000 SSE receivers have been reported by Fritz Brunner (Investigation of Height Repeatability From GPS Measurements, Fritz Brunner and Paul Tregoning, Australian Journal of Geodetic and Photogrammetric Surveying, No. 60 June, 1994, pp. 33-48). By collecting and analyzing data from short and zero baseline configurations, he suggests that differences in how each of the receiver internally processes the observations can cause vertical position errors of up to 40 mm.

In addition to full wavelength L1 and half wavelength L2 phase measurements, the Trimble 4000 SST receiver records C/A pseudorange observations. The SST receiver is not capable of tracking a second type of pseudorange signal, nor is it able to track full wavelength L2 phase observations. On the other hand, the Trimble 4000 SSE and Trimble 4000 SSI receivers are capable of observing two pseudorange observation types and tracking full wavelength L1 and L2 phase measurements. The types of pseudorange observables produced by the SSE and SSI receiver depend on whether or not A/S is activated.

Experiment Description

To verify the effect Brunner describes, UNAVCO repeated the zero baseline tests. We collected data for two days. On the first day, we operated one SST receiver and one SSE receiver both connected through a signal splitter to a single Trimble 4000 SST (defined by the IGS as a Trimble 4000ST L1/L2 GEOD) antenna. On the second day, we operated two SSI receivers in a similar zero baseline configuration. The second day of data was collected as part of the 1995 UNAVCO ARI receiver tests. In this configuration, the receivers are receiving signals with the same environmental errors and biases. These errors include tropospheric delay, orbit errors, S/A dithering errors, and multipath errors. The zero baseline computations will essentially difference out these environmental error sources. The solutions then reflect the differences in how the receiver internally processes the incoming signal.

Processing Strategies
All data were processed using the Bernese GPS Software V3.5. The entire sixteen hours of data were processed in one long observation session using the following six processing strategies.

- L1 Phase Resolve Ambiguities
- L2 Phase Resolve Ambiguities
- L3 Phase Use L1 and L2 Ambiguities
- L1 Phase Use Resolved Ambiguities Estimate Hourly Troposphere Parameter
- L2 Phase Use Resolved Ambiguities Estimate Hourly Troposphere Parameter
- L3 Phase Use Resolved Ambiguities Estimate Hourly Troposphere Parameter

In addition, the data were divided into 16 individual one hour observation sessions. The data from these short sessions were processed with the L3 ionopshere free linear combination of phase observables. The L1 and L2 ambiguities that were resolved in the during the long session processing were applied in the one hour observation windows. Finally, one troposphere parameter was estimated between the two receivers.

Results
The scatter of the sixteen hour session solutions for the Trimble 4000 SST and Trimble 4000 SSE zero baseline are summarized in Table 1.

Table 1: Scatter of Long Observation Session For Timble 4000 SST Trimble 4000 SSE Zero Baseline

Solution T ype	Length (m)	Height (m)
L1	0.0008	0.0005
L2	0.0003	0.0001
L3	0.0019	0.0010
L1 With T ropo Estimate	0.0005	-0.0004
L2 With T ropo Estimate	0.0007	0.0005
L3 With T ropo Estimate	0.0023	-0.0018

The L3 solution has a baseline length of 1.9 millimeters, and the L3 solution with hourly troposphere estimates has a baseline length of 2.3 millimeters. The other four solution types have baseline lengths and height components of less than 1 millimeter.

The scatter of the long session solutions for zero baseline with the two Trimble 4000 SSI receivers is show in Table 2.

Table 1: Scatter of Long Observation Session For Timble 4000 SSI Trimble 4000 SSI Zero Baseline

Solution T ype	Length (m)	Height (m)
L1	0.0000	-0.0001
L2	0.0000	-0.0001
L3	0.0001	-0.0001
L1 With T ropo Estimate	0.0000	-0.0001
L2 With T ropo Estimate	0.0006	-0.0007
L3 With T ropo Estimate	0.0010	0.0010

Only the L3 solution with an hourly troposphere estimate has a baseline length of 1.0 millimeters. The other five solutions have much better than one millimeter agreement in the length and height solutions.

The one hour sessions have a much higher baseline and height scatter. The baseline height scatter of each of the one hour solutions is plotted in Figure 1. The baseline length scatter is plotted in Figure 2. It can be seen from these two figures that the hourly solutions are much worse for the mixed Trimble 4000 SST and the Trimble 4000 SSE zero baseline.

Figure 1: Scatter of the vertical component of the hourly solutions for the two different zero baselines. The circles represent the individual hourly solutions of the Trimble 4000 SST and Trimble 4000 SSE mixed solutions. These solutions have an RMS of 20.5 millimeters. The plus marks are the individual solutions of the zero baseline with two Trimble 4000 SSI receivers. These solutions have an RMS of 2.5 millimeters.

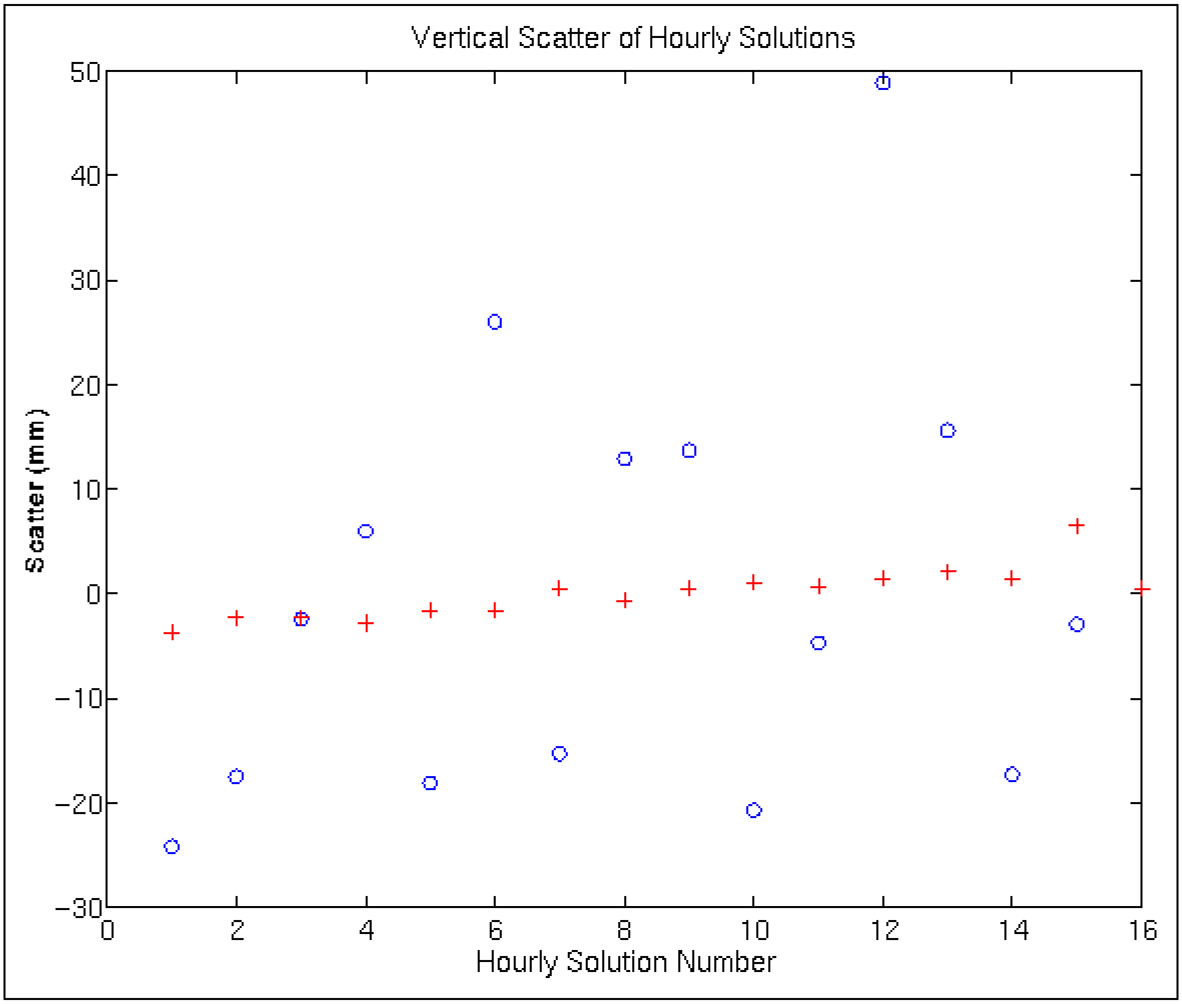
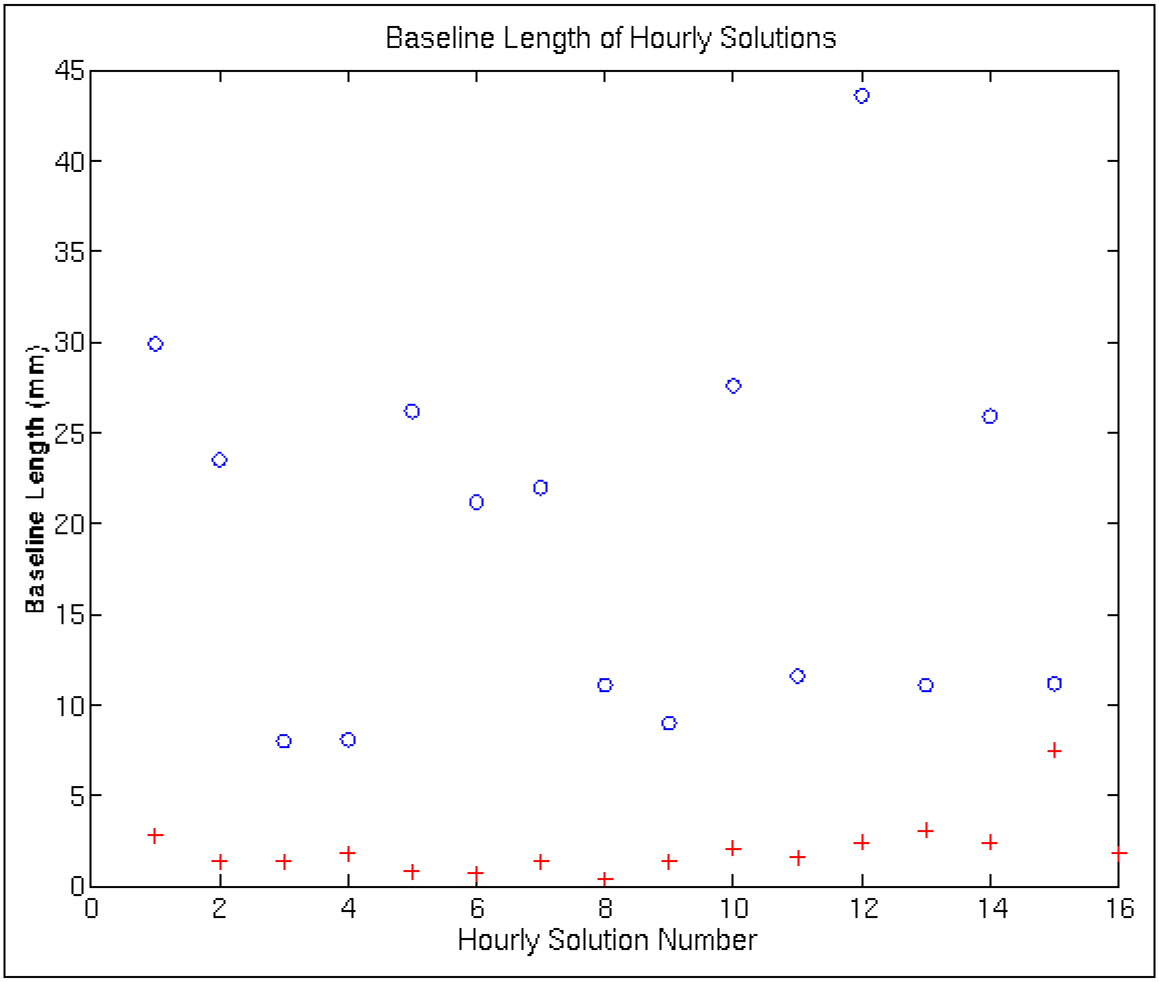


Figure 2: Scatter of the baseline length of the hourly solutions for the two different zero baselines. The circles represent the individual hourly solutions of the Trimble 4000 SST and Trimble 4000 SSE mixed solutions. These solutions have an RMS of 19.3 millimeters. The plus marks are the individual solutions of the zero baseline with two Trimble 4000 SSI receivers. These solutions have an RMS of 2.1 millimeters.



Conclusions
The results presented here and previously by Fritz Brunner indicate that mixing of the Trimble 4000 SST with the Trimble 4000 SSE and Trimble 4000 SSI receivers over short observation times (less than a few hours) can cause vertical height errors of up to five centimeters. These errors appear to be caused by differences in how each receiver internally processes the incoming carrier phase signals.

Much like other types of multipath errors, this mixing problem seems to average out over longer observation sessions. This is illustrated in the comparison of the different solution types of the sixteen hour observation session solutions. For these long periods of data, the scatter of the solutions drops to the few millimeter level or less.