1995 UNAVCO ANTENNA HEIGHT TESTS - PART I

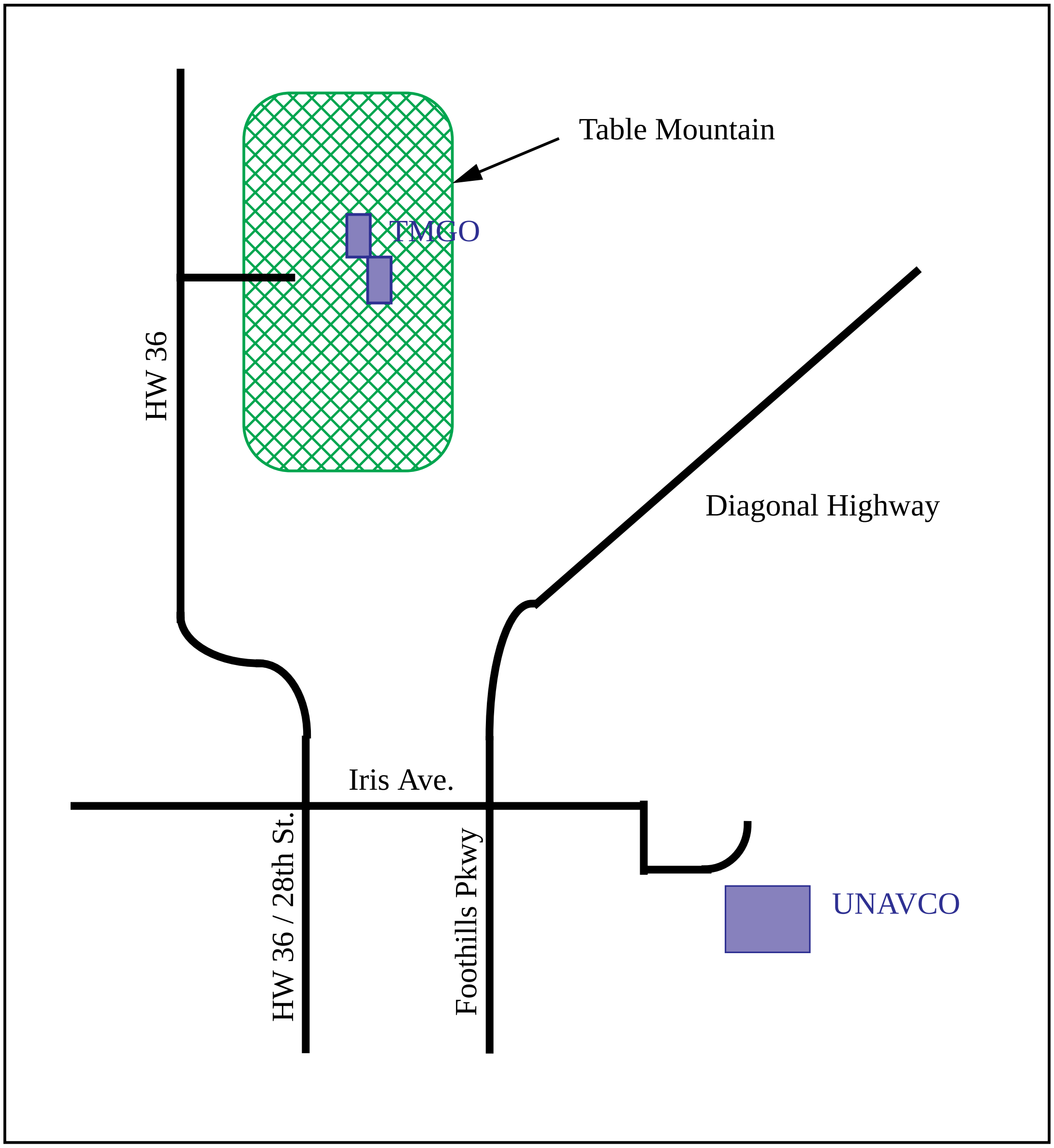
Experiment Purpose/Introduction

At the 1995 UNAVCO Users Meeting (May 2 and 3), Working Group 3 (WG3) asked the facility to conduct tests to determine the effect of different antenna mounts on GPS baseline results. Especially the effect of mounting antennas low above the ground versus high on a tripod was to be investigated.

Map Of Antenna Test Range

The Table Mountain Observatory is a Department of Commerce facility. This observatory is approximately 10 km. north of Boulder, CO and is the location of the NOAA Precision Gravity Group (see Figure “Map From UNAVCO To Table Mountain Gravity Observatory” on page 1).This group has agreed to let UNAVCO conduct experiments near their buildings, and to use their electricity, phone, etc. The observatory is a large mesa (approximately 10 square km) that allows for GPS antennas to be operated in a relatively benign multipath environment.

Figure 1 : Map From UNAVCO To Table Mountain Gravity Observatory



Monument Description and Location

In early 1995, UNAVCO installed a geodetic quality pillar for future GPS experiments. This pillar will be used for the entire antenna experiment. In addition, the Equipment Services Group (ESG) has installed six 1.5 inch stainless steel rods adjacent to the NOAA pillar. These rods are mounted in approximately one meter of concrete and covered with 50 centimeters of dirt (figure 2). Each of these rods has a 5/8 inch standard thread and dimple close to the ground. Finally, two stainless steel pins were installed into two existing concrete pads.

Figure 2 : Schematic of ESG Monument Diagram

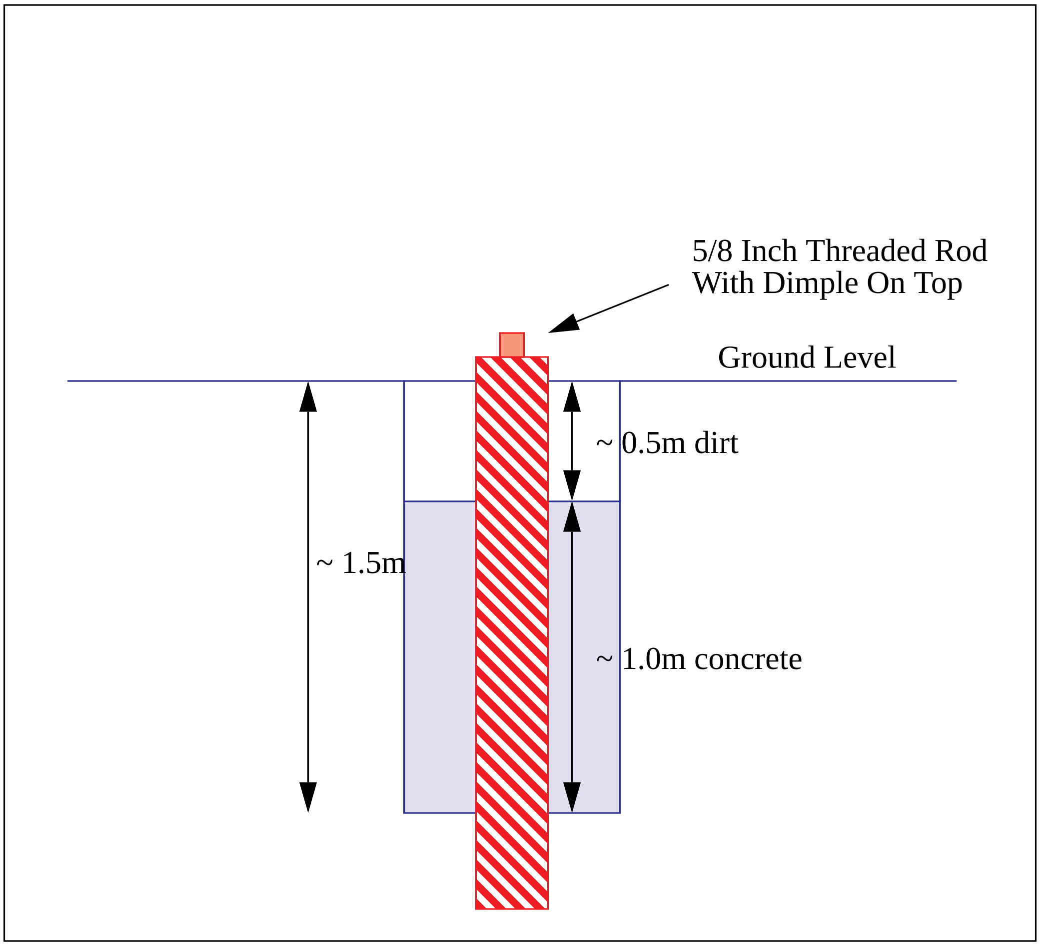


Table 1 lists the names and types of each of the monuments. The relative location of the monu-

Table 1: Names and Types of Monuments

Monument Name	Monument Type	Marker Type
TBL0	Concrete Pillar	5/8” Thread with Dimple
TBL1	Stainless Steel Pin	Dimple
TBL2	Stainless Steel Pin	Dimple
DN01	ESG Rod	5/8” Thread with Dimple
DS01	ESG Rod	5/8” Thread with Dimple
DE01	ESG Rod	5/8” Thread with Dimple
DW01	ESG Rod	5/8” Thread with Dimple

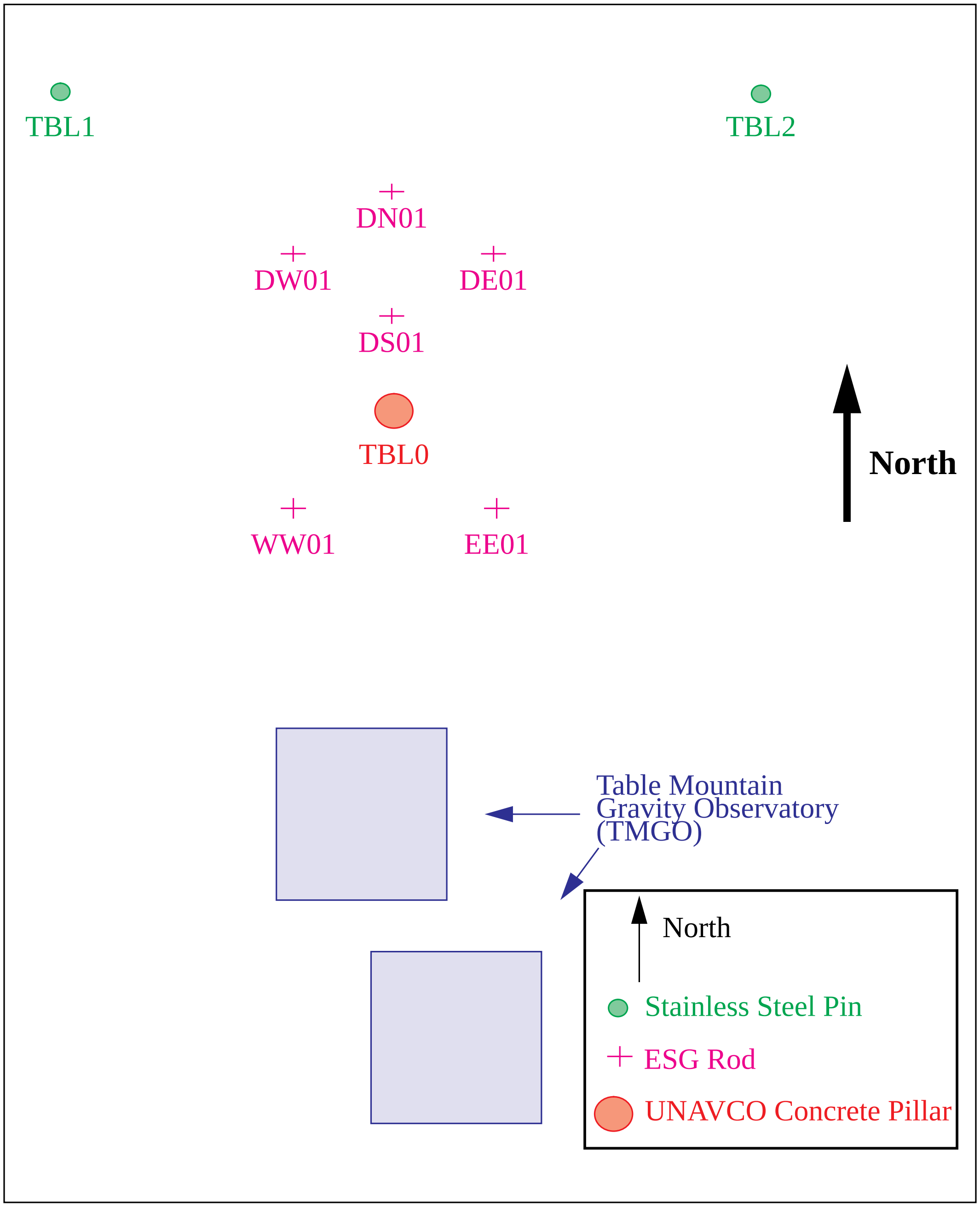
Table 1: Names and Types of Monuments

Monument Name	Monument Type	Marker Type
WW01	ESG Rod	5/8” Thread with Dimple
EE01	ESG Rod	5/8” Thread with Dimple

ments is outlined in figure 3

Figure 3 : Schematic of the relative marker locations. “Diamond Sites” DW01, DN01 etc.

are spaced approximately 5 meters. TBL0 - TBL1 and TBL2 are spaced about 70 meters.



Ground Truth

In addition to the GPS measurements, the location of the marks relative to the NOAA pillar (site TBL0) were determined using conventional surveying methods. The conventional survey was performed by UNAVCO engineer Jim Normandeau.

Survey # 1. (conducted on 1 JUN 95)[1]

A traverse was completed using stations TBL0,TBL1,and TBL2. From stations TBL1 sideshots were taken to the six UNAVCO antenna mounts. Due to high wind conditions sideshots were not taken from TBL2.

Results of survey #1.[1]

STATION	Horizontal Distance [m]	Vertical Difference [m]	
TBL1 to TBL0	57.884	0.986	(TBL1 is lower than TBL0)
TBL0 to TBL2	51.609	-2.063	
TBL2 to TBL1	97.693	1.070	
TBL1 to DN01	50.782	-0.562	
TBL1 to DW01	48.419	-0.467	
TBL1 to DE01	55.045	-0.617	
TBL1 to DS01	52.984	-0.495	
TBL1 to WW01	58.853	-0.233	
TBL1 to EE01	63.474	-0.293	

Survey # 2. (conducted on 15 JUN 95)

Due to significant differences (.004-.009m) between GPS measurements and theodolite/EDM measurements for four of the baselines the traverse and a sideshot to DN01 was redone. The results show the theodolite/EDM measurements are relatively consistent between surveys.

Results of Survey #2.

STATION	Horizontal Distance [m]	Vertical Difference [m]
TBL1 to TBL0	57.886	0.988
TBL0 to TBL2	51.609	-2.063
TBL2 to TBL1	97.692	1.067
TBL1 to DN01	50.782	-0.558

Table 2: dh [m] from station in top row to station left in column

	TBL0	TBL1	TBL2	DN01	DW01	DS01	DE01
TBL0	0	0.986	2.056	1.548	1.453	1.480	1.601
TBL1		0	1.070	0.562	0.467	0.494	0.615
TBl2			0	-0.508	-0.603	-0.576	-0.455
DN01				0	-.095	-0.068	0.053
DW01					0	0.027	0.148
DS01						0	0.121

1. A Wild T1600 Theodolite and a DI2000 Distomat were used for measurements.Technical Data: Standard deviation is: Hz: 1.5", V: 1.5" and dist.: 1mm +/- 1pmm
1. Traverse computations calculated using the WildSoft Survey System Software.

Table 2: dh [m] from station in top row to station left in column

	TBL0	TBL1	TBL2	DN01	DW01	DS01	DE01
DE01							0

Observation Schedule, Logs, And Data Availability

The following table summarizes the data that were collected during the first phase of the tests. All of these data are available from UNAVCO in RINEX or in raw format. Each file contains 23 hours of data. One hour per day was reserved for downloading and for changing the antenna setup. The columns in the table mean: DAY - day of the year, 1995, SITE - name of Table Mountain mark, RX# - receiver number, RAWDATA - name of the raw-data file (RINEX files have the same prefix), SHGT - slant height from mark to bottom of preamp, VHGT - Vertical antenna height in meters to bottom of antenna preamp, ANTS - antenna serial number, UN# - UNAVCO equipment tracking number, MONTYP - type of monument, SETUP - type of antenna mount, COMMENTS - describe what was done at the site.

DAY	SITE	RX#	RAWDATA		VISITID	SHGT	VHGT	ANTSN	UN#	MONTYP	SETUPCOMMENTS
157	TBL0	2532	TBL01570.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
157	TBL1	2530	TBL11570.DAT	16116	*****	0.5	218	3384	ss_pin	50cm_spike	
157	TBL2	4781	TBL21570.DAT	16118	*****	0.5	68498	5211	ss_pin	50cm_spike	
157	DN01	5140	DN011570.DAT	16121	1.454	1.3722	9091	3184	esg_rod	leveling_mount	
157	DW01	2198	DW011570.DAT	16127	*****	0.0777	67315	4487	esg_rod	leveling_mount	Data_Deleted
157	DE01	3452	DE011570.DAT	16125	1.415	1.3327	275	6984	esg_rod	tripod	
157	DS01	3446	DS011570.DAT	16123	*****	0.0783	68601	5451	esg_rod	leveling_mount	
158	TBL0	2532	TBL01580.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
158	TBL1	2530	TBL11580.DAT	16116	*****	0.5	218	3384	ss_pin	50cm_spike	
158	TBL2	4781	TBL21580.DAT	16118	*****	0.5	68498	5211	ss_pin	50cm_spike	
158	DN01	5140	DN011580.DAT	16161	1.454	1.3722	9091	3184	esg_rod	tripod	
158	DW01	2198	DW011580.DAT	16127	*****	0.0777	67315	4487	esg_rod	leveling_mount	Data_Deleted
158	DE01	3452	DE011580.DAT	16125	1.415	1.3327	275	6984	esg_rod	tripod	
158	DS01	3446	DS011580.DAT	16123	*****	0.0783	68601	5451	esg_rod	leveling_mount	
159	TBL0	2532	TBL01590.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
159	TBL1	2530	TBL11590.DAT	16129	1.5165	1.4355	218	3384	ss_pin	tripod	Changed_Setup
159	TBL2	4781	TBL21590.DAT	16118	*****	0.5	68498	5211	ss_pin	50cm_spike	
159	DN01	5140	DN011590.DAT	16121	1.454	1.3722	9091	3184	esg_rod	tripod	
159	DW01	2198	DW011590.DAT	16132	1.384	1.3013	67315	4487	esg_rod	tripod	Changed_Setup
159	DE01	3452	DE011590.DAT	16134	*****	0.0777	275	6984	esg_rod	leveling_mount	Changed_Setup
159	DS01	3446	DS011590.DAT	16123	*****	0.0783	68601	5451	esg_rod	leveling_mount	
160	TBL0	2532	TBL01600.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
160	TBL1	2530	TBL11600.DAT	16129	1.5165	1.4355	218	3384	ss_pin	tripod	
160	TBL2	4781	TBL21600.DAT	16118	*****	0.5	68498	5211	ss_pin	50cm_spike	
160	DN01	5140	DN011600.DAT	16121	1.454	1.3722	9091	3184	esg_rod	tripod	
160	DW01	2198	DW011600.DAT	16123	1.384	1.3013	67315	4487	esg_rod	tripod	
160	DE01	3452	DE011600.DAT	16134	*****	0.0777	275	6984	esg_rod	leveling_mount	
160	DS01	3446	DS011600.DAT	16132	*****	0.0783	68601	5451	esg_rod	leveling_mount	
161	TBL0	2532	TBL01610.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
161	TBL1	2530	TBL11610.DAT	16129	1.5165	1.4355	218	3384	ss_pin	tripod	
161	TBL2	4781	TBL21610.DAT	16118	*****	0.5	68498	5211	ss_pin	50cm_spike	
161	DN01	5140	DN011610.DAT	16121	1.454	1.3722	9091	3184	esg_rod	tripod	
161	DW01	2198	DW011610.DAT	16132	1.384	1.3013	67315	4487	esg_rod	tripod	

161	DE01	3452	DE011600.DAT	16134	*****	0.0777	275	6984	esg_rod	leveling_mount	
161	DS01	3446	DS011610.DAT	16123	*****	0.0783	68601	5451	esg_rod	leveling_mount	
162	TBL0	2532	TBL01620.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
162	TBL1	2530	TBL11620.DAT	16129	1.5165	1.4355	218	3384	ss_pin	tripod	
162	TBL2	4781	TBL21620.DAT	16118	*****	0.5	68498	5211	ss_pin	50cm_spike	
162	DN01	5140	DN011620.DAT	16121	1.454	1.3722	9091	3184	esg_rod	tripod	
162	DW01	2198	DW011620.DAT	16132	1.384	1.3013	67315	4487	esg_rod	tripod	
162	DE01	3452	DE011620.DAT	16134	*****	0.0777	275	6984	esg_rod	leveling_mount	
162	DS01	3446	DS011620.DAT	16123	*****	0.0783	68601	5451	esg_rod	leveling_mount	
163	TBL0	2532	TBL01630.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
163	TBL1	2530	TBL11630.DAT	16129	1.5165	1.4355	218	3384	ss_pin	tripod	
163	TBL2	4781	TBL21630.DAT	16118	*****	0.5	68498	5211	ss_pin	50cm_spike	
163	DN01	5140	DN011630.DAT	16121	1.454	1.3722	9091	3184	esg_rod	tripod	
163	DW01	2198	DW011630.DAT	16132	1.384	1.3013	67315	4487	esg_rod	tripod	
163	DE01	3452	DE011630.DAT	16134	*****	0.0777	275	6984	esg_rod	leveling_mount	
163	DS01	3446	DS011630.DAT	16123	*****	0.0783	68601	5451	esg_rod	leveling_mount	
164	TBL0	2532	TBL01640.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	Downloaded_Data
164	TBL1	2530	TBL11640.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	Changed_Setup
164	TBL2	4781	TBL21640.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	Changed_Setup
164	DN01	5140	DN011640.DAT	16121	1.4535	1.3717	9091	3184	esg_rod	tripod	
164	DW01	2198	DW011640.DAT	16141	*****	0.0777	67315	4487	esg_rod	leveling_mount	Changed_Setup
164	DE01	3452	DE011640.DAT	16143	1.4985	1.4173	275	6984	esg_rod	tripod	Changed_Setup
164	DS01	3446	DS011640.DAT	16123	*****	0.0783	68601	5451	esg_rod	leveling_mount	
165	TBL0	2532	TBL01650.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
165	TBL1	2530	TBL11650.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	
165	TBL2	4781	TBL21650.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	
165	DN01	5140	DN011650.DAT	16121	1.4535	1.3717	9091	3184	esg_rod	tripod	
165	DW01	2198	DW011650.DAT	16141	*****	0.0777	67315	4487	esg_rod	leveling_mount	
165	DE01	3452	DE011650.DAT	16145	1.4985	1.4173	275	6984	esg_rod	tripod	
New_Optical_Plummet											
165	DS01	3446	DS011650.DAT	16123	*****	0.0783	68601	5451	esg_rod	leveling_mount	
166	TBL0	2532	TBL01660.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	Downloaded_Data
166	TBL1	2530	TBL11660.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	
166	TBL2	4781	TBL21660.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	

166	DN01	5140	DN011660.DAT	16121	1.4535	1.3717	9091	3184	esg_rod	tripod	
166	DW01	2198	DW011660.DAT	16141	*****	0.0777	67315	4487	esg_rod	leveling_mount	
166	DE01	3452	DE011660.DAT	16145	1.4985	1.4173	275	6984	esg_rod	tripod	
166	DS01	3446	DS011660.DAT	16123	*****	0.0783	68601	5451	esg_rod	leveling_mount	
167	TBL0	2532	TBL01670.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
167	TBL1	2530	TBL11670.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	
167	TBL2	4781	TBL21670.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	
167	DN01	5140	DN011670.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount	Changed_Setup
167	DW01	2198	DW011670.DAT	16141	*****	0.0777	67315	4487	esg_rod	leveling_mount	
167	DE01	3452	DE011670.DAT	16145	1.4985	1.4173	275	6984	esg_rod	tripod	
167	DS01	3446	DS011670.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod	Changed_Setup
168	TBL0	2532	TBL01680.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
168	TBL1	2530	TBL11680.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	
168	TBL2	4781	TBL21680.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	
168	DN01	5140	DN011680.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount	
168	DW01	2198	DW011680.DAT	16141	*****	0.0777	67315	4487	esg_rod	leveling_mount	
168	DE01	3452	DE011680.DAT	16145	1.4985	1.4173	275	6984	esg_rod	tripod	
168	DS01	3446	DS011680.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod	
169	TBL0	2532	TBL01690.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
169	TBL1	2530	TBL11690.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	
169	TBL2	4781	TBL21690.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	
169	DN01	5140	DN011690.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount	
169	DW01	2198	DW011690.DAT	16141	*****	0.0777	67315	4487	esg_rod	leveling_mount	
169	DE01	3452	DE011690.DAT	16145	1.4985	1.4173	275	6984	esg_rod	tripod	
169	DS01	3446	DS011690.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod	
170	TBL0	2532	TBL01700.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
170	TBL1	2530	TBL11700.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	
170	TBL2	4781	TBL21700.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	
170	DN01	5140	DN011700.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount	
170	DW01	2198	DW011700.DAT	16141	*****	0.0777	67315	4487	esg_rod	leveling_mount	
170	DE01	3452	DE011700.DAT	16145	1.4985	1.4173	275	6984	esg_rod	tripod	
170	DS01	3446	DS011700.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod	
171	TBL0	2532	TBL01710.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
171	TBL1	2530	TBL11710.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	

171	TBL2	4781	TBL21710.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	
171	DN01	5140	DN011710.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount	
171	DW01	2198	DW011710.DAT	16141	*****	0.0777	67315	4487	esg_rod	leveling_mount	Short_File
171	DE01	3452	DE011710.DAT	16145	1.4985	1.4173	275	6984	esg_rod	tripod	
171	DS01	3446	DS011710.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod	
172	TBL0	2532	TBL01720.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	Short_File
172	TBL1	2530	TBL11720.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	Short_File
172	TBL2	4781	TBL21720.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	Short_File
172	DN01	5140	DN011720.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount	Short_File
172	DE01	3452	DE011720.DAT	16145	1.4985	1.4173	275	6984	esg_rod	tripod	Short_File
172	DS01	3446	DS011720.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod	Short_File
173	TBL0	2532	TBL01730.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
173	TBL1	2530	TBL11730.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	
173	TBL2	4781	TBL21730.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	
173	DN01	5140	DN011730.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount	
173	DW01	2198	DW011730.DAT	16152	1.3970	1.3145	67315	4487	esg_rod	tripod	Changed_Setup
173	DE01	3452	DE011730.DAT	16154	*****	0.0777	275	6984	esg_rod	leveling_mount	Changed_Setup
173	DS01	3446	DS011730.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod	
174	TBL0	2532	TBL01740.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
174	TBL1	2530	TBL11740.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	
174	TBL2	4781	TBL21740.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	
174	DN01	5140	DN011740.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount	
174	DW01	2198	DW011740.DAT	16152	1.3970	1.3145	67315	4487	esg_rod	tripod	
174	DE01	3452	DE011740.DAT	16154	*****	0.0777	275	6984	esg_rod	leveling_mount	
174	DS01	3446	DS011740.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod	
175	TBL0	2532	TBL01750.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
175	TBL1	2530	TBL11750.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	
175	TBL2	4781	TBL21750.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod	
175	DN01	5140	DN011750.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount	
175	DW01	2198	DW011750.DAT	16152	1.3970	1.3145	67315	4487	esg_rod	tripod	
Break_in_Session											
175	DW01	2198	DW011751.DAT	16152	1.3970	1.3145	67315	4487	esg_rod	tripod	
Break_in_Session											
175	DE01	3452	DE011750.DAT	16154	*****	0.0777	275	6984	esg_rod	leveling_mount	
175	DS01	3446	DS011750.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod	
176	TBL0	2532	TBL01760.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount	
176	TBL1	2530	TBL11760.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike	

176	TBL2	4781	TBL21760.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod
176	DN01	5140	DN011760.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount
176	DW01	2198	DW011760.DAT	16152	1.3970	1.3145	67315	4487	esg_rod	tripod
176	DE01	3452	DE011760.DAT	16154	*****	0.0777	275	6984	esg_rod	leveling_mount
176	DS01	3446	DS011760.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod
177	TBL0	2532	TBL01770.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
177	TBL1	2530	TBL11770.DAT	16136	*****	0.5	218	3384	ss_pin	50cm_spike
177	TBL2	4781	TBL21770.DAT	16138	1.4285	1.3464	68498	5211	ss_pin	tripod
177	DN01	5140	DN011770.DAT	16149	*****	0.0783	9091	3184	esg_rod	leveling_mount
177	DE01	3452	DE011770.DAT	16154	*****	0.0777	275	6984	esg_rod	leveling_mount
177	DS01	3446	DS011770.DAT	16147	1.3285	1.2449	68601	5451	esg_rod	tripod
178	TBL0	2532	TBL01780.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
179	TBL0	2532	TBL01790.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
180	TBL0	2532	TBL01800.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
181	TBL0	2532	TBL01810.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
182	TBL0	2532	TBL01820.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
183	TBL0	2532	TBL01830.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
184	TBL0	2532	TBL01840.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
185	TBL0	2532	TBL01850.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
186	TBL0	2532	TBL01860.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
187	TBL0	2532	TBL01870.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
188	TBL0	2532	TBL01880.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
189	TBL0	2532	TBL01890.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
190	TBL0	2532	TBL01900.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount
191	TBL0	2532	TBL01900.DAT	16114	*****	0.0794	68497	5235	pillar	leveling_mount

These data, converted into RINEX, can be found in UNAVCO's anonymous ftp area.

Mounting Types And Site Photos

Several types of antenna mounting were tested during the first phase of the experiment.

We used the conventional tripod (TP), setting up at about 1.5 meter, the UNAVCO-designed Levelling Spikemount (LM) as shown in figure 4, and a second 50-cm UNAVCO Spikemount (S-50) as shown in figure 5. Photos show Trimble antennas mounted on the LM (figure 6) and the on the S-50 (figure 7).

Figure 4 : Schematic drawing and dimensions of the compact UNAVCO spike mount called the "leveling mount" (LM).

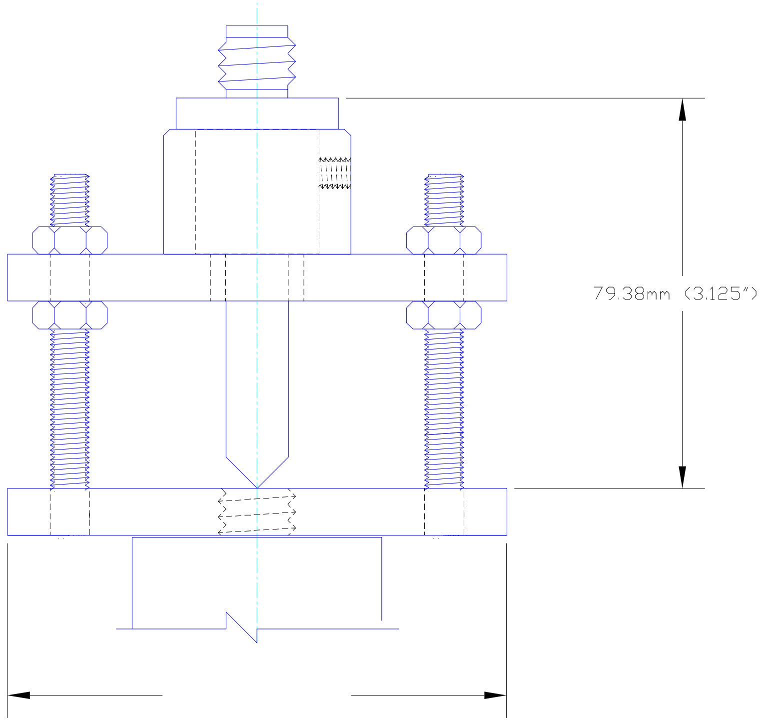


Figure 5 : Schematic drawing and dimensions of the 50-cm UNAVCO spike mount called

the S-50 in this report.

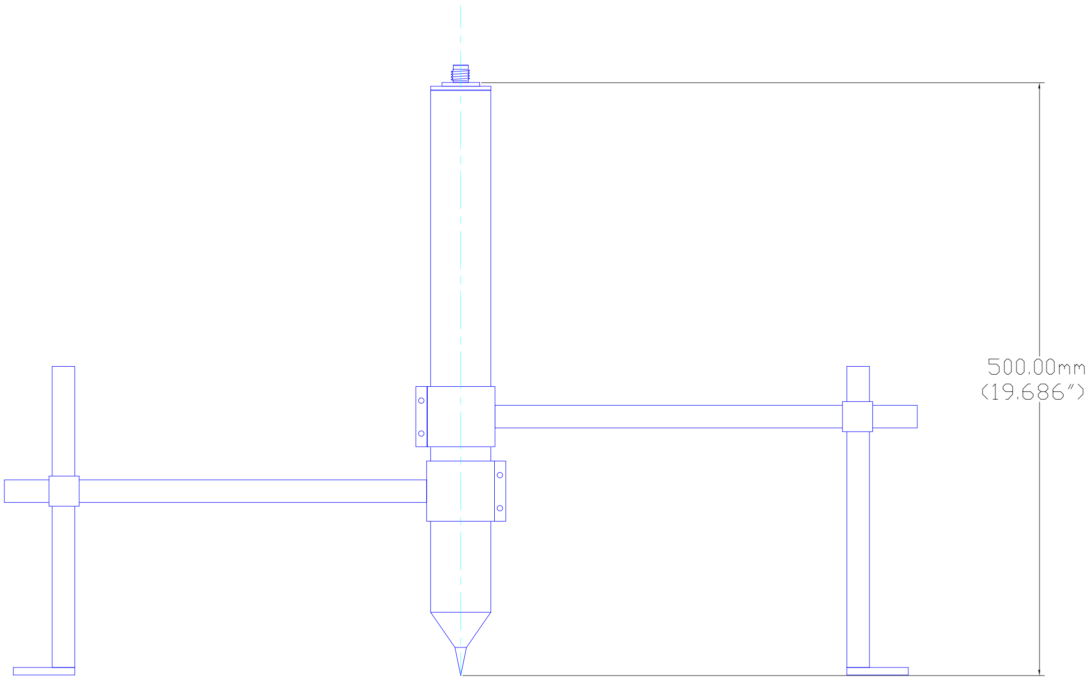


Figure 6 : Photo of the LM and a Trimble antenna at Table Mountain.

Figure 7 : Photo of the S-50 and a Trimble antenna at Table Mountain.

The LM requires a 5/8 inch threaded bolt with a centered dimple for insertion of the pointed end of the spike. An antenna mounted with the LM is typically 10-20 cm above the ground or above a pillar, rooftop, etc. The S-50 can be mounted atop a benchmark and it requires a flat surface for bolting its feet to the ground. For the tests described here the S-50 was mounted on concrete pads.

The advantage of spike mounts is that antennas are installed at known heights above benchmarks because the height is defined by the known length of the spike-mount.

Data Analysis

The data from the tests were analyzed at the UNAVCO facility with the Bernese software. The Bernese software version 3.5 plus the Bernese Processing Engine (BPE) were used for the analysis.

The data were converted to RINEX using the TRRINEXO translator developed at the University of Bern. All data were processed as individual baselines (not in seven-station network solutions) and redundant baselines were formed. Processing for each of these baselines was done in the following sequence:

(1) Process L1 and resolve carrier phase ambiguities
(2) Process L2 “ “ “ “ “
(3) Process L3 (or LC) with resolved ambiguities

(4) Same as (1) but estimate tropospheric delay at one end of baseline every hour
(5) Same as (2) but estimate tropospheric delay at one end of baseline every hour

(6) Same as (3) but estimate tropospheric delay at one end of baseline every hour

Thus each baseline was analyzed in 6 different ways. Baseline results with tropospheric estimation were computed to determine if antenna phase center patterns are affected by the height, and/or type of antenna mount. It has been shown that phase center pattern differences between antennas cause vertical baseline errors, especially when tropospheric parameters are estimated.

The reason for these vertical baseline errors is that phase center pattern differences between two antennas are interpreted as tropospheric delay differences between the two antennas by the GPS analysis software. Tropospheric delays are highly correlated to the station vertical, causing the observed vertical errors.

If the objective is highest geodetic precision it does not make sense to estimate tropospheric delays for baselines only several meters in length. In this case one would, for the short test baselines only compute an L1 solution. However, typical baseline analysis for geodetic GPS campaigns requires tropospheric estimation, using the ionospheric free linear combination L3. Thus if antenna mounting differences cause height errors for these solutions on short test baselines, these errors will also effect geodetic GPS campaigns.

Results

The effect of the LM mount is most clearly demonstrated by summarizing the results of the DE01 - DN01 baseline. This baseline had three different setups. First, both antennas were mounted on tripods at ~ 1.5 meters. Second, both antennas were mounted on LM mounts near to the ground. Third, one end of the baseline was low on an LM and the other end of the baseline was high on a tripod.

Figure 8 : This figure shows the effect of different antenna set-up on the DE01 - to - DN01 baseline for the L1 solutions when no tropospheric parameters were estimated. The bottom panels show the antenna setup height on the DE01 marker (bottom left) and on DN01 (bottom right). Scatter in the length (top left) for the different setups is on the order of 0.5 mm, scatter in the height (top right) on the order of a few mm. This indicates that there is no significant effect on the L1 results at the 1-mm level and that the antenna setups were done cor-

rectly.

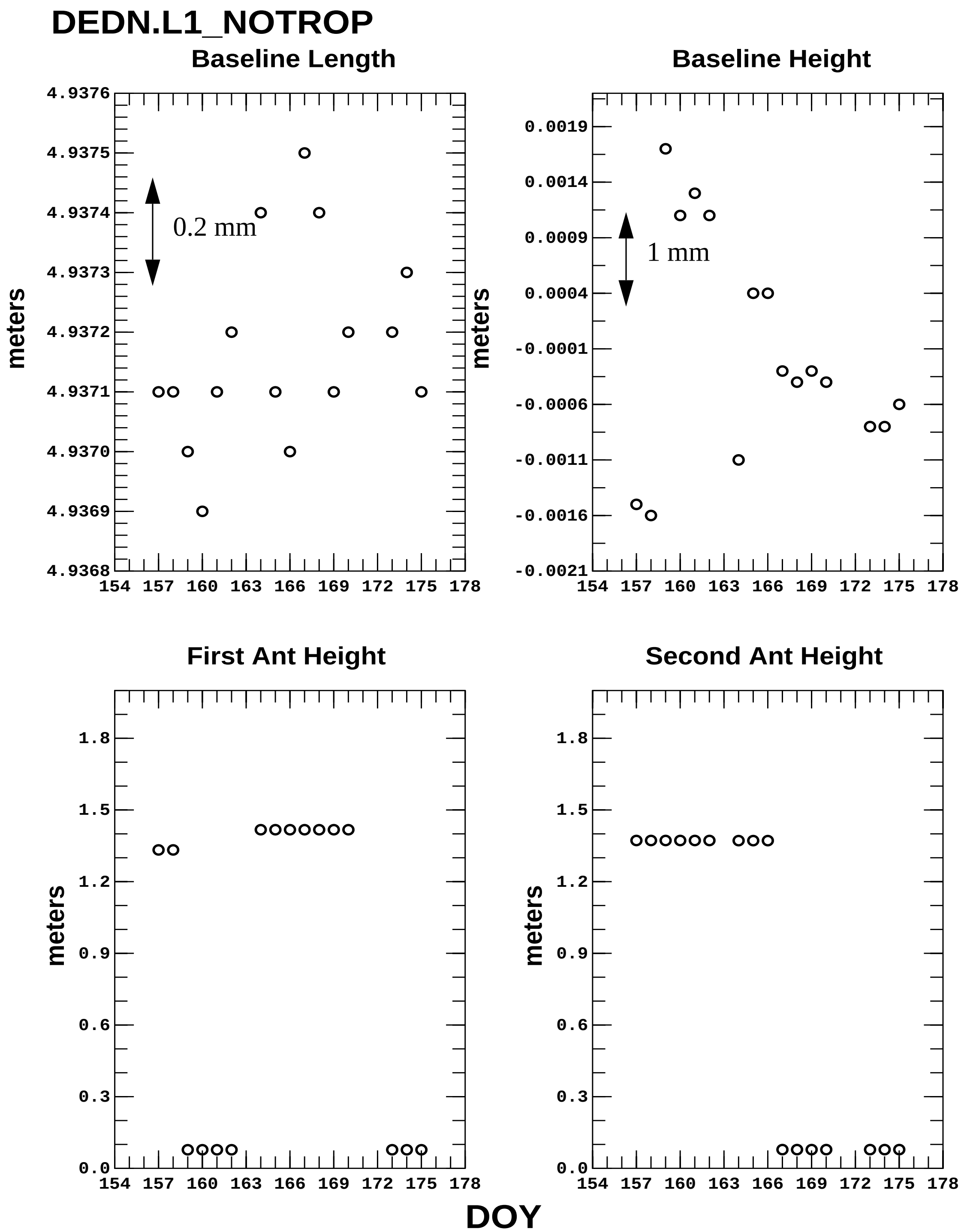
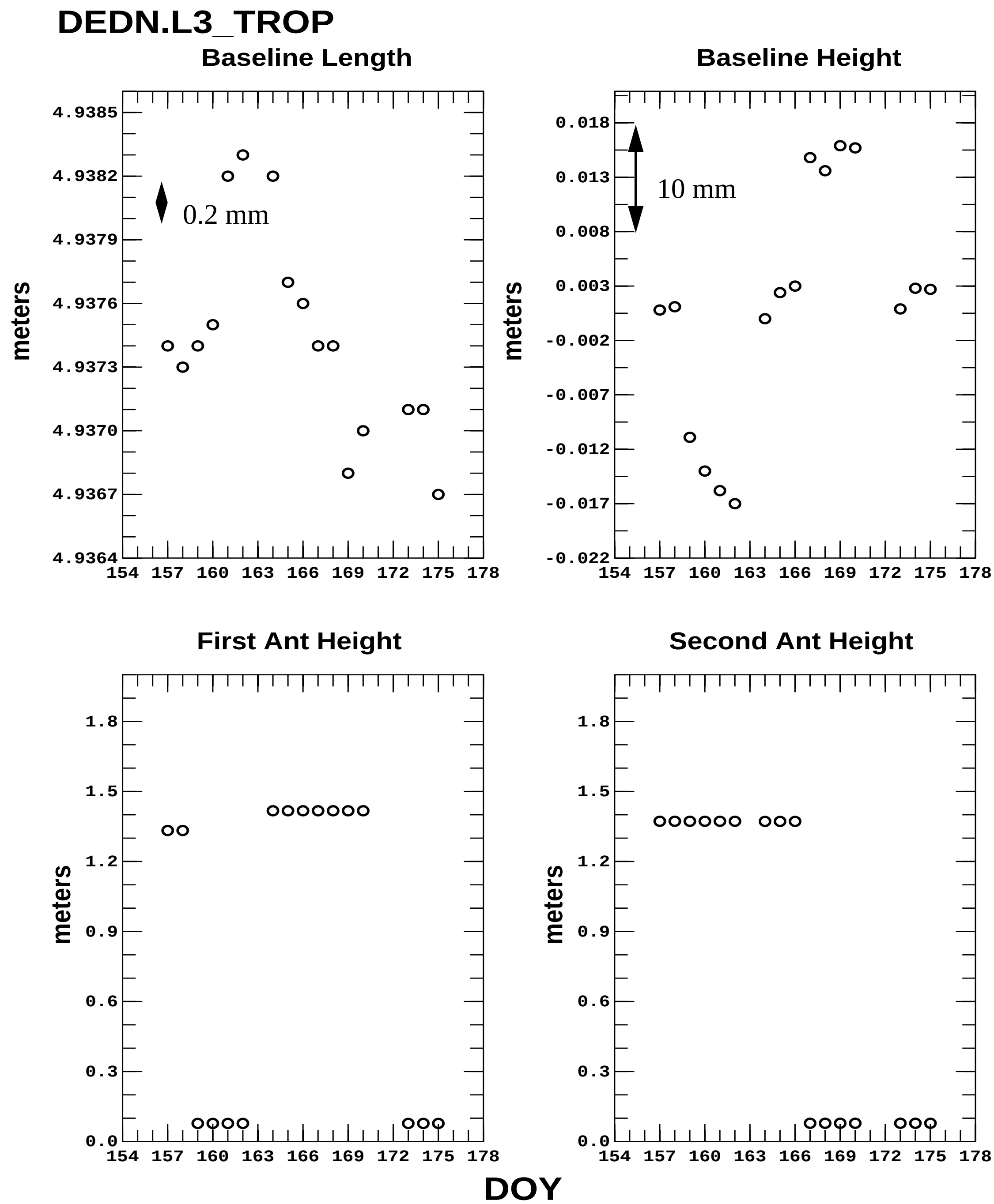


Figure 9 : Same as Figure 8 for the L3 solutions when tropospheric delays were estimated hourly. Scatter in the length for the different setups is on the order of 1.5 mm, scatter in the height on the order of 4 cm. There is an apparent significant effect of the antenna setup

on the baseline results in the vertical.

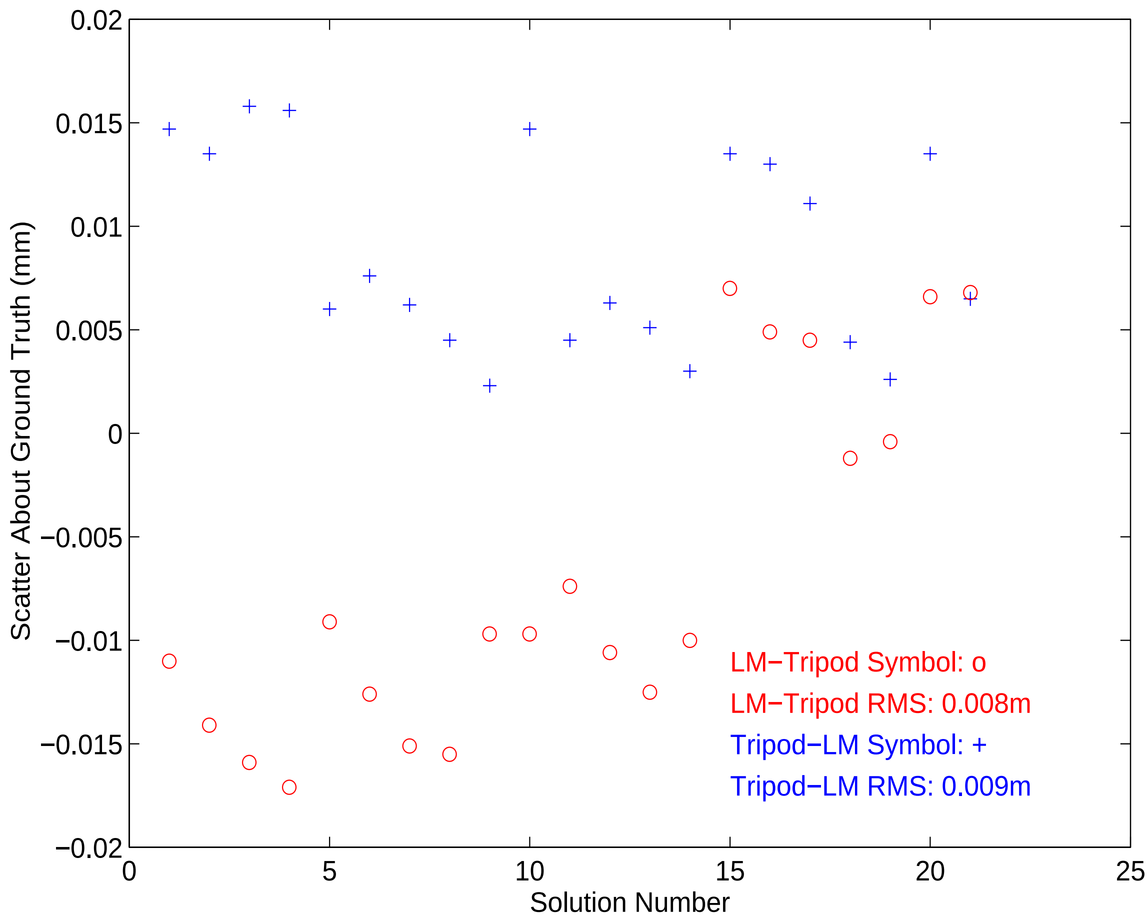


In Figure 8 we show two things. (a) L1 solutions without estimating the troposphere are not affected by antenna setups and (b) There were no setup blunders above the 1-2 mm level during this experiment.

In Figure 9 we find that the setup significantly affects the baseline at the several-cm level. On days 157 and 158 and on days 164 - 166 both antennas are mounted on tripods. These results are in good agreement. However, when DE01 is mounted low on the LM and DS01 is mounted high on a tripod on days 159-163 results differ by almost - 2 cm in the vertical from the tripod-tripod results. With the opposite setup on days 167-169 results differ by almost + 2 cm.

Similar results demonstrating that tripod-tripod results differ from mixed tripod-LM results at the 1-2 cm level were observed for many of the other baselines in the test diamond. Figure 11 plots all the mixed tripod-LM solutions about ground truth. This plot shows that there are differences of up to 16 millimeters between the GPS estimated and the ground truth solutions.

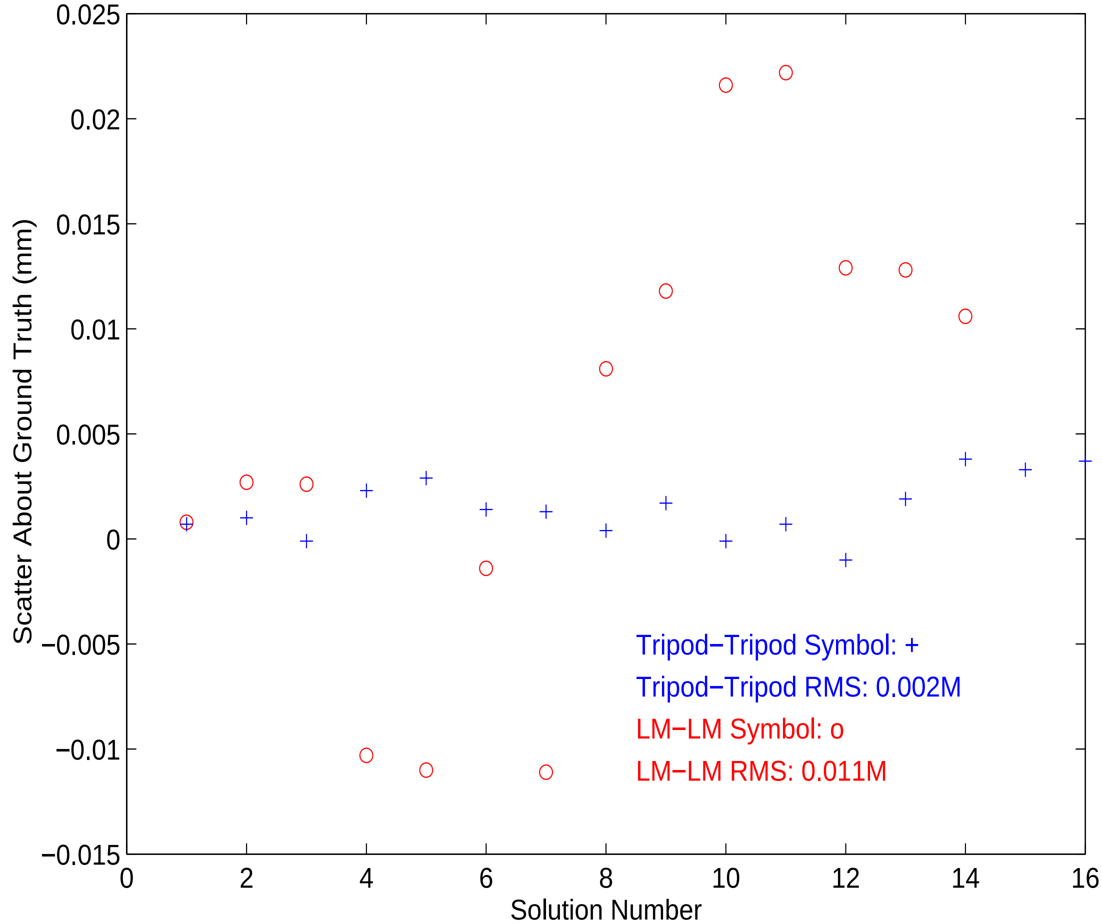
Figure 10 : Vertical component Scatter of Tripod-LM and LM-Tripod solutions within the "diamond" network. Ionosphere free L3 solutions with hourly troposphere parameter estimated.



A comparison of the tripod-tripod setups and the LM-LM setups with respect to ground truth is plotted in Figure 11. This figure shows that the scatter about ground truth of the low antenna setups is much larger than the scatter of the high antenna setups. The RMS of the LM-LM solutions about ground truth is 11 millimeters, while the tripod-tripod setups have an RMS of 1.4 millimeters.

Figure 11 : Vertical Scatter of LM-LM and Tripod-Tripod solutions within the "diamond"

network. Ionosphere free L3 solutions with hourly troposphere parameters estimated.



DESCRIBE S-50 RESULTS - to be completed

Conclusions and Future Tests

Our tests have shown that geodetic results with the Trimble SST antenna are affected by antenna mounts and/or antenna mounting heights.

(a) Antenna mounting height and/or type of mount can affect geodetic baseline results at the several cm-level when tropospheric correction parameters are estimated.

(b) Even if both ends of a baseline are mounted on the same spike mount and approximately at the same height spike-mount to spike-mount baselines do not agree with tripod to tripod results if tropospheric parameters are estimated. This indicates that antenna phase patterns are very sensitive to the antenna environment for low setups. (See Figure 11)

(c) Tripod setups generally agree better with ground-truth than low spike-mount setups. (See Figure 11)

Results (a), (b) and (c) demonstrate that GPS investigators should avoid low near-the ground set-ups. We have not yet tested what happens with pillar, pole or rooftop mounts.

It is also not clear to what extend the observed effects are due to the ground and to what extend they are caused by the LM or S-50 mounts. Additional tests are required to investigate this.

We also plan to test if other antennas, such as the AOA choke ring antenna, are similarly sensitive to the setup if tropospheric parameters are estimated.