UNAVCO SCIGN DOME TESTING

TEST PERFORMED BY:
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Abstract

The purpose of this test was to see the effects on station coordinates when a SCIGN radome is placed on a choke ring antenna. This report presents results from a test that was conducted at the UNAVCO facility in Boulder Colorado. Previous results of Arnadottir et al. (Reference 1), showed up to a 22 mm vertical offset due to radome installation. The results of UNAVCO's SCIGN dome testing indicate sub-centimeter offsets in the vertical, with the largest offset of 5.65 mm +/- 2.07 mm for the Trimble 4000 SSI receiver pair at a 15 degree elevation cutoff. The largest North and East offsets are sub-milimeter with the largest North offset of -0.49 mm +/- 0.55 mm observed in L2 with a 5 degree elevation cutoff for the Trimble 4000 SSI receiver pair. The largest East offset observed was -0.79 mm +/- 0.96 mm in L3 with troposphere parameters estimated, for the Trimble 4000 SSI receiver pair at a 15 degree elevation angle cutoff. Only the worst cases for North and East offset are shown in the report since they are much smaller compared to the vertical offset seen due to radome installation. (Figures 10 and 11) See Appendix C for a complete list of North offsets and Appendix D for a complete list of East offsets.

Introduction

This document describes an experiment conducted to see whether the short SCIGN radome (part number 0010) introduced significant shifts, of up to 22 mm in the vertical (Reference 1), in the apparent phase center of a standard choke ring antenna. This test was conducted on the rooftop of the UNAVCO building shown in Figure 1 with the red arrows indicating the monuments that were used for testing.

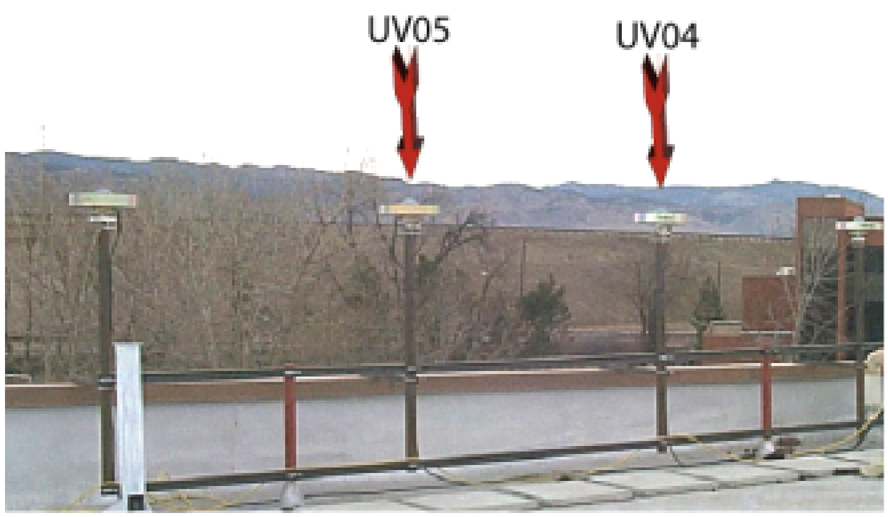

Figure 1: Picture of UNAVCO rooftop testing area showing the two mounts used for this test, looking North West.

The tests were conducted using the short model of the SCIGN radome mounted on Trimble Dorne Margolin Choke Ring (DMCR) antennas (TRM29659.00). Both antennas were connected to a splitter which was connected to a Trimble 4700 and a Trimble 4000 SSI, thus allowing short baseline analysis for each pair of receivers see (Figure 2).

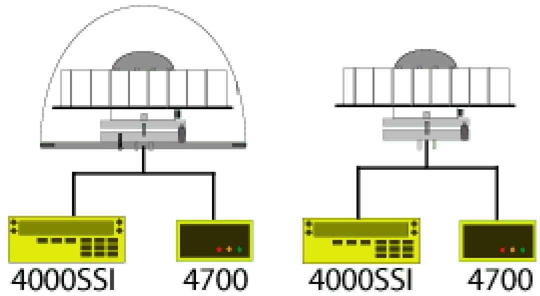

Figure 2: Short and zero baseline configuration used in this test with 6 days of data before dome was placed on antenna, and 5 days of data collection with dome in place as shown above.

The setup for this test remained consistent throughout the entire phase of testing. The SCIGN dome was placed directly onto the antenna and then removed. No equipment changes were made. The day to day repeatability of the data, both before and after the setup, are the best indicator of the short term stability of the test mounts. The mounts on the UNAVCO roof are heavy and well anchored so the weight of a dome would not be an issue.

Processing Strategies

All data were processed using the Bernese GPS Software V4.2. There were 6 days of 24 hour files before the dome was placed on one of the antennas (Days 341-347). Five more days of 24 hour files were collected with the dome in place (Days 349-353). All data were processed using the following strategies:

- Estimate baseline for L1 and resolve phase ambiguities, no troposphere
- Estimate baseline for L2 and resolve phase ambiguities, no troposphere
- Estimate baseline for L3 and resolve phase ambiguities, no troposphere
- Estimate baseline for L1 and resolve phase ambiguities, estimate troposphere parameter every 2 hours using the Saastamoinen model
- Estimate baseline for L2 and resolve phase ambiguities, estimate troposphere parameter every 2 hours using the Saastamoinen model
- Estimate baseline for L3 and resolve phase ambiguities solve for troposphere parameter every 2 hours using the Saastamoinen model

In addition, each short baseline (Trimble 4700 - 4700 & Trimble 4000 SSI - 4000 SSI) was processed for a 5, 10, and 15 degree elevation cutoff angle.

Results

Our results indicate that the short model of the SCIGN radome introduces sub-centimeter baseline offsets, with the largest offset being 5.65 mm +/- 2.07 mm in the vertical for the Trimble 4000 SSI4000 SSI receiver pair at a 15 degree elevation angle cutoff. See Figures 9 and 3A. The vertical offset due to the dome is larger than the horizontal offset for all cases. The largest North offset is -0.49 mm +/- 0.55 mm for a 5 degree elevation cutoff in L2 with troposphere parameters estimated for the Trimble 4000 SSI receiver pair (See Figure 10). The largest East offset is -0.79 mm +/- 0.96 mm for a 15 degree elevation angle cutoff in L3 with troposphere parameters estimated for the Trimble 4000 SSI receiver pair (see Figure 11). Only the worst cases for North and East offsets are shown since they are much smaller compared to the vertical offset seen due to radome installation. Hudnut et al. (Reference 3) says that “Preliminary results indicate that each of the two radomes tested introduced marginally significant shifts in the vertical phase center but no significant shifts in the horizontal phase center. It appears that the vertical shift introduced by the short radome may be slightly larger than that introduced by the tall radome (it is not clear why this would happen - the radome portions of each are manufactured identically - the only differences are physical and have to do with attachment to the antenna or adapter).”

The vertical offset has an elevation angle cutoff dependence and appears to increase the usual dependence of change in vertical phase center with higher elevation angle cutoffs. This is similar to the elevation angle dependence seen in the JPL SCIGN dome test analysis assuming that JPL included the estimated troposphere parameter in the solution (Reference 2). Results from Martin Schmitz and Gerhard Wubbena also present the large change in elevation dependency at high elevation angle cutoffs (Reference 4). They have also reported that changes in the height coordinate can be additionally magnified by the location of the station and the so called “Northern Hole”, which in turn could be related to the large vertical offset seen by Arnadottir et al. Below are sky plots of Denver (Figure 12) and Iceland (Figure 13) in order to compare satellite visibility. In all cases, however, radome induced biases determined in this study are much lower in magnitude than those reported by Arnadottir et al. (2000) (Reference 1). Please see Appendix A for Trimble 4000 SSI receiver pair graphs.

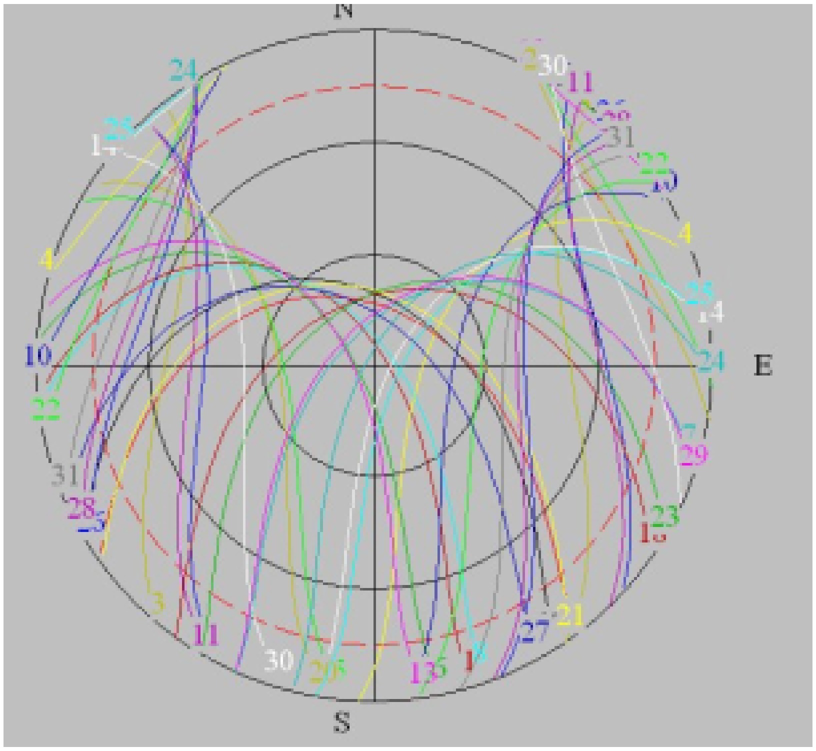

Figure 3: Sky plot showing geometric configuration of satellite coverage above Denver, Colorado

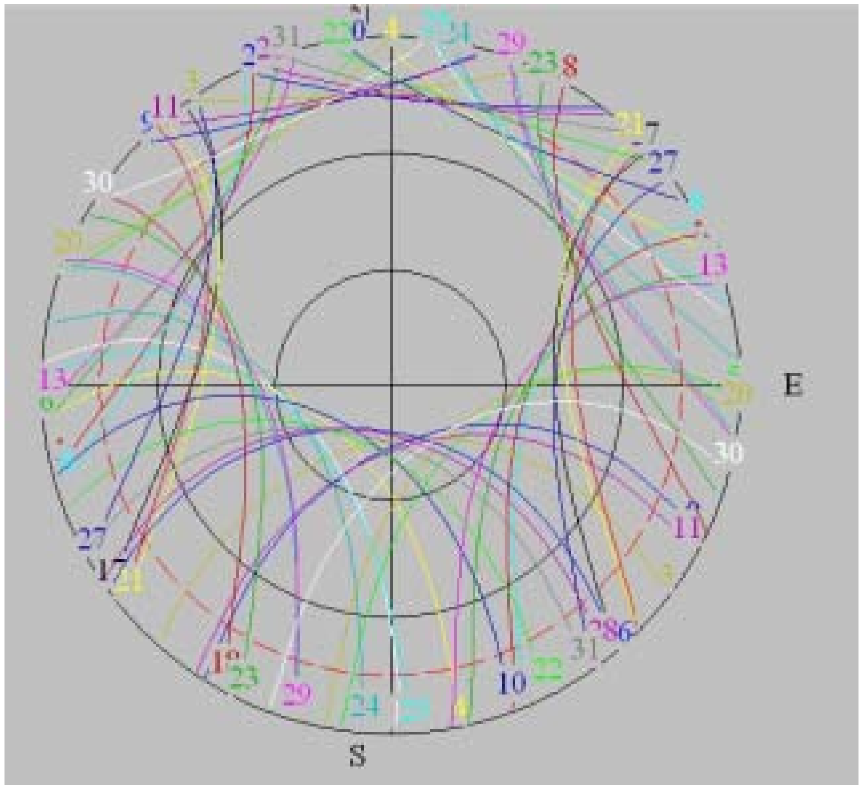

Figure 4: Sky plot showing geometric configuration of satellite coverage above Reykja- vik , Iceland

Figures 6-13 were all normalized to the L3 no troposphere 15 degree elevation angle cut-off, Trimble 4700 receiver pair solution. The legend for Figures 6-13 is shown below. (Figure 5)

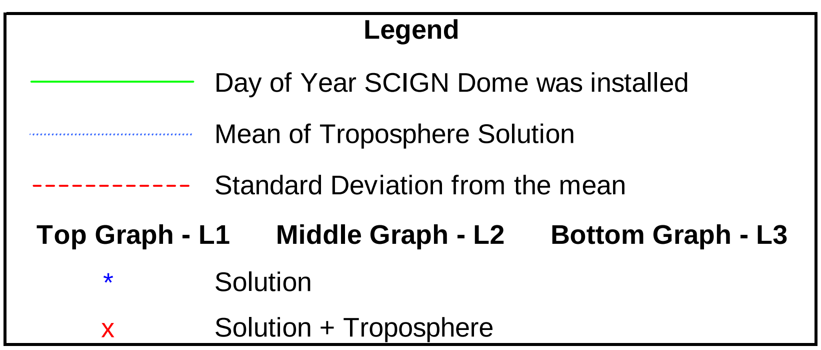

Figure 5: Legend for the following plots. The green line indicates the day of the year that the dome was installed. The blue dash-dot line indicates the mean of the Troposphere solution. The magenta dashed line indicates the standard deviation from the mean. The blue stars indicate the solution (L1, L2, or L3) and the red x's indicate the solution plus

troposphere estimation (L1, L2, L3). For each Figure below: the top graph indicates L1, the middle graph indicates L2, and the bottom graph indicates L3.

Trimble 4700 receiver pair 5 degree elevation angle cutoff - L1, L2, L3

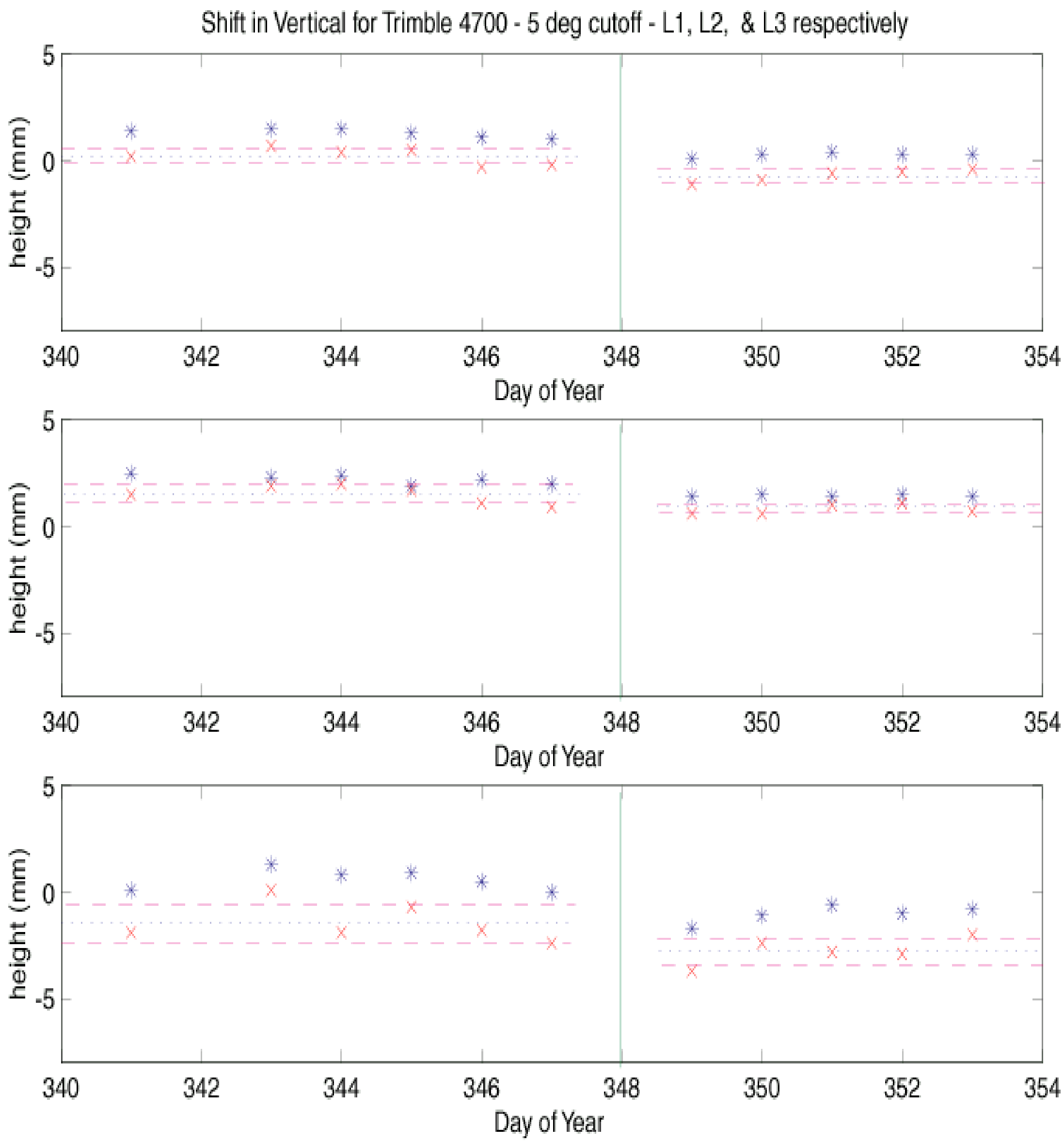

Figure 6: Shift in Vertical for Trimble 4700 - 5 degree elevation angle cutoff, blue stars indicate solution, red x's indicate solution with troposphere estimation. The largest jump and the largest deviation from the mean can be seen in L3 (bottom graph) for the Trimble 4700 receiver pair with a 5 degree elevation angle cutoff.

Trimble 4000 SSI receiver pair 5 degree elevation cutoff - L1, L2, L3

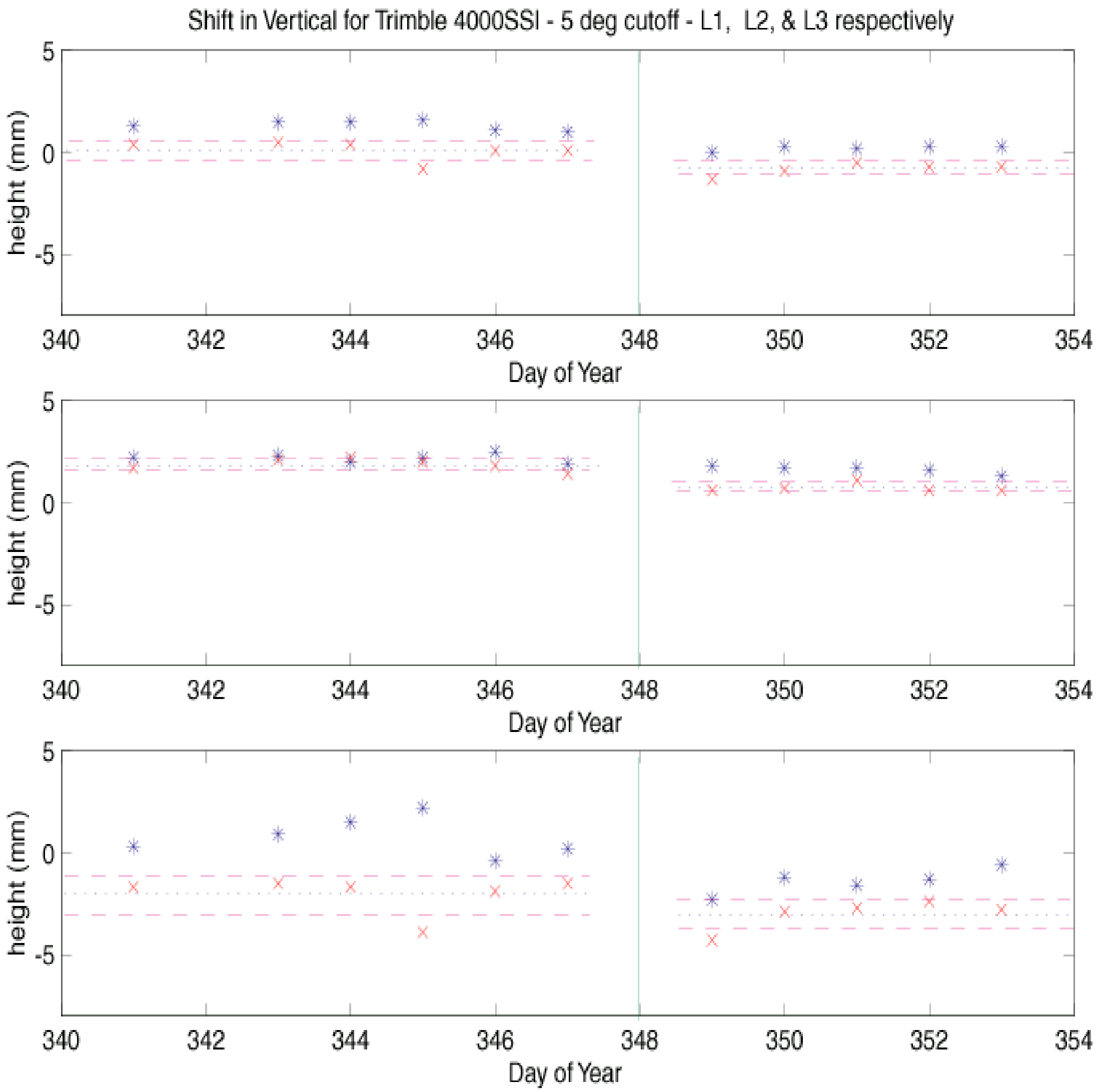

Figure 7: Shift in Vertical for Trimble 4000 SSI - 5 degree elevation angle cutoff, blue stars indicate solution, red x's indicate solution with troposphere estimation. The largest jump and largest deviation from the mean can be seen in the L3 solution for the Trimble 4000 SSI receiver pair, which is similar to what can be seen in the previous graph for the Trimble 4700 receiver pair.

Trimble 4700 receiver pair 10 degree elevation cutoff - L1, L2, L3

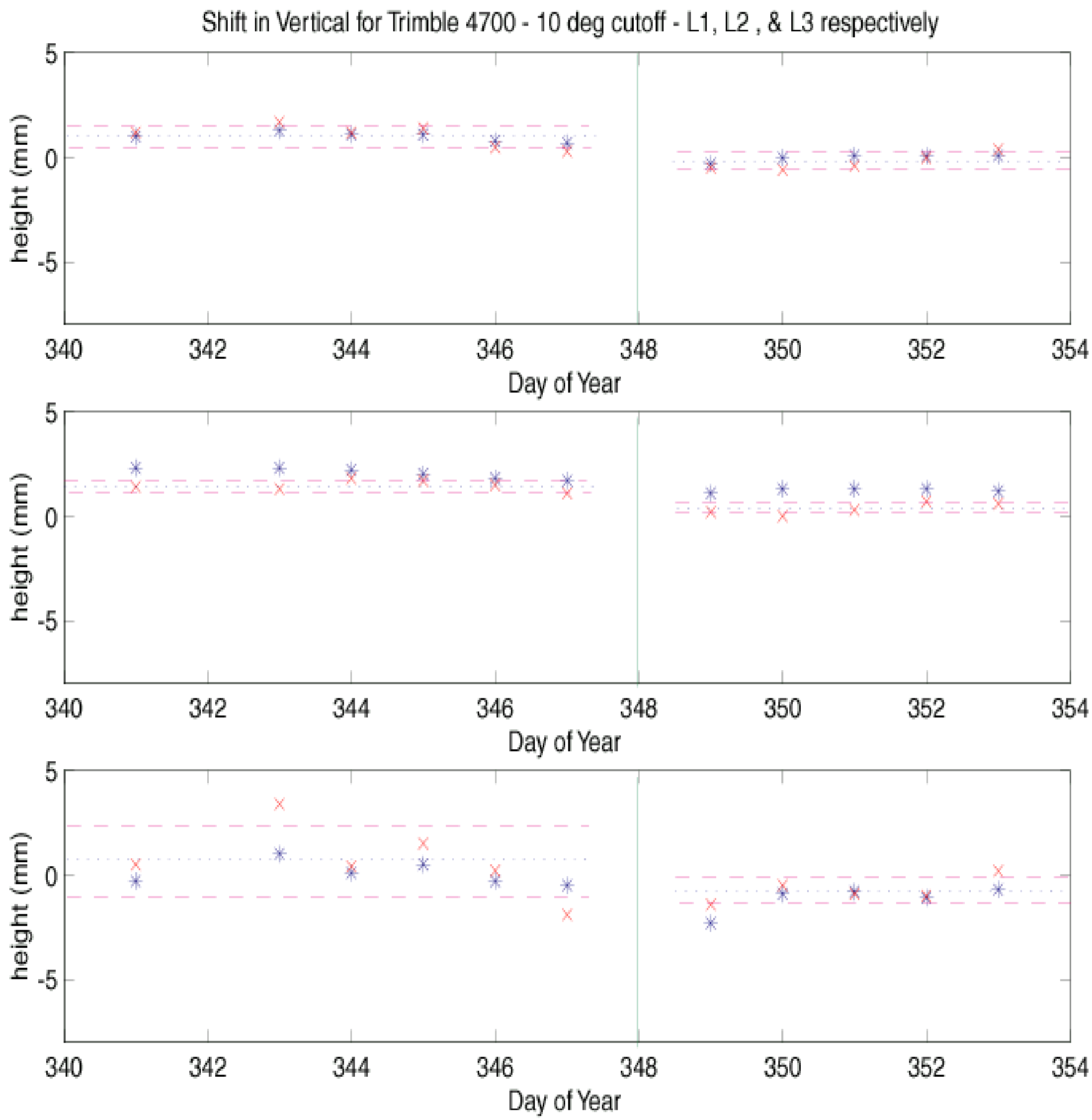

Figure 8: Shift in vertical for Trimble 4700 - 10 degree elevation angle cutoff, blue stars indicate solution, red x's indicate solution with troposphere estimation. The L3 solution shows the largest jump and the largest standard deviation from the mean.

Trimble 4000 SSI receiver pair 10 degree cutoff - L1, L2, L3

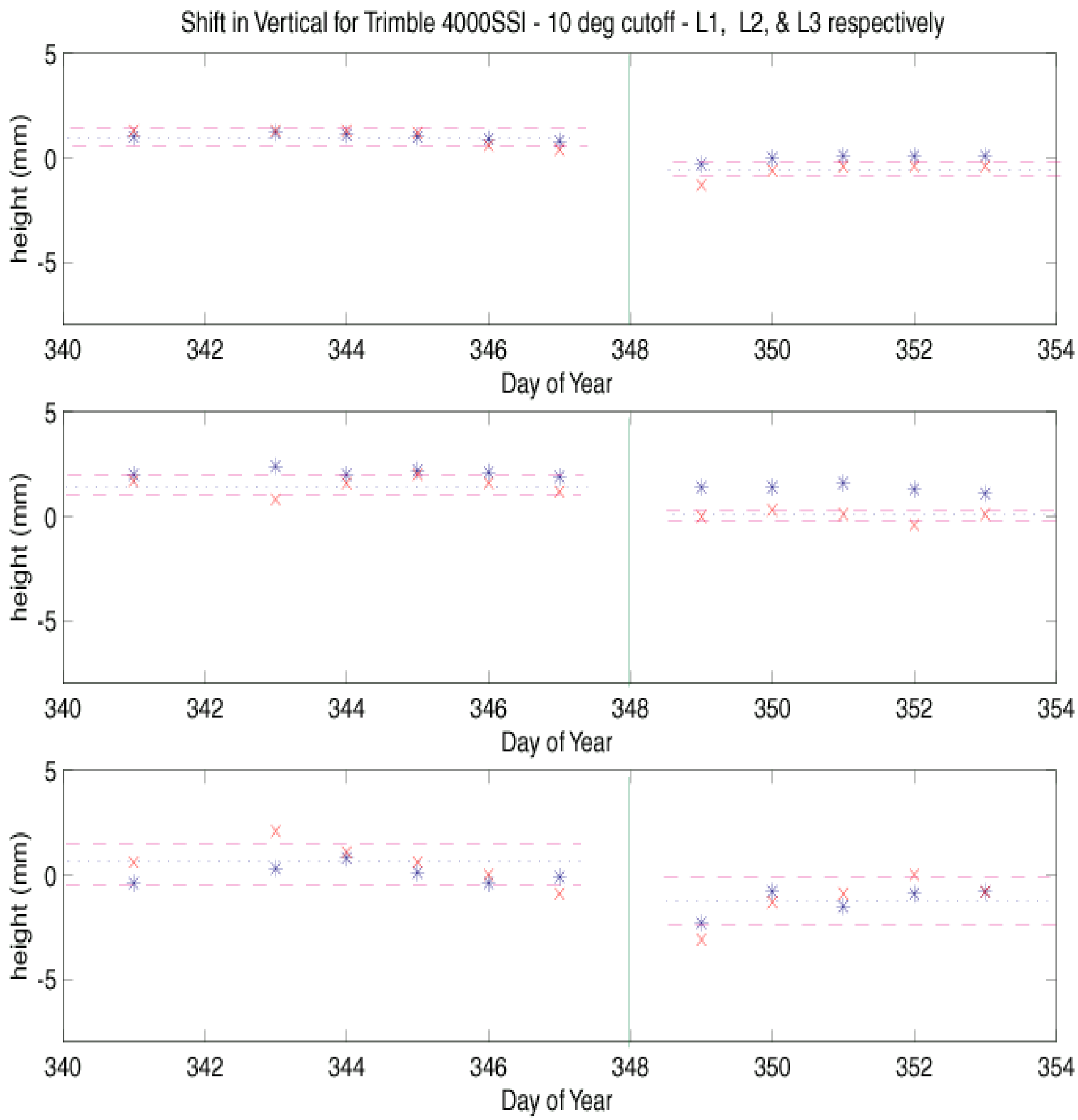

Figure 9: Shift in vertical for Trimble 4000 SSI - 10 degree cutoff, blue stars indicate solution, red x's indicate solution with troposphere estimation. The L3 solution shows the largest jump and the largest standard deviation from the mean.

Trimble 4700 receiver pair 15 degree elevation cutoff - L1, L2, L3

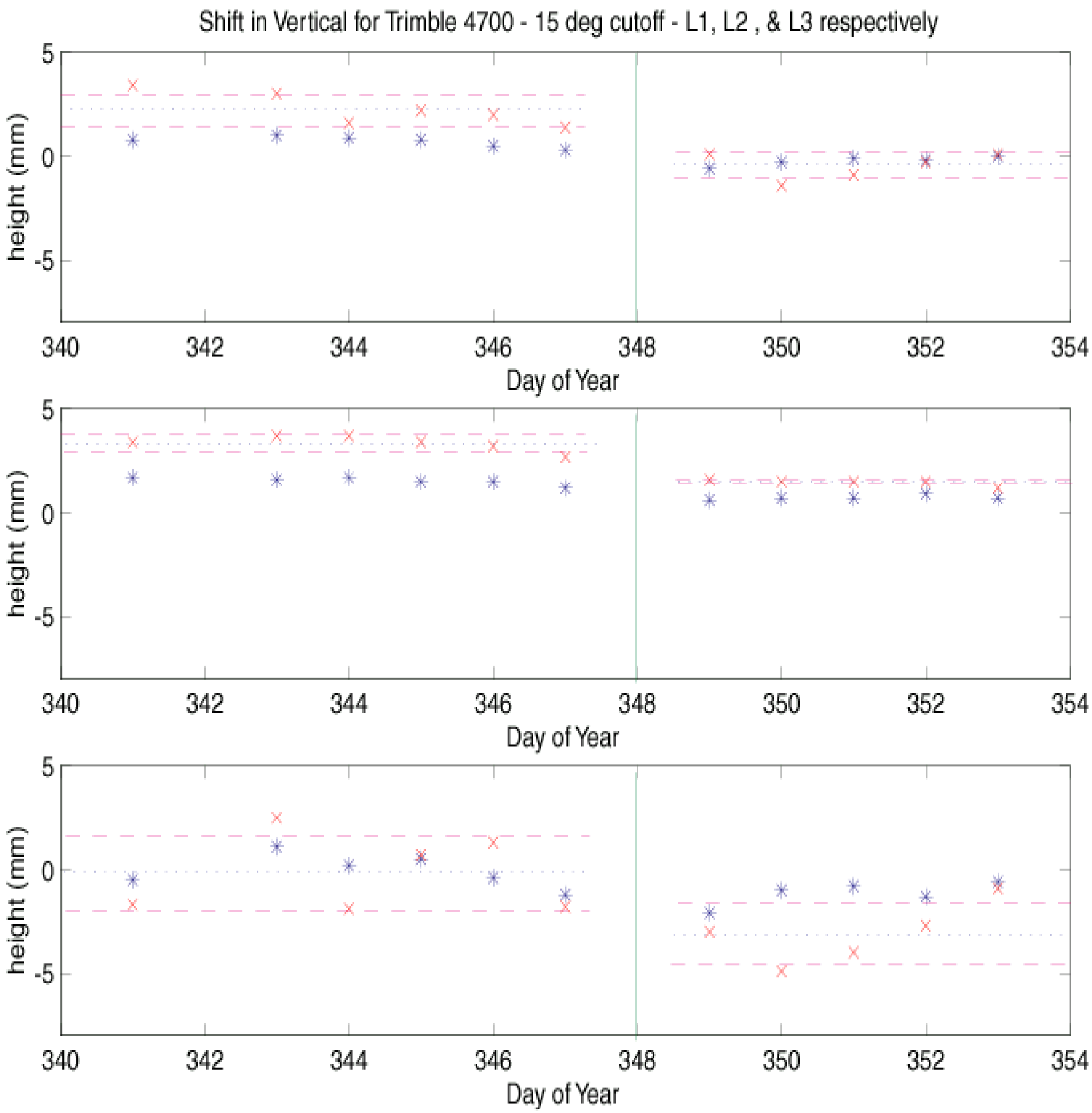

Figure 10: Shift in vertical for the Trimble 4700 - 15 degree elevation angle cutoff, blue stars indicate solution, red x's indicate solution with troposphere estimation. The L3 solution shows the largest jump for this receiver pair at a 15 degree elevation angle cutoff due to radome installation along with the largest deviation from the mean for this figure. The vertical height for the L2 solution without troposphere estimation is lower than the vertical height solution including troposphere.

Trimble 4000 SSI receiver pair 15 degree elevation cutoff - L1, L2, L3

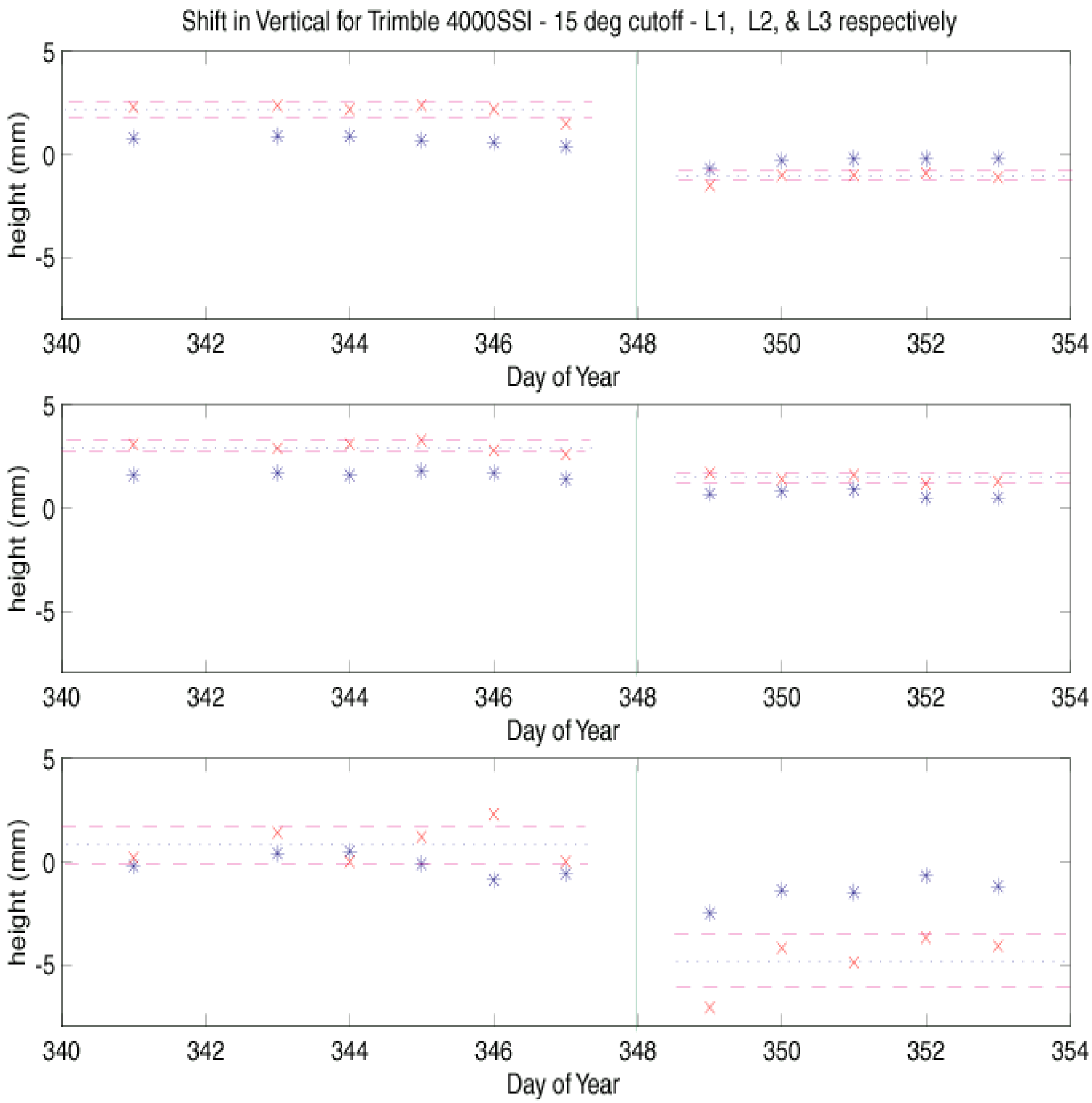

Figure 11: Shift in vertical for the Trimble 4000 SSI - 15 degree elevation angle cutoff, blue stars indicate solution, red x's indicate solution with troposphere estimation. Note the lower graph shows the largest bias of 5.65 mm observed in this study. The vertical height for the L2 solution without troposphere is lower than the vertical height solution including troposphere estimation.

Trimble 4000 SSI receiver pair North offset - 5 degree elevation cutoff - L1, L2, L3

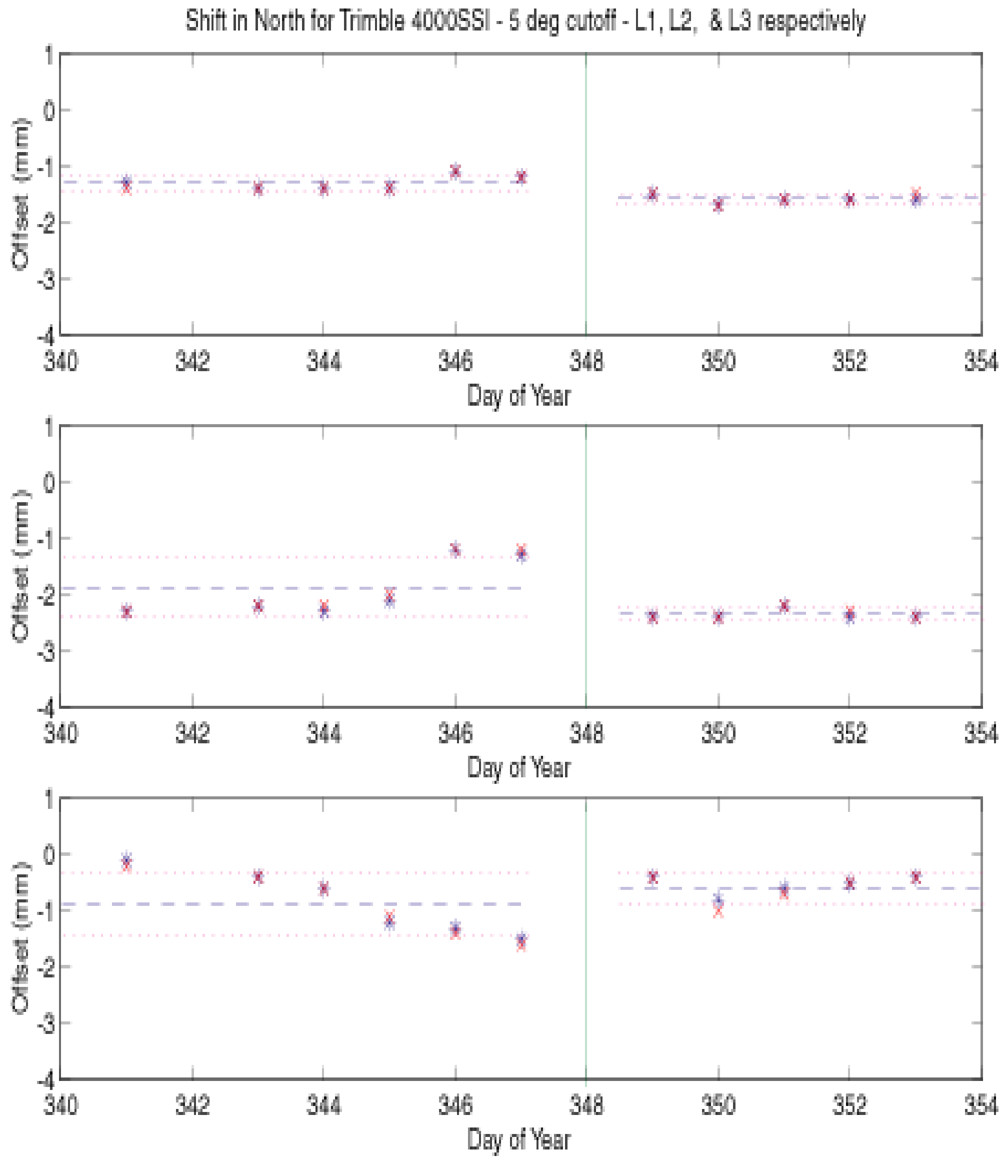

Figure 12: Showing worst case offset for North which is seen in L2 for Trimble 4000 SSI receiver pair, 5 degree elevation cutoff.

Trimble 4000 SSI receiver pair East offset - 15 degree elevation cutoff - L1, L2, L3

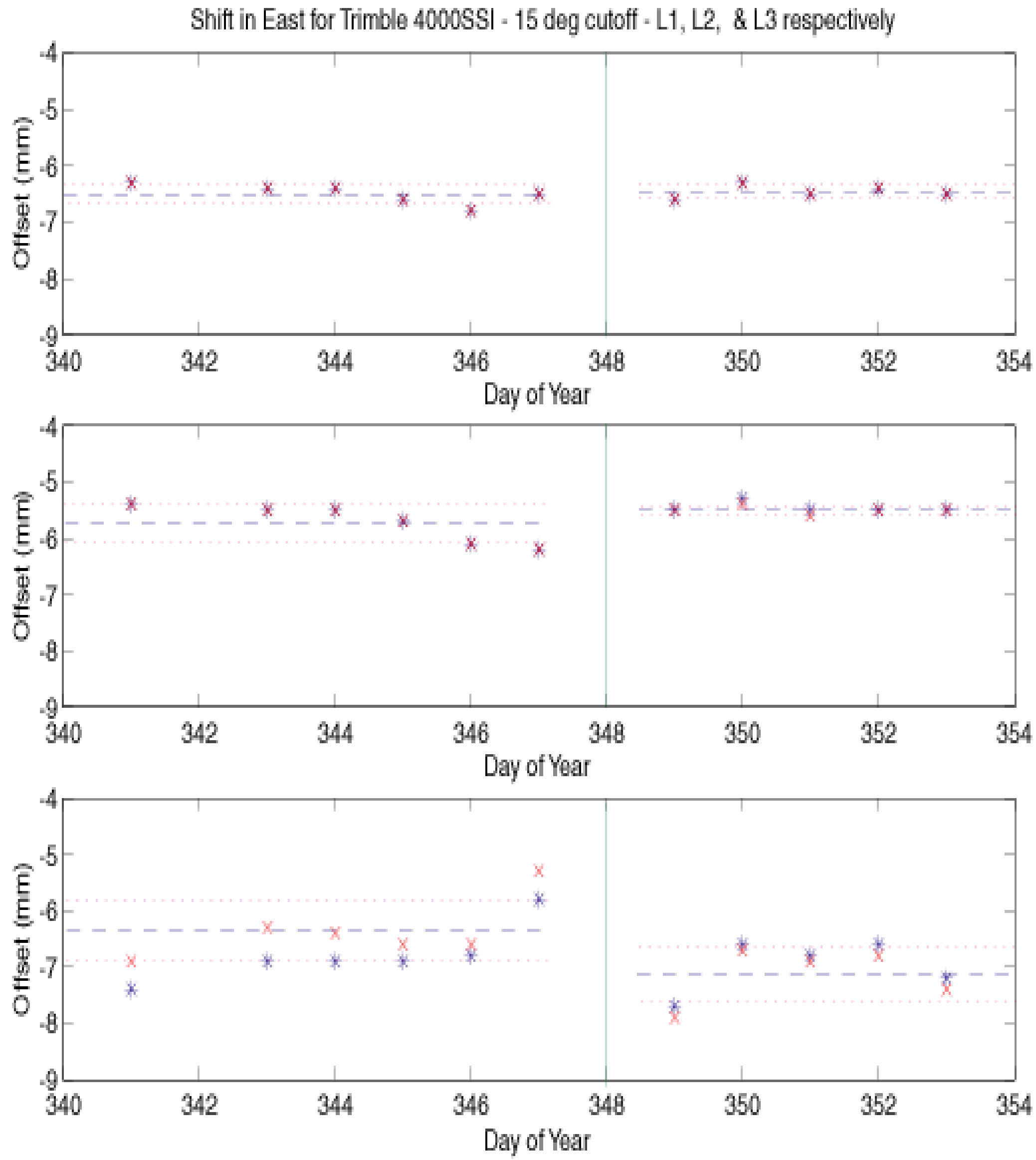

Figure 13: Plot of Trimble 4000 SSI receiver pair showing worst case East offset which is seen in L3 with a 15 degree elevation cutoff.

The tables below show the vertical shift for each receiver pair and each elevation angle cutoff including the estimated troposphere parameter. As you can see from Table 9, the largest offset seen from the SCIGN dome is for the Trimble 4000 SSI, L3 including Troposphere at a 15 degree elevation angle cutoff.

Table 1: Shows the offset and standard deviation of L1 due to the SCIGN dome for a 5 degree elevation angle cutoff. The numbers in the table indicate the mean of the Troposphere solution in the vertical.

5 degree cutoff - Troposphere solution					
(mm)	L1 before	std	L1 after	std	Offset L1
4700	0.22	0.397	-0.7	0.292	0.92
4000SSI	0.12	0.479	-0.82	0.03	0.94

Table 2: Shows the offset and standard deviation of L2 due to the SCIGN dome for a 5 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the vertical.

5 degree cutoff - Troposphere solution					
(mm)	L2 before	std	L2 after	std	Offset L2
4700	1.52	0.44	0.8	0.235	0.72
4000SSI	1.87	0.294	0.72	0.217	1.15

Table 3: Shows the offset and standard deviation of L3 due to the SCIGN dome for a 5 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the vertical.

5 degree cutoff - Troposphere solution					
(mm)	L3 before	std	L3 after	std	Offset L3
4700	-1.43	0.937	-2.76	0.635	1.33
4000SSI	-2.03	0.927	-3.02	0.74	0.99

Table 4: Shows the offset and standard deviation of L1 due to the SCIGN dome for a 10 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the vertical.

10 degree cutoff - Troposphere solution					
(mm)	L1 before	std	L1 after	std	Offset L1
4700	1.05	0.539	-0.22	0.415	1.27
4000SSI	1.02	0.407	-0.62	0.39	1.64

Table 5: Shows the offset and standard deviation of L2 due to the SCIGN dome for a 10 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the vertical.

10 degree cutoff - Troposphere solution					
(mm)	L2 before	std	L2 after	std	Offset L2
4700	1.47	0.258	0.36	0.288	1.11
4000SSI	1.48	0.422	0.02	0.259	1.46

Table 6: Shows the offset and standard deviation of L3 due to the SCIGN dome for a 10 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the vertical.

10 degree cutoff - Troposphere solution					
(mm)	L3 before	std	L3 after	std	Offset L3
4700	0.68	1.736	-0.72	0.606	1.4
4000SSI	0.58	1.011	-1.22	1.152	1.8

Table 7: Shows the offset and standard deviation of L1 due to the SCIGN dome for a 15 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the vertical.

15 degree cutoff - Troposphere solution					
(mm)	L1 before	std	L1 after	std	Offset L1
4700	2.27	0.787	-0.48	0.657	2.75
4000SSI	2.17	0.339	-1.1	0.235	3.27

Table 8: Shows the offset and standard deviation of L2 due to the SCIGN dome for a 15 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the vertical.

15 degree cutoff - Troposphere solution					
(mm)	L2 before	std	L2 after	std	Offset L2
4700	3.35	0.373	1.46	0.152	1.89
4000SSI	2.97	0.25	1.44	0.207	1.53

Table 9: Shows the offset and standard deviation of L3 due to the SCIGN dome for a 15 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the vertical.

15 degree cutoff - Troposphere solution					
(mm)	L3 before	std	L3 after	std	Offset L3
4700	-0.15	1.899	-3.1	1.505	2.95
4000SSI	0.85	0.938	-4.8	1.356	5.65

Table 10: Shows the worst case offset for the North component. The numbers in the table below indicate the mean of the Troposphere solution for the North component. Worst case being Trimble 4000 SSI receiver pair with 5 degree elevation cutoff.

5 degree cutoff - Troposphere solution - North					
(mm)	L2 before	std	L2 after	std	Offset L2
4700	0.1	0.49	0.51	0.08	-0.41
4000SSI	-0.02	0.47	0.47	0.08	-0.49

Table 11: Shows the worst case offset for the East component. The numbers in the table below indicate the mean of the troposphere solution for the East component. Worst case being the L3 Troposphere solution for theTrimble 4000 SSI reciever pair with a 15 degree elevation angle cutoff.

15 degree cutoff - Troposphere solution - East					
(mm)	L3 before	std	L3 after	std	Offset L3
4700	-0.23	0.35	0.09	0.25	-0.32
4000SSI	-0.5	0.51	0.29	0.45	-0.79

Elevation Angle Cutoff Dependence

The elevation angle cutoff dependence graphs were all normalized to the L1 troposphere solution with a 10 degree elevation angle cutoff. The following graphs show the change in height verses the elevation angle cutoff. The Trimble 4700 receiver pair are shown below. Please see Appendix A for the Trimble 4000 SSI receiver pair graphs. Certain graphs show that the elevation angle dependence changes sign when the troposphere is estimated. The following plot shows the elevation angle cutoff dependence for the Trimble 4700's in L1.

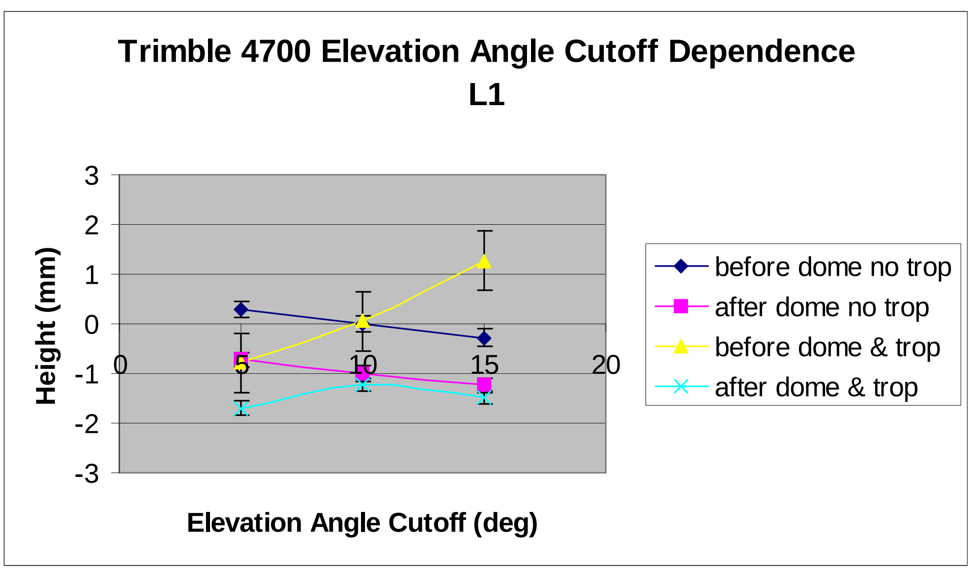

Figure 14: This graph shows that without troposphere estimation, the 4700's see the same height difference at each respective elevation angle cutoff, which is the same height difference seen by the 4000 SSI's. When the troposphere is estimated, the height difference grows as the elevation angle cutoff increases, the 4700's see a 0.92 mm height difference at a 5 degree cutoff, a 1.27 mm height difference at a 10 degree cutoff, and a 2.75 mm height difference at a 15 degree elevation angle cutoff.

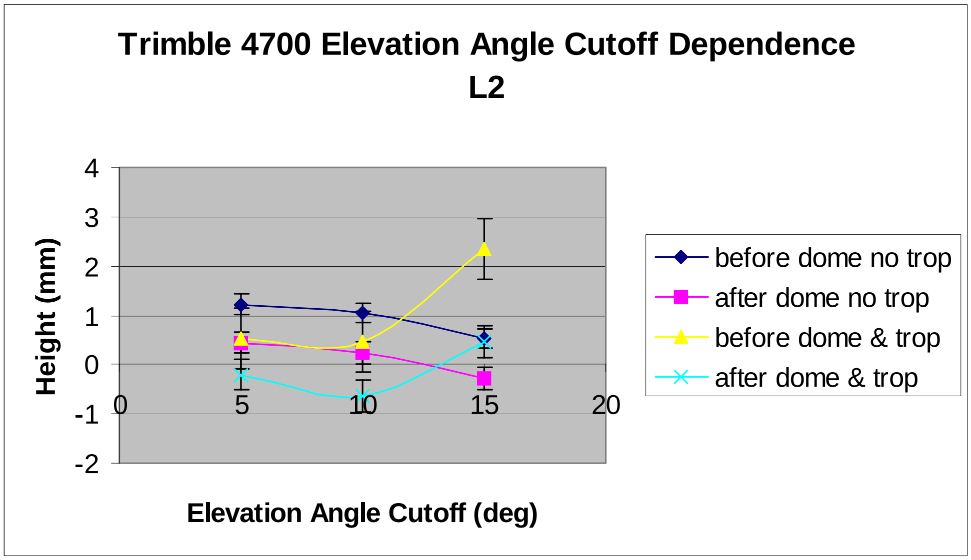

Figure 15: This graph shows that without troposphere estimation, the 4700's see the same height difference at each respective elevation angle cutoff. When the troposphere is estimated, the height difference grows as the elevation angle cutoff increases. This can also be seen in JPL's SCIGN dome analysis report (Reference 2). The 4700's see a 1.89 mm height difference due to the radome installation at a 15 degree elevation angle cutoff.

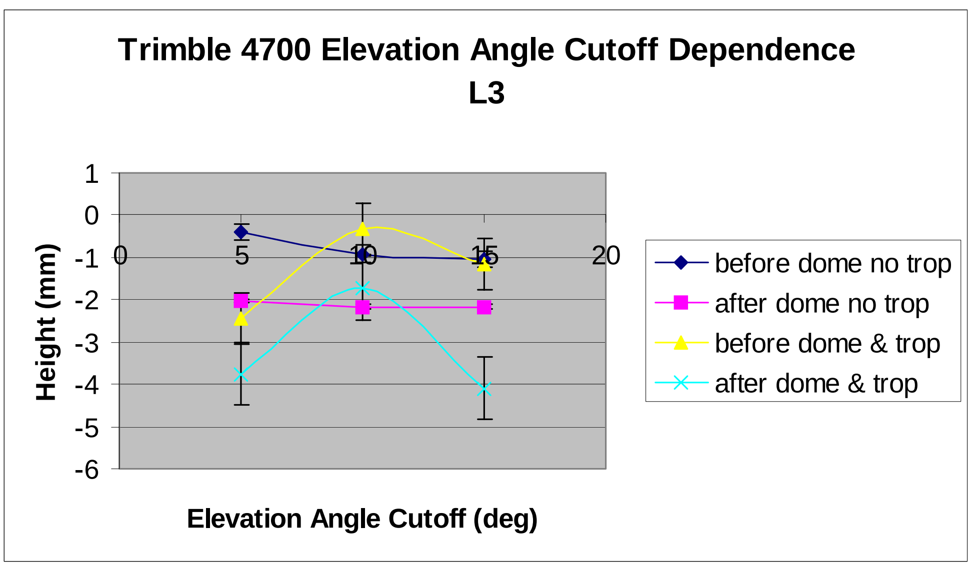

Figure 16: This graph shows that with no troposphere estimation, the height difference seen before and after radome installation is different for 5 and 10 degree elevation angle cutoff, but similar for a 15 degree elevation angle cutoff. When the troposphere is estimated, the same height difference can be seen for a 5 and 10 degree elevation angle cutoff, but increases at the 15 degree elevation angle cutoff.

Appendix A

Elevation Angle Cutoff Dependence Graphs for Trimble 4000 SSI receiver pair

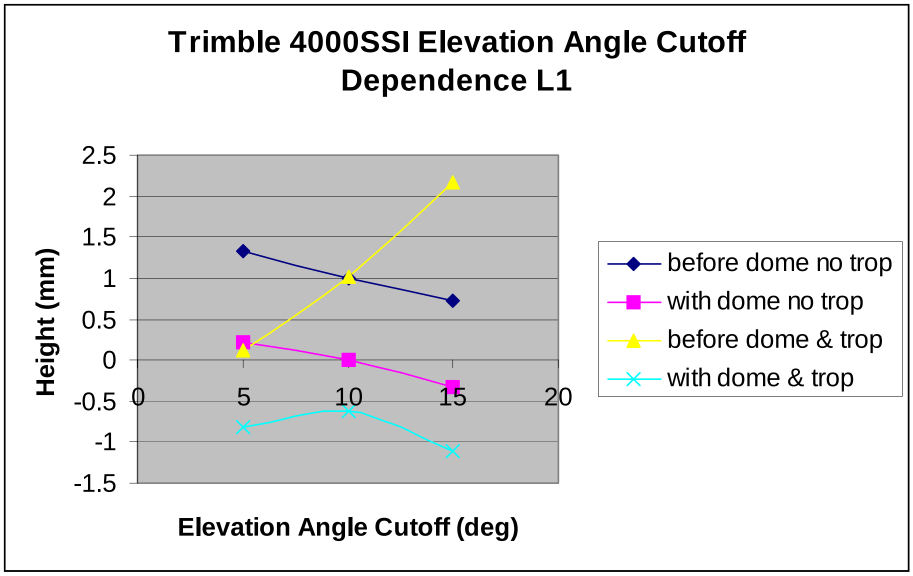

Figure 1A: This graph shows that without troposphere estimation, the 4000 SSI's see the same height difference at each respective elevation angle cutoff. This height difference is the same as what the 4700's see without troposphere estimation for L1 (approximately 1 mm height difference). When the troposphere is estimated, the height difference grows as the elevation angle cutoff increases, which is similar to what the 4700's see. The 4000 SSI's see a height difference of 0.94 mm at a 5 degree elevation angle cutoff, 1.64 mm height difference at 10 degree elevation angle cutoff, and a 3.27 mm height difference at a 15 degree elevation angle cutoff.

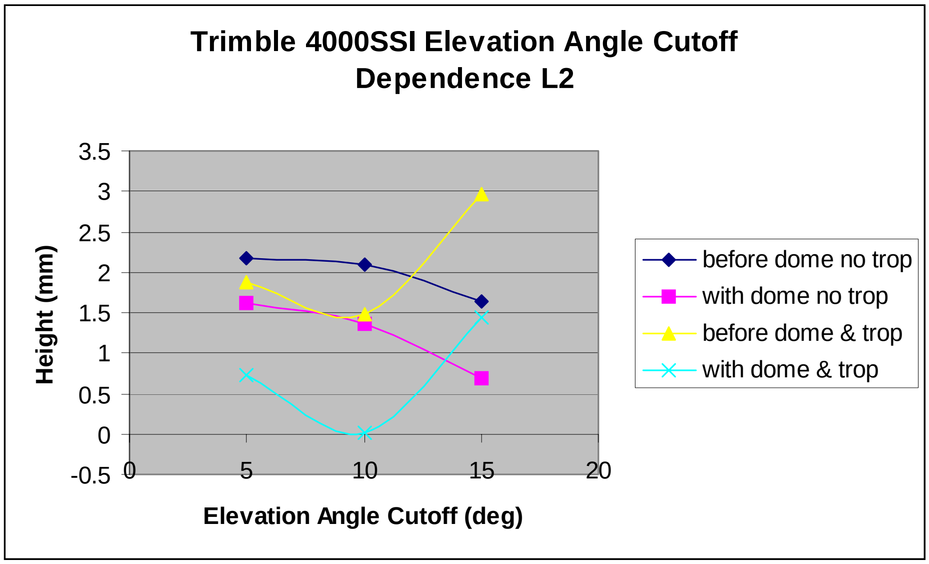

Figure 2A: This graph shows that without troposphere estimation, the 4000 SSI's see an increasing height difference as the elevation angle cutoff increases. When the troposphere is estimated, the height difference increases with increasing elevation angle cutoff. The 4000 SSI's see a 1.15 mm height difference at a cutoff of 5 degrees, a 1.46 mm height difference at a 10 degree cutoff, with the largest height difference of 1.53 mm at a 15 degree elevation angle cutoff. This is smaller than what the 4700's see (1.89 mm) at a 15 degree elevation angle cutoff for L2 including troposphere, but follows the same trend as the 4700's.

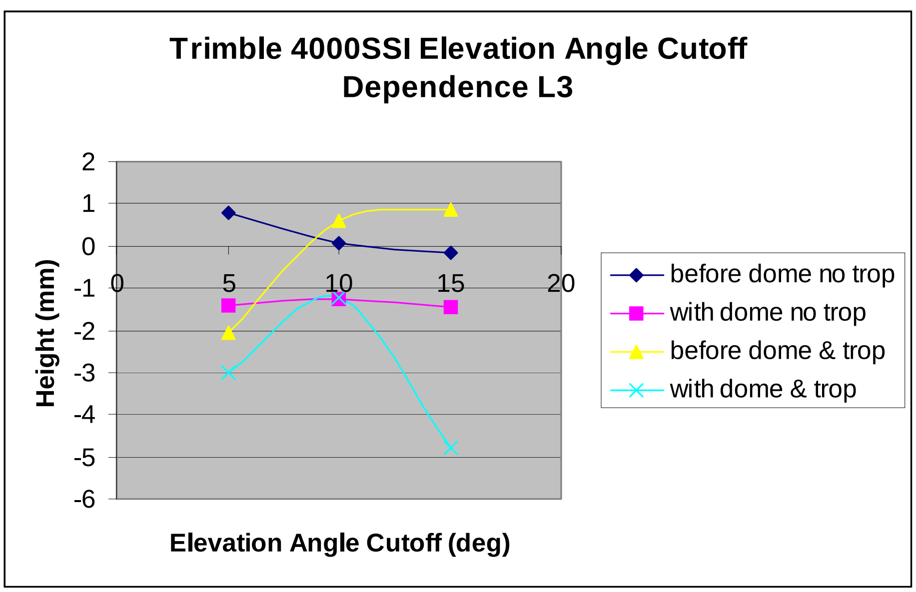

Figure 3A: This graph shows that with no troposphere estimation, the height difference is largest for a 5 degree elevation angle cutoff and decreases as the elevation angle cutoff increases. This is the same trend that can be seen in Figure 11, the Trimble 4700 elevation angle cutoff dependence for L3. When the troposphere is estimated, the same trend can be seen for both sets of receivers. The height difference increases as the elevation angle cutoff increases. The graph above shows a height difference of 0.99 mm for a 5 degree cutoff, 1.8 mm for a 10 degree cutoff, and 5.65 mm height difference for a 15 degree cutoff. The height difference of 5.65 mm is the largest offset observed in the SCIGN radome testing.

Appendix B

Elevation Angle Cutoff Dependence Graphs showing the Trimble 4700 and Trimble 4000 SSI receiver pairs in order to look at similarities between receivers.

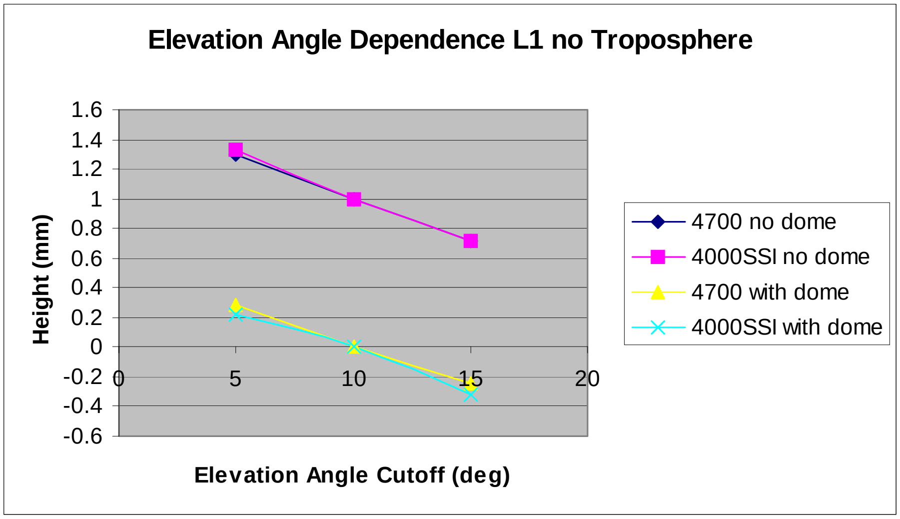

Figure 1B: This graph shows that the receivers see the same offset corresponding to elevation angle cutoff with and without a radome installed for L1 no troposphere.

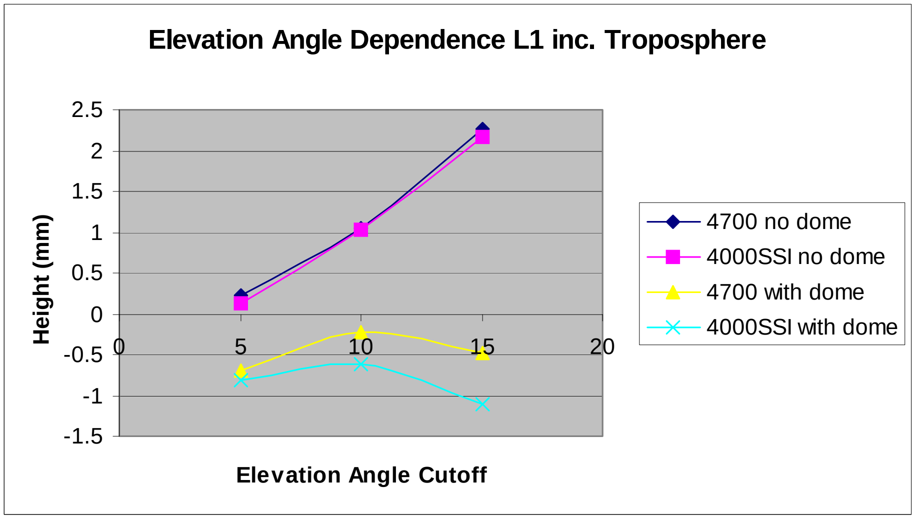

Figure 2B: This graph shows that the receivers see the same height difference for each relevant elevation angle cutoff with no dome. The receivers see similar results, and have the same trend for elevation angle cutoff dependence for L1 including troposphere. The 4700 pair see a height difference of 2.75 mm while the 4000 SSI's see a height difference of 3.27 mm at a 15 degree elevation angle cutoff.

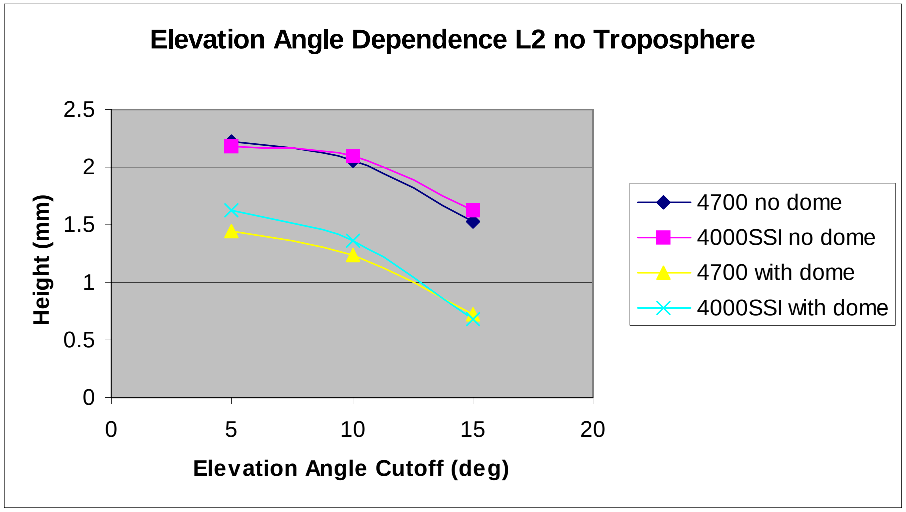

Figure 3B: This graph shows that the 4700 receiver pair sees a slightly larger height difference than the 4000 SSI receiver pair due to the radome installation at a 5 degree elevation angle cutoff.

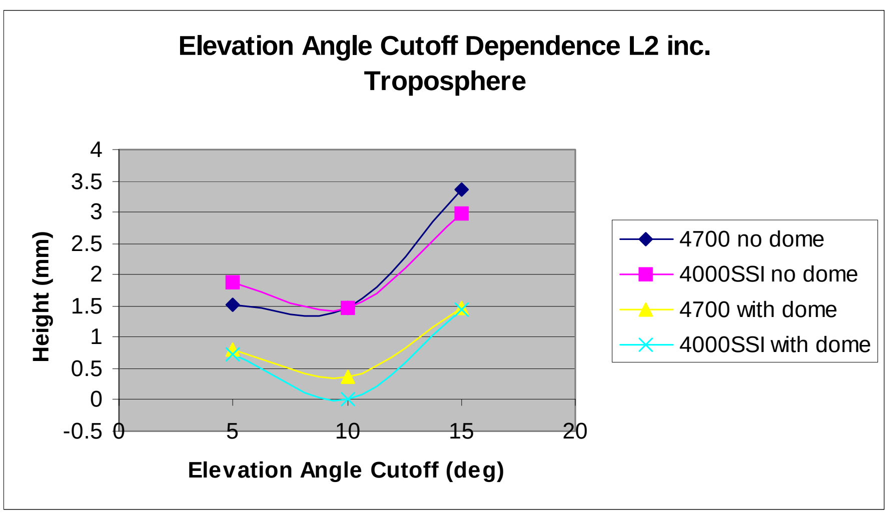

Figure 4B: This graph shows that the 4700 and the 4000 SSI receiver pairs see a height difference of 0.62 mm before the radome installation at a 5 degree elevation angle cutoff, and a 0.8 mm height difference after the radome installation. The receiver pairs see a height difference of 0.01 mm before radome installation at a 10 degree elevation angle cutoff, and a 0.34 mm height difference after radome installation. The receiver pair sees a 0.38 mm height difference before radome installation for a 15 degree elevation angle cutoff and a 0.02 mm height difference after radome installation.

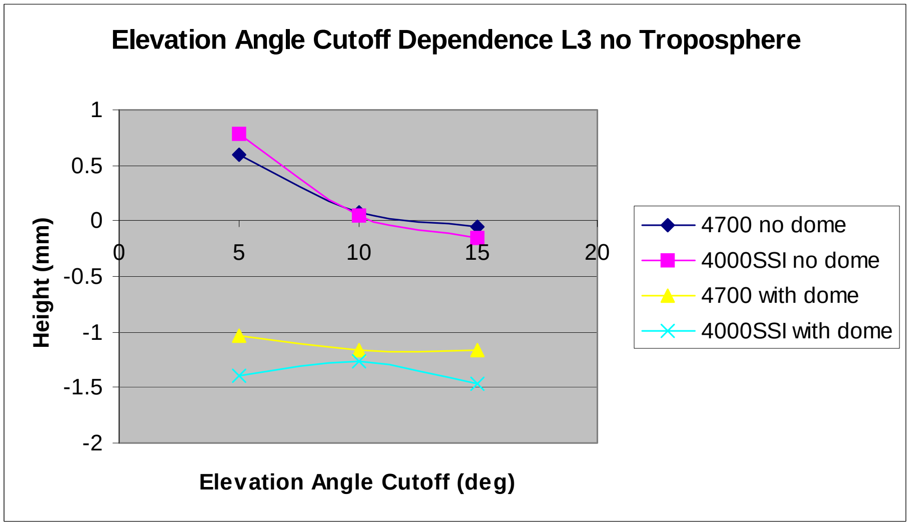

Figure 5B: This graph shows that the 4000 SSI's see a larger height difference than the 4700's due to radome installation with the largest height difference seen at a 5 degree elevation cutoff.

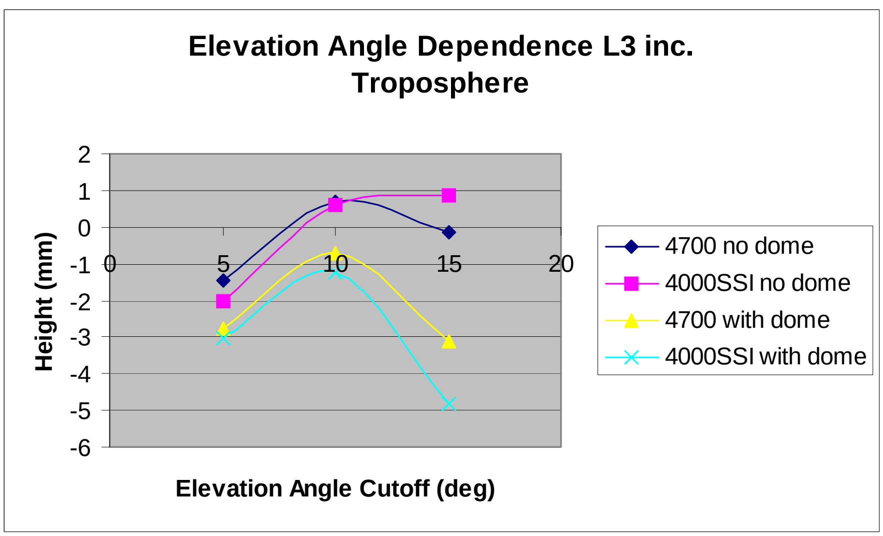

Figure 6B: This graph shows the largest offset observed due to radome installation which is a 5.65 mm difference in height at a 15 degree elevation angle cutoff for the Trimble 4000 SSI receiver pair. The 4700's see a height difference of 2.95 mm at a 15 degree elevation angle cutoff.

Appendix C

Tables showing the North offsets for L1, L2, L3

Table 12: Shows the offset and standard deviation of L1 due to the SCIGN dome for a 5 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the North.

5 degree cutoff - Troposphere solution - North					
(mm)	L1 before	std	L1 after	std	Offset L1
4700	0.28	0.08	0.58	0.06	-0.3
4000SSI	0.3	0.12	0.56	0.08	-0.26

Table 13: Shows the offset and standard deviation of L1 due to the SCIGN dome for a 10 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the North.

10 degree cutoff - Troposphere solution - North					
(mm)	L1 before	std	L1 after	std	Offset L1
4700	0.13	0.1	0.38	0.09	-0.25
4000SSI	0.1	0.13	0.42	0.05	-0.32

Table 14: Shows the offset and standard deviation of L1 due to the SCIGN dome for a 15 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the North.

15 degree cutoff - Troposphere solution - North					
(mm)	L1 before	std	L1 after	std	Offset L1
4700	0.2	0.44	0.36	0.08	-0.16
4000SSI	0.06	0.1	0.36	0.08	-0.3

Table 15: Shows the offset and standard deviation of L2 due to the SCIGN dome for a 5 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the North.

5 degree cutoff - Troposphere solution - North					
(mm)	L2 before	std	L2 after	std	Offset L2
4700	0.1	0.49	0.51	0.08	-0.41
4000SSI	-0.02	0.47	0.47	0.08	-0.49

Table 16: Shows the offset and standard deviation of L2 due to the SCIGN dome for a 10 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the North.

10 degree cutoff - Troposphere solution - North					
(mm)	L2 before	std	L2 after	std	Offset L2
4700	0.11	0.53	0.55	0.1	-0.44
4000SSI	0.13	0.5	0.59	0.05	-0.46

Table 17: Shows the offset and standard deviation of L2 due to the SCIGN dome for a 15 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the North.

15 degree cutoff - Troposphere solution - North					
(mm)	L2 before	std	L2 after	std	Offset L2
4700	0.01	0.52	0.47	0.1	-0.46
4000SSI	0	0.51	0.45	0.04	-0.45

Table 18: Shows the offset and standard deviation of L3 due to the SCIGN dome for a 5 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the North.

5 degree cutoff - Troposphere solution - North					
(mm)	L3 before	std	L3 after	std	Offset L3
4700	0.7	0.58	0.66	0.16	0.04
4000SSI	0.89	0.52	0.6	0.23	0.29

Table 19: Shows the offset and standard deviation of L3 due to the SCIGN dome for a 10 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the North.

10 degree cutoff - Troposphere solution - North					
(mm)	L3 before	std	L3 after	std	Offset L3
4700	0.15	0.6	-0.06	0.16	0.21
4000SSI	0.29	0.56	-0.06	0.26	0.35

Table 20: Shows the offset and standard deviation of L3 due to the SCIGN dome for a 15 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the North.

15 degree cutoff - Troposphere solution - North					
(mm)	L3 before	std	L3 after	std	Offset L3
4700	0.04	0.76	0.06	0.08	-0.02
4000SSI	0.22	0.72	0.04	0.21	0.18

Appendix D

Tables showing the East offsets for L1, L2, L3

Table 21: Shows the offset and standard deviation of L1 due to the SCIGN dome for a 5 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the East.

5 degree cutoff - Troposphere solution - East					
(mm)	L1 before	std	L1 after	std	Offset L1
4700	0.05	0.16	0.05	0.13	0
4000SSI	0.12	0.15	0.09	0.1	0.03

Table 22: Shows the offset and standard deviation of L1 due to the SCIGN dome for a 10 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the East.

10 degree cutoff - Troposphere solution - East					
(mm)	L1 before	std	L1 after	std	Offset L1
4700	0	0.18	-0.15	0.13	-0.15
4000SSI	-0.03	0.16	-0.09	0.1	0.06

Table 23: Shows the offset and standard deviation of L1 due to the SCIGN dome for a 15 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the East.

15 degree cutoff - Troposphere solution - East					
(mm)	L1 before	std	L1 after	std	Offset L1
4700	-0.16	0.43	-0.11	0.17	-0.05
4000SSI	-0.03	0.16	-0.07	0.1	0.04

Table 24: Shows the offset and standard deviation of L2 due to the SCIGN dome for a 5 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the East.

5 degree cutoff - Troposphere solution - East					
(mm)	L2 before	std	L2 after	std	Offset L2
4700	-0.27	0.3	-0.44	0.15	0.17
4000SSI	-0.18	0.33	-0.4	0.06	0.22

Table 25: Shows the offset and standard deviation of L2 due to the SCIGN dome for a 10 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the East.

10 degree cutoff - Troposphere solution - East					
(mm)	L2 before	std	L2 after	std	Offset L2
4700	-0.15	0.29	-0.42	0.15	0.27
4000SSI	-0.12	0.3	-0.4	0.06	0.28

Table 26: Shows the offset and standard deviation of L2 due to the SCIGN dome for a 15 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the East.

15 degree cutoff - Troposphere solution - East					
(mm)	L2 before	std	L2 after	std	Offset L2
4700	0.02	0.31	-0.2	0.11	0.22
4000SSI	0.03	0.31	-0.2	0.06	0.23

Table 27: Shows the offset and standard deviation of L3 due to the SCIGN dome for a 5 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the East.

5 degree cutoff - Troposphere solution - East					
(mm)	L3 before	std	L3 after	std	Offset L3
4700	0.43	0.36	0.81	0.33	-0.38
4000SSI	0.38	0.75	0.59	0.24	-0.21

Table 28: Shows the offset and standard deviation of L3 due to the SCIGN dome for a 10 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the East.

10 degree cutoff - Troposphere solution - East					
(mm)	L3 before	std	L3 after	std	Offset L3
4700	0.38	0.66	0.69	0.27	-0.31
4000SSI	0.1	0.7	0.47	0.25	-0.37

Table 29: Shows the offset and standard deviation of L3 due to the SCIGN dome for a 15 degree elevation angle cutoff. The numbers in the table below indicate the mean of the Troposphere solution in the East.

15 degree cutoff - Troposphere solution - East					
(mm)	L3 before	std	L3 after	std	Offset L3
4700	-0.23	0.35	0.09	0.25	-0.32
4000SSI	-0.5	0.51	0.29	0.45	-0.79

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