NORRÆNA ELDFJALLASTÖÐIN

Nordic Volcanological Institute 9201
University of Iceland
Reykjavík, December 1992

SOUTH ICELAND 1992 GPS-MEASUREMENTS: Summary and daily observation logs

by

Freysteinn Sigmundsson[1+3]
Páll Einarsson [2]
Roger Bilham [3]
Erik Sturkell [1]

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1 Nordic Volcanological Institute, University of Iceland Geoscience Building, IS 101 Reykjavík, Iceland.
2 Science Institute, University of Iceland, Dunhaga 5, IS 107 Reykjavík, Iceland.
3 CIRES and Dept. of Geological Sciences, University of Colorado, CB 216, Boulder, Colorado 80309-0216, USA.

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Contents

Introduction

The GPS network in South Iceland was re-measured July 23 - August 16, 1992 in a cooperative effort by University of Colorado at Boulder, The Nordic Volcanological Institute and the Science Institute, University of Iceland. The GPS network encompasses the Reykjanes peninsula, the western volcanic zone, the eastern volcanic zone and the south Iceland seismic zone (Figure 1). The network was established in 1986 [*Foulger et al.*, 1987; *Foulger et al.*, 1992] and reoccupied and densified in 1989 [*Hackman* 1990; *Hackman* 1991]. Minor part of the network was remeasured in 1991 in response to the 1991 Hekla eruption [*Sigmundsson* 1992; *Sigmundsson et al.*, 1992]. The aim of the 1992 re-measurements were to provide constraints on the development of shear strain and rift widening in South Iceland, thereby providing constraints on rift-transform kinematics in the area.

Equipment

Five Trimble 4000 SST receivers were used in the project. The Nordic Volcanological Institute provided three P code receivers. The University Navstar Consortium (UNAVCO) provided one P code and one C/A code receiver. Two vehicles were used for most of the survey, one provided by the Nordic Volcanological Institute and one by the Science Institute, University of Iceland. In addition the Iceland Geodetic Survey provided one vehicle for a part of the survey. Solar panels were used for the first time in GPS measurements in Iceland. The receivers where hooked to one or two car batteries, and the solar panels where used to charge the batteries. The solar panels did, however, not charge the batteries at a sufficient rate so they were of little use.

The measurements

Two measurement sessions were observed per day: Session 0 extending from 9:15 to 18:40 UTC (same as local Icelandic time), and session 1 extending from 18:45 to 9:10 the following day (e.g. the two sessions beginning on julian day 206 are called 206-0 and 206-1). One receiver was moved between sessions. When a receiver was being moved it was picked up few hours before the end of the last session at a site. The first few hours of the next session were also lost while transferring the receiver (but not at the other 4 receivers). Once a receiver was at a control point it was stationary at that point for the next 4 sessions. When the receivers had been programmed to collect data they were left unattended at the sites inside plastic boxes. Most GPS stations in Iceland are remotely located so vandalism is not a problem. The recording interval was set at 15 seconds and the satellite elevation mask angle was 10°. All satellites in view were tracked. No meteorological data were collected.

The five receivers where used to measure a network of 41 points during the 25 day period July 23 - August 16, 1992. The measured control points are listed in Table 1, Figure 2 illustrates the point distribution, and Table 2 the sequence in which the points where occupied. Description of all the GPS stations is compiled by *Einarsson* [1992]. Initially the westernmost points were occupied and then the receivers were gradually moved eastwards. Station *Arnagarður (arna)* was used as a reference station for the western part of the network and occupied continuously from July 23 to August 4. The station is located on the top of a University building in Reykjavík. The marker is a steel pin drilled in the roof. A permanent steel tripod is above the marker. The receiver is placed inside the building and connects directly to AC current. Station *Ísakot (0s13)* was used as a reference station for the eastern part of the network and occupied continuously from August 1 to August 16.

Three new control points were measured. The *Arnagarður* reference station is new. Previously station *Valhúsahæð (0rvk)* and station *Ísakot (0s13)* have been used as reference stations in South Iceland. These older reference stations and the new reference station were measured simultaneously in 8 sessions to provide extra good ties between these stations. A new station was measured near the Hekla volcano, station *Hafurshorn (s112).* It will be important for monitoring of magmatic activity in Hekla. The third new point is control point *Surtsey (s621)* on the Surtsey island. The island was formed in an eruption in 1963-67. Since then the island has been subsiding because of compaction of the volcanic edifice and flexure of the lithosphere under the island load. The current rate of subsidence is very uncertain, but the GPS tie to the Icelandic mainland will provide good constraints on the subsidence rate in the next few years. In addition, a kinematic survey of a number of points on Surtsey was performed to monitor relative subsidence rates of the island, to monitor magmatic/seismic activity, and for mapping purposes.

Anti-Spoofing (AS), the encryption of the P code, was activated during weekends in August (on days 214, 215, 221, 222, 228, 229 during the survey). The P code receivers turned automatically into squaring mode (halving the wavelength of the recorded L2 signal) and behaved like C/A-code receivers without problems.

The raw Trimble data as well as a rinex translation of the data has been stored on an "exabyte" tape. For each julian day there is directory which includes both the raw and rinex data for this day in compressed form. A directory called run, includes shellscripts to run the rinex data through the Bernese programs in a batch mode [*UNAVCO*, 1992]. The total amount of data on the tape is ≈250 Mbyte. Four copies have been made of this tape. One copy will be located at the Nordic Volcanological Institute, one at the Science Institute University of Iceland, one at University of Colorado Boulder and one at UNAVCO.

Acknowledgment

The 1992 GPS survey was financed by NSF grant to University of Colorado, University of Iceland grant to the Science Institute, University of Iceland and by the Nordic Volcanological Institute. UNAVCO provided 2 GPS receivers for the survey. The Iceland Geodetic Survey provided a vehicle and operator for part of the survey. The National Power Company of Iceland provided site support at Ísakot. The Surtsey Research Society provided transport to and lodging in Surtsey. Unnur Svavarsdóttir, Kári Bergsson and Ingvar Magnússon participated in the field work.

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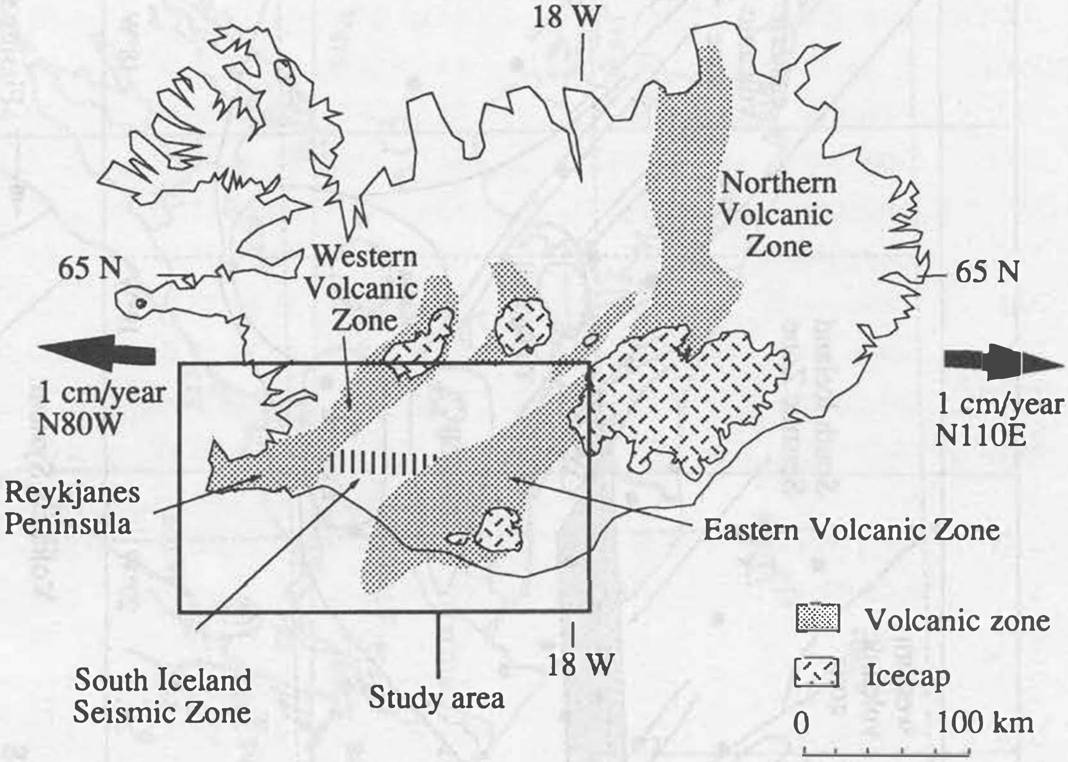

Figure 1. Map showing the study area and the volcanic zones of Iceland.

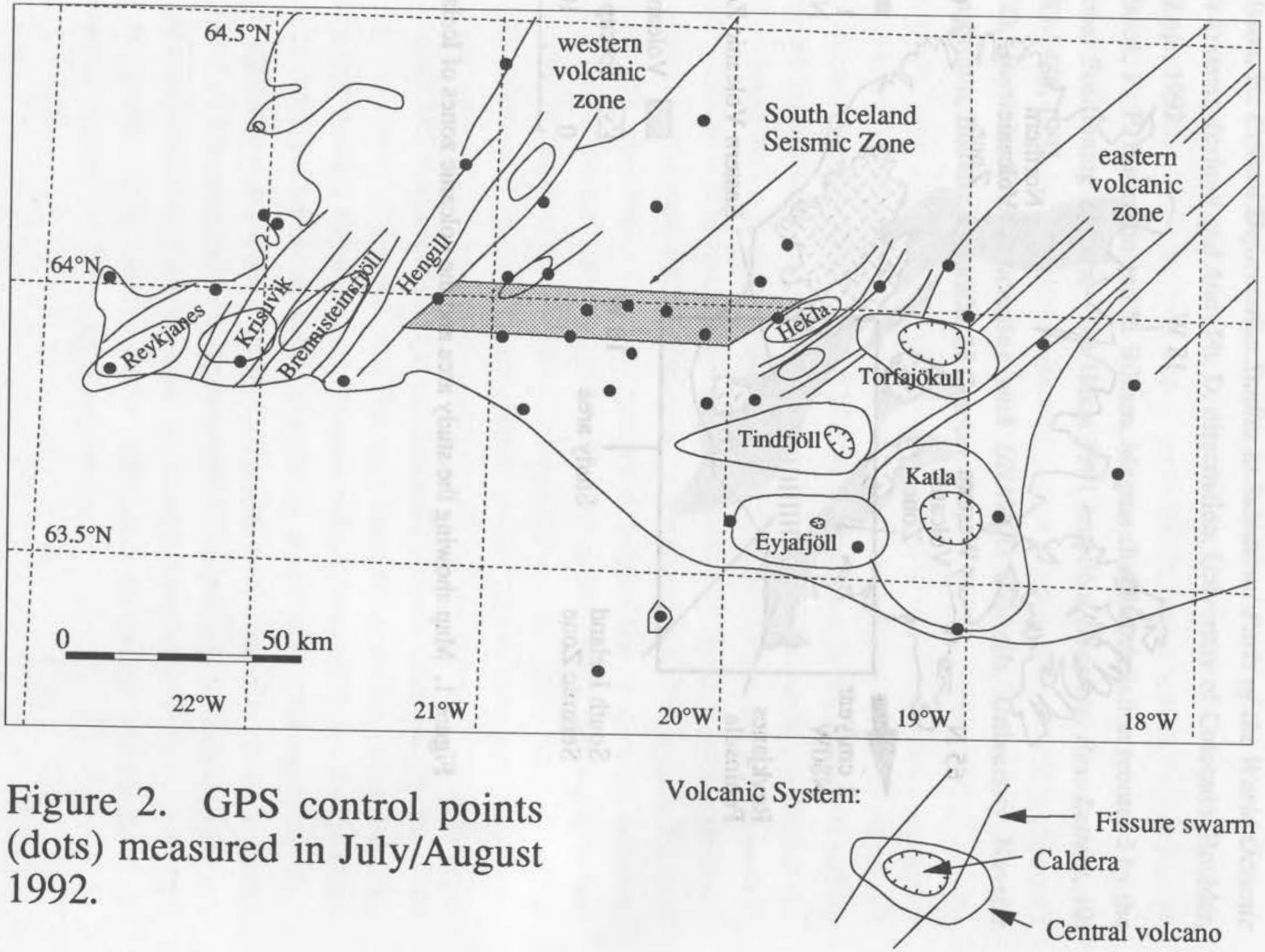

Figure 2. GPS control points (dots) measured in July/August 1992.

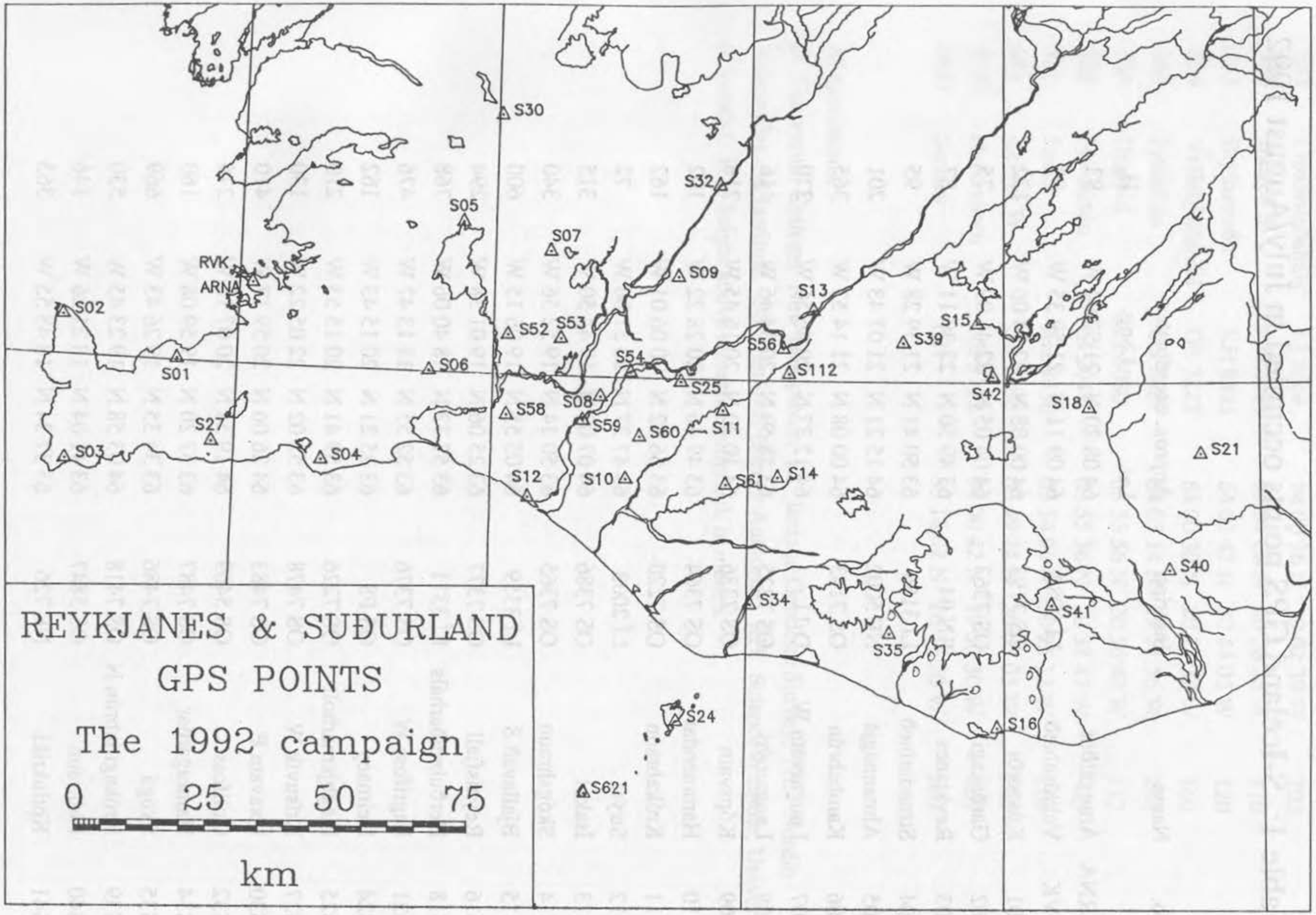

Figure 3. GPS control points measured in July/August 1992

Table 1: S-Iceland GPS points occupied in July/August 1992

No.	Name	Inscript.	Approx. coordinates Lat.	Long.	H
ARNA	Árnagarður		64 08 20 N	21 57 04 W	93
RVK	Valhúsahæð	LÍ 0082	64 09 11 N	21 59 35 W	93
S01	Kúagerði	OS 7193	64 00 08 N	22 14 06 W	122
S02	Garðskagi	OS 7363	64 04 05 N	22 41 09 W	75
S03	Reykjanes	RN 04	63 49 30 N	22 39 11 W	87
S04	Strandarhæð	LÍ 3166	63 50 41 N	21 39 28 W	95
S05	Almannagjá	NE 5002	64 15 21 N	21 07 43 W	201
S06	Kambabrún	OS 7143	64 00 08 N	21 14 57 W	365
S07	Laugarvatn W	D 11	64 12 37 N	20 46 56 W	279
S08	Langamýri	OS 7225	63 58 59 N	20 34 46 W	116
S09	Kópsvatn	OS 7336	64 10 20 N	20 16 45 W	216
S10	Hamraendar	OS 7364	63 49 46 N	20 28 22 W	102
S11	Krókahraun	OS 7220	63 56 52 N	20 06 01 W	162
S12	Strýta	LÍ 2003	63 47 37 N	20 51 06 W	72
S13	Ísakot	OS 7386	64 07 09 N	19 44 50 W	315
S14	Skógshraun	OS 7365	63 50 14 N	19 52 56 W	340
S15	Bjallavað S	LÍ 3359	64 05 55 N	19 06 15 W	600
S16	Reynisfjall	OS 7377	63 25 06 N	19 01 38 W	294
S18	Herðubreiðarháls	LÍ 3371	63 57 33 N	18 40 06 W	768
S21	Fagrifoss W	OS 7376	63 52 55 N	18 13 47 W	476
S24	Heimaey	OS F8	63 25 21 N	20 15 43 W	162
S25	Flagbjarnarholt	OS 7226	63 59 41 N	20 15 53 W	210
S27	Krísuvík W	OS 7478	63 52 02 N	22 05 22 W	130
S30	Uxavatn E	OS 7483	64 26 06 N	20 59 17 W	410
S32	Gullfoss	OS 5469	64 19 38 N	20 07 18 W	276
S34	Hamragarðar	OS 7487	63 37 20 N	19 59 08 W	160
S35	Skógá	OS 7486	63 34 35 N	19 26 43 W	669
S39	Krókagiljabrún N	OS 7418	64 03 58 N	19 23 45 W	530
S40	Eldhraun	OS 5847	63 41 04 N	18 21 26 W	146
S41	Kötlukriki	NE 726	63 37 34 N	18 48 55 W	363

S42	Frostastaðaháls	LÍ 3364	64 00 36 N	19 02 39 W	705
S52	Búrfell S	RH 8426	64 04 02 N	20 56 33 W	170
S53	Brjánsstaðir	RH 8421	64 03 47 N	20 44 05 W	120
S54	Veiðibjölluhóll	OS 7223	64 00 30 N	20 27 32 W	160
S56	Þjófafoss	OS 7481	64 03 14 N	19 51 56 W	244
S58	Háaleiti	LÍ 3080	63 55 56 N	20 56 40 W	112
S59	Þjórsártún	LÍ 2047	63 55 36 N	20 38 47 W	90
S60	Snasir	RH 8430	63 54 05 N	20 25 12 W	110
S61	Keldur W	OS 7480	63 49 24 N	20 05 05 W	165
S112	Hafurshorn	NE 9112	64 00 42 N	19 50 30 W	420
S621	Surtsey	621	63 18 02 N	20 36 20 W	100

Abbreviations:
D Dartmouth College, New Hampshire, LÍ Iceland Geodetic Survey, NE Nordic Volcanological Institute, OS National Energy Authority, RH Science Institute, University of Iceland, H is height above reference ellipsoid, in meters.

1992	Session	arna	0s02	0s03	0s01	0s27	0s04	0s06	0s05	0s07	0s30	0s32	0s52	0s09	0s12	0s08	0s58	0s53	0rvk	0s13	0s10	0s54	0s39	0s15
July																								
23	205-0	x	x		x																			
23	205-1	x	x	x	x	x																		
24	206-0	x		x	x		x																	
24	206-1	x		x	x	x	x																	
25	207-0	x		x	x	x	x																	
25	207-1	x			x	x	x	x																
26	208-0	x				x	x	x	x															
26	208-1	x					x	x	x	x														
27	209-0	x						x	x	x	x													
27	209-1	x							x	x	x	x												
28	210-0	x								x	x	x	x											
28	210-1	x									x	x	x	x										
29	211-0	x										x	x	x	x									
29	211-1	x											x	x	x	x								
30	212-0	x												x	x	x	x							
30	212-1	x													x	x	x	x						
31	213-0	x														x	x	x	x					
31	213-1	x															x	x	x	x				
Aug. 1	214-0	x																x	x	x	x			
1	214-1	x																	x	x	x	x		
2	215-0	x																	x	x	x	x		
2	215-1	x																	x	x	x	x		
3	216-0	x																	x	x		x	x	
3	216-1	x																	x	x			x	x
4	217-0																			x			x	x

Table 2: Station occupation - part 1

1992	Session	Os13	Os10	Os54	Os39	Os15	Os42	Os18	Os40	Os21	Os41	Os16	s621	Os24	Os35	Os34	Os60	Os61	Os14	Os25	Os59	s112	Os56	Os11
August																								
4	217-1	x			x	x	x	x																
5	218-0	x				x	x	x	x															
5	218-1	x					x	x	x	x														
6	219-0	x						x	x	x	x													
6	219-1	x							x	x	x	x												
7	220-0	x									x	x												
7	220-1	x									x	x												
8	221-0	x										x	x	x	x									
8	221-1	x										x	x	x	x									
9	222-0	x											x	x	x	x								
9	222-1	x											x	x	x	x								
10	223-0	x														x	x							
10	223-1	x														x	x							
11	224-0	x														x	x							
11	224-1	x														x	x							
12	225-0	x														x	x	x	x					
12	225-1	x															x	x	x	x				
13	226-0	x																x	x	x	x			
13	226-1	x																x	x	x	x			
14	227-0	x																	x	x	x	x	x	x
14	227-1	x																			x	x	x	x
15	228-0	x																			x	x	x	x
15	228-1	x																			x	x	x	x
16	229-0	x																				x	x	x

Table 2: Station occupation - part 2

Antenna heights table

The measured heights are slant heights to the upper edge of the Trimble antenna ground planes, inside a notch. The RINEX vertical heights are according to rinex standards, the vertical height to the bottom surface of the antenna preamplifier. Rinex heights are found using the formula:

$$\text{rinex H} = -0.0629 + \text{sqrt}((\text{slant H})^2 - (0.2334)^2)$$

where 0.2334 is the radius of the antenna ground plane (to notch) and 0.0629 is the offset from the top of ground plane to bottom of the antenna preamplifier.

Table 3: Antenna heights

rinex H = -0,0629 + sqrt((slant H)*(slant H)-0,2334*0,2334)

Session	Station	RINEX Vertical H (meters)	MEASURED (m) Slant H (meters)	MEASURED (m) Vertical H (meters)
205-0	arna	0,9701	1,059	
	0s02	1,2465	1,330	
	0s01	0,9967	1,085	
205-1	arna	0,9701	1,059	
	0s02	1,2465	1,330	
	s027	1,0315	1,119	
	0s03	1,1315	1,217	
	0s01	0,9967	1,085	
206-0	arna	0,9701	1,059	
	0s04	1,4026	1,484	
	0s01	0,9967	1,085	
	0s03	1,1305	1,216	
206-1	arna	0,9701	1,059	
	0s04	1,4026	1,484	
	0s27	1,0315	1,119	
	0s03	1,1305	1,216	
	0s01	0,9967	1,085	
207-0	arna	0,9701	1,059	
	0s04	1,4026	1,484	
	0s03	1,1305	1,216	
	0s01	0,9967	1,085	
	0s27	1,0315	1,119	
207-1	arna	0,9701	1,059	
	0s04	1,4026	1,484	
	0s06	1,2200	1,304	
	0s01	0,9967	1,085	
	0s27	1,0315	1,119	
208-0	arna	0,9701	1,059	
	0s04	1,4026	1,484	
	0s06	1,2200	1,304	
	0s27	1,0315	1,119	
	0s05	1,0815	1,168	
208-1	arna	0,9701	1,059	
	0s04	1,4026	1,484	

	0s06	1,2200	1,304	
	0s05	1,0815	1,168	
	0s07	1,1193	1,205	
209-0	arna	0,9701	1,059	
	0s30	1,0856	1,172	
	0s05	1,0815	1,168	
	0s06	1,2200	1,304	
	0s07	1,1193	1,205	
209-1	arna	0,9701	1,059	
	0s32	0,9875	1,076	
	0s30	1,0856	1,172	
	0s05	1,0815	1,168	
	0s07	1,1193	1,205	
210-0	arna	0,9701	1,059	
	0s32	0,9875	1,076	
	0s30	1,0856	1,172	
	0s52	0,9772	1,066	
	0s07	1,1193	1,205	
210-1	arna	0,9701	1,059	
	0s09	1,1366	1,222	
	0s32	0,9875	1,076	
	0s30	1,0856	1,172	
	0s52	0,9772	1,066	
211-0	arna	0,9701	1,059	
	0s09	1,1366	1,222	
	0s12	0,0541		0,117
	0s32	0,9875	1,076	
	0s52	0,9772	1,066	
211-1	arna	0,9701	1,059	
	0s09	1,1366	1,222	
	0s08	0,7492	0,845	
	0s12	0,0541		0,117
	0s52	0,9772	1,066	
212-0	arna	0,9701	1,059	
	0s09	1,1366	1,222	
	0s08	0,7492	0,845	
	0s58	1,1274	1,213	
	0s12	0,0541		0,117
212-1	arna	0,9701	1,059	
	0s08	0,7492	0,845	
	0s58	1,1274	1,213	
	0s12	0,0541		0,117
	0s53	1,0489	1,136	

213-0	arna	0,9701	1,059
	0rvk	0,3714	0,493
	0s08	0,7492	0,845
	0s58	1,1274	1,213
	0s53	1,0489	1,136
213-1	arna	0,9701	1,059
	0rvk	0,3714	0,493
	0s13	0,9352	1,025
	0s58	1,1274	1,213
	0s53	1,0489	1,136
214-0	arna	0,9701	1,059
	0rvk	0,3714	0,493
	0s13	0,9352	1,025
	0s53	1,0489	1,136
	0s10	1,0744	1,161
214-1	arna	0,9701	1,059
	0rvk	0,3714	0,493
	0s13	0,9352	1,025
	0s54	0,9793	1,068
	0s10	1,0744	1,161
215-0	arna	0,9701	1,059
	0rvk	0,3714	0,493
	0s13	0,9352	1,025
	0s54	0,9793	1,068
	0s10	1,0744	1,161
215-1	arna	0,9701	1,059
	0rvk	0,3714	0,493
	0s13	0,9352	1,025
	0s54	0,9793	1,068
	0s10	1,0744	1,161
216-0	arna	0,9701	1,059
	0rvk	0,3714	0,493
	0s13	0,9362	1,026
	0s39	0,9403	1,030
	0s54	0,9793	1,068
216-1	arna	0,9701	1,059
	0rvk	0,3714	0,493
	0s13	0,9362	1,026
	0s39	0,9403	1,030
	0s15	1,1834	1,268
217-0	0s13	0,9362	1,026
	0s39	0,9403	1,030
	0s15	1,1834	1,268

217-1	0s13	0,9362	1,026
	0s39	0,9403	1,030
	0s15	1,1834	1,268
	0s42	1,0683	1,155
	0s18	1,1101	1,196
218-0	0s13	0,9362	1,026
	0s40	1,0243	1,112
	0s15	1,1834	1,268
	0s42	1,0683	1,155
	0s18	1,1101	1,196
218-1	0s13	0,9362	1,026
	0s40	1,0243	1,112
	0s42	1,0683	1,155
	0s18	1,1101	1,196
	0s21	1,1488	1,234
219-0	0s13	0,9362	1,026
	0s40	1,0243	1,112
	0s41	0,9824	1,071
	0s18	1,1101	1,196
	0s21	1,1488	1,234
219-1	0s13	0,9362	1,026
	0s40	1,0243	1,112
	0s16	1,0202	1,108
	0s41	0,9824	1,071
	0s21	1,1488	1,234
220-0	0s13	0,9352	1,025
	0s16	1,0202	1,108
	0s41	0,9824	1,071
220-1	0s13	0,9352	1,025
	0s16	1,0202	1,108
	0s41	0,9824	1,071
221-0	0s13	0,9352	1,025
	s621	1,1621	1,247
	0s24	1,0550	1,142
	0s35	1,0346	1,122
	0s16	1,0202	1,108
221-1	0s13	0,9352	1,025
	s621	1,1621	1,247
	0s24	1,0550	1,142
	0s35	1,0346	1,122
	0s16	1,0202	1,108
222-0	0s13	0,9352	1,025
	s621	1,1621	1,247

	0s24	1,0550	1,142
	0s34	1,0673	1,154
	0s35	1,0346	1,122
222-1	0s13	0,9352	1,025
	s621	1,1621	1,247
	0s24	1,0550	1,142
	0s34	1,0683	1,155
	0s35	1,0346	1,122
223-0	0s13	0,9352	1,025
	0s60	0,9660	1,055
	0s34	1,0683	1,155
223-1	0s13	0,9352	1,025
	0s60	0,9660	1,055
	0s34	1,0683	1,155
224-0	0s13	0,9352	1,025
	0s60	0,9660	1,055
	0s34	1,0673	1,154
224-1	0s13	0,9352	1,025
	0s60	0,9660	1,055
	0s34	1,0673	1,154
225-0	0s25	0,9711	1,060
	0s60	0,9660	1,055
	0s34	1,0673	1,154
	0s61	0,9444	1,034
	0s14	1,2911	1,374
225-1	0s13	0,9362	1,026
	0s25	0,9711	1,060
	0s60	0,9660	1,055
	0s61	0,9444	1,034
	0s14	1,2911	1,374
226-0	0s13	0,9362	1,026
	0s25	0,9711	1,060
	0s59	0,9331	1,023
	0s61	0,9444	1,034
	0s14	1,2911	1,374
226-1	0s13	0,9352	1,025
	0s25	0,9711	1,060
	0s59	0,9331	1,023
	0s61	0,9444	1,034
	0s14	1,2911	1,374
227-0	0s13	0,9362	1,026
	0s25	0,9711	1,060
	s112	0,9608	1,050

	0s56	1,0202	1,108
	0s14	1,2911	1,374
	0s59	0,9331	1,023
	0s11	0,6182	0,720
227-1	0s13	0,9352	1,025
	s112	0,9608	1,050
	0s56	1,0202	1,108
	0s59	0,9331	1,023
	0s11	0,6182	0,720
228-0	0s13	0,9362	1,026
	s112	0,9608	1,050
	0s56	1,0202	1,108
	0s59	0.9331	1,023
	0s11	0,6182	0,720
228-1	0s13	0,9352	1,025
	s112	0,9608	1,050
	0s56	1,0202	1,108
	0s59	0,9331	1,023
	0s11	0,6182	0,720
229-0	s112	0,9608	1,050
	0s56	1,0202	1,108
	0s11	0,6182	0,720

Appendix

Daily observation logs

The daily observation logs are 1 page per station per session. No meteorological data were recorded. Antenna heights were measured to the upper edge of the antenna ground planes.

This copy of the report does not include the daily observation logs. Please contact the Nordic Volcanological Institute if you need the observation logs and/or a copy of the GPS data.