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Mt Etna's east flank surface displacements & the siting of future eruptions

Leica system 530 GPS set up on the unstable east flank, with summit behind, 20th September 2010

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NERC GEF loan 929 scientific report

Mt Etna's east flank surface displacements and the siting of future eruptions

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Abstract: This project is aimed at determining not the time, but the position of the next eruption of Mt Etna volcano, by measuring the detailed relative displacements of a dense network of GPS stations.

Background: In 2009, Etna completed its longest flank eruption in 17 years (13th May 2008 – 6th July 2009). Like the eruptions of 2004 and 2006 October, the main eruptive vents were associated with the Southeast Crater, and were situated at the head of the Valle del Leone in its southern part. The activity was largely effusive, with comparatively little explosive activity. The lavas from these three eruptions have covered much of the lower part of the Valle del Leone, and the central Valle del Bove. In 2010 there was an ashy emission at SE Crater on April 10th.

The Etna ground deformation network is the longest-lived and by far the densest of such networks on Etna, with 95 stations at present, and it is the only one with stations within the Valle del Leone and the Valle del Bove, (where the recent eruptions have taken place) installed in 1983 and 1987. These stations were measured initially by trilateration, and from 1994 by dual-frequency GPS. Three of these long-lived stations were destroyed by the lavas of 2008-9, so one objective for 2010 will be the installation of new stations to replace these lost stations, and to add 3 more to increase the detail in this region.

Previous results: The results of these measurements have shown a marked difference in behaviour between the east side of the volcano and the west. Those stations on the east side have shown movements towards the sea (mainly easterly or southeasterly) of more than 2 metres in some cases, i.e. an average of 10 cm per year, though the rate of movement has varied greatly from year to year. Those on the west, on the other hand, have shown radial outward movements about one third of the magnitude of those on the east. On the lower flanks they have been comparatively stable, showing movement of about 1 cm per year or less. The dividing line between the two halves is marked by the northeast rift, continuing into the Pernicana fault to the north, and by the southern rift to the south, with other discontinuities within the unstable sector.

Underlying rationale: The apparent consequence of these movements has been the persistent opening of new fissures as a result of the tensional movement between the two halves of the volcano. The 1985, 1989, 1991-3, 2001, 2002-3 and 2008-9 eruptions all included north-south to NE-SW fissures, some of them intrusions from which no magma was erupted. There is also clear evidence from the data that once magma pathways had been determined by these large scale events, magma pressure greatly added to the movement, and that this magmatic component had a different proportion of the total movement for each eruption.

Another factor in the determination of eruption sites and supply channels has been the loading effect of erupted lava. This was first noticed in regard to the levelling measurements (Murray 1988) and was evident after the 1991-3 eruption (Massonet et al. 1995). In its simplest form, shear stress following flow emplacement reaches a maximum at the flow edge, causing fissures to open here which may later be used by erupting lavas.

Application of the three-dimensional measurements of movements at Etna to determine likely fissure positions and directions using mathematical modelling of the stress regime was attempted

by Dowden et al (1995). As an extension of this work, Dowden et al. (1997) took the three dimensional movements as surface boundary conditions, then integrated downwards to determine internal displacements, from which stress distributions within the mountain could be calculated. These studies pinpointed an area at depth from the 1989-1990 displacements that later marked the site of the 1991-3 eruption, and an area beneath the Southeast Crater and another SW of the Torre del Filosofo visible in the 1991-2 displacements marked the site of the February 1999 fissure eruption and the initial fractures of the 2001 eruption respectively (La Delfa et al. 2001, Bonnacorso et al. 2002).

Specific objectives

1. To determine the effect of recent surface displacements and lava loading on subsequent eruption position.
2. To measure the surface displacement 2009-2010 to determine internal stress distributions and likely positioning and orientation of future eruptive fissures.
3. To measure the 96-station dual-frequency GPS network, using 7 Leica System 530 sets.
4. To install and measure new GPS stations, to replace those destroyed 2008-9 and intensify the network on the upper eastern flank.
5. To occupy and extend the 236-station precise levelling network.
6. To measure the 27 Dry Tilt stations on the flanks.

All the practical objectives were achieved, and substantive advances in objective 1 are ongoing.

Volcanic activity

Since the previous trip in Sep-Oct 2009, Mt Etna had been essentially inactive, apart from quiet degassing from the summit and the 2008-9 eruptive fissure. Earlier in the year there had been occasional collapses and emissions of ashy clouds, such as that on June 19th, when ash was emitted from a vent at the southeast foot of the Southeast Crater for about an hour in the early morning.

During the trip, there was little sign of activity apart from quiet degassing from the Chasm, Northeast & Southeast craters and the Bocca Nuova. During visits to the summit, no noises could be heard from the Chasm or Bocca Nuova, but on September 12th strong prolonged rumbling could be heard from the Northeast Crater, indicating gas escape from the magma.

Survey procedure

We reoccupied all the ground deformation networks first established in 1975 (levelling and dry tilt) and between 1981 and 1987 (trilateration to 1994, GPS from 1994-2008). At the present time, the ground deformation stations consist of 95 dual-frequency GPS stations which are habitually measured as a static survey with occupation times 30 minutes to 18 hours, depending upon line lengths. Results give error ellipses to <9mm accuracy, precise levelling benchmarks which yield precisions of <1mm per km, and 27 dry tilt stations at widely scattered locations around the summit and flanks of the volcano, which measure changes in ground tilt of 3 to10μ.

Data quality was good, similar to previous years, though some stations on the lower western flank experienced satellite problems, apparently due to the ever increasing height and density of conifer trees in the Corpo Forestale territory. Data were post-processed using Noto, Cagliari and Matera permanent GPS stations, using Leica GeoOffice software.

Two new GPS stations were installed, and during October, we again occupied the new precise levelling branches linking the southern traverse to the Rifugio Sapienza, and the one linking the northern traverse to the Piano della Concazze. We also established a new loop following the Corpo Forestale track, linking the Sapienza to the Piano Provenzana, to create a new giant levelling network extending the previous 236 station network to 343 stations, and more than

doubling the distance levelled from 34 km to 78 km. The aim of this levelling is to provide more accurate height control of GPS stations, 32 of which are common to both networks.

Personnel
The measurements were carried out by the following volunteer assistants:

Toby Balaam, University of Sheffield.
Guillermo Caravantes-Gonzalez, Open University
Anne Forbes, Open University
John B.Murray, Open University
Anne Peterson, Open University
Andrew Pitty, University College London
Phil Sargent, Nottignham Trent University
Julia Scott, Cambridge University,
Richard Wall, University College London
Xiomara Gabriela Villagomez, Tarragona, Spain.

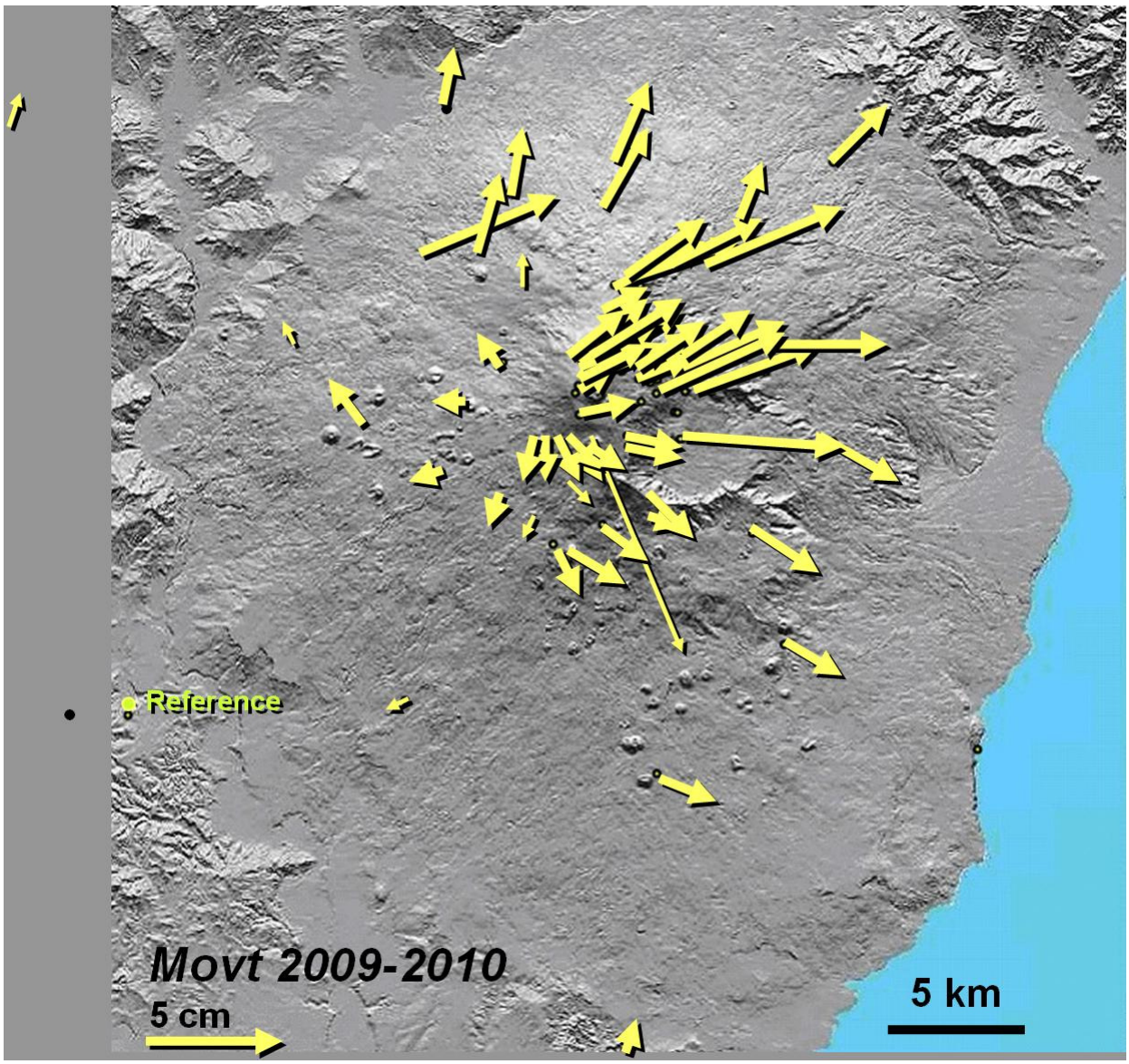

Fig. 1: Vectors of horizontal movement 2009-2010, derived from GPS values at 95 stations

Preliminary findings

On previous occasions, it has been noted that whilst horizontal movements of benchmarks prior to eruptions could broadly be described as radial to the summit region, in detail the movement could be broken up into groups of stations with movements almost parallel to each other. This suggests that whilst the volcano as a whole is behaving elastically and/or plastically (Murray & Pullen 1984), at a smaller scale the volcano surface is breaking up into slabs, with increased tensional strain or fissures between. This was particularly the case in 1987-1988 in the Valle del Leone, where such movements indicated tensional strain nearly one year prior to the 1989 eruption which included a voluminous eruptive fissure there, and also in 2005-6 prior to the flank eruption which began on 2006 October 13th, right at the end of our trip that year.

The measurements 2009-2010 (see fig. 1, opposite) suggest a similar difference between the movements in three areas of the volcano: the northeast, southeast and the lower northern sectors. Most stations in a block approximately 5 x 5 km northeast of the summit moved parallel to each other 4-6 cm ENE, whereas those southeast of a line running diagonally across the middle of the Valle del Bove have moved in parallel 2-3 cm ESE. Another block is represented by those stations north of Monte Maletto, which effectively comprise the most northerly quarter of the volcanic edifice, and which have moved 2-3 cm NNE. The remaining stations show a slight outward spreading from the summit of 0.5-1.5 cm.

Discussion

The most commonly used models of volcano deformation, developed initially by Anderson (1936) and later applied to deformation observed in active volcanoes by Mogi (1958), describe elastic displacement in an infinite half-space, and other more recent models are largely based on the same premises (e.g. Okada 1992). Although observed displacements in real volcanoes follow the predicted models reasonably well on a scale of several kilometres, the models break down at smaller scales when fractures develop. The above observations of 1987-8, 2005-6 and 2009-10 show that observed departures from elastic behaviour prior to eruption might be used to determine the most likely location of future fracture development, and therefore of future eruption locations.

Interpretation to date

An initial interpretation of the 2009-2010 data suggests that the northeast sector and the lower northern block could be moving transcurrently in a sinistral direction, but without accumulating much tensional strain. This interpretation is supported by the fact that the Pernicana fault runs between these two sectors. Similarly there is no appreciable increase in tension indicated at the junction between the summit spreading and the southeast sector, since movements at the join would tend to take up most of the strain. However, the line between the northeast and southeast sectors, where tensional strain is accumulating, runs east from the summit, and may represent a future eruptive fissure. The division between the lower northern sector and the summit is also a site of increased tensional strain, and so may represent a future eruptive fissure running northwest from the summit.

Preliminary findings

From the work carried out so far, the most likely position and orientation of the next flank eruption is from a fissure east of the summit, oriented east-west. This has partly been fulfilled in that on 11th January 2011, the first of a series of short-lived but violent paroxysmal pyroclastic eruptions lasting a few hours took place from a new vent at the eastern foot of the southeast crater. Since then there have been 20 such paroxysms, the most recent on 9th February 2012. At the time of writing, strombolian activity has started again within the new vent, where a new cone has built up over the past year now more than 200m high. However, it remains to be seen whether the next flank eruption fissure follows the same trend.

Instrument deployment

TABLE 1: List of static observations carried out

	Station No.	*Start date & time*	*End date & time*	*Duration*		*Height*	*Setup*
1	2	08/28/2010 08:08:16	08/28/2010 16:19:11	8h 10' 55"	0.344	AT502	Pole
2	26	08/28/2010 09:54:16	08/28/2010 15:44:51	5h 50' 35"	0.344	AT502	Pole
3	19	08/28/2010 10:32:06	08/28/2010 15:29:56	4h 57' 50"	0.344	AT502	Pole
4	77	08/28/2010 12:07:26	08/28/2010 12:28:06	20' 40"	0.739	AT502	Tripod
5	93	08/28/2010 12:14:36	08/28/2010 14:47:01	2h 32' 25"	0.344	AT502	Pole
6	76	08/28/2010 12:48:06	08/28/2010 14:28:51	1h 40' 45"	0.824	AT502	Tripod
7	34	08/28/2010 12:53:51	08/28/2010 13:15:01	21' 10"	0.648	AT502	Tripod
8	40	08/28/2010 13:33:36	08/28/2010 13:56:56	23' 20"	0.564	AT502	Tripod
9	75	08/28/2010 13:34:21	08/28/2010 14:04:06	29' 45"	0.838	AT502	Tripod
10	22	08/28/2010 14:41:31	08/28/2010 15:01:31	20' 00"	0.942	AT502	Tripod
11	2	08/29/2010 06:28:16	08/29/2010 17:03:46	10h 35' 30"	0.344	AT502	Pole
12	20	08/29/2010 07:06:26	08/29/2010 16:25:31	9h 19' 05"	0.344	AT502	Pole
13	52	08/29/2010 07:55:36	08/29/2010 13:49:06	5h 53' 30"	0.344	AT502	Pole
14	93	08/29/2010 08:29:41	08/29/2010 15:17:36	6h 47' 55"	0.344	AT502	Pole
15	39	08/29/2010 09:51:31	08/29/2010 12:28:11	2h 36' 40"	0.627	AT502	Tripod
16	12	08/29/2010 10:12:31	08/29/2010 11:07:51	55' 20"	1.066	AT502	Tripod
17	50	08/29/2010 10:31:46	08/29/2010 10:59:11	27' 25"	0.344	AT502	Pole
18	24	08/29/2010 12:07:51	08/29/2010 12:42:21	34' 30"	0.344	AT502	Pole
19	7	08/29/2010 13:44:41	08/29/2010 14:23:46	39' 05"	0.730	AT502	Tripod
20	52	08/29/2010 13:56:56	08/29/2010 15:41:51	1h 44' 55"	0.344	AT502	Pole
21	73	08/29/2010 13:58:01	08/29/2010 14:18:26	20' 25"	0.531	AT502	Tripod
22	47	08/29/2010 14:56:11	08/29/2010 15:40:31	44' 20"	1.082	AT502	Tripod
23	2	08/30/2010 06:30:26	08/30/2010 15:34:06	9h 03' 40"	0.344	AT502	Pole
24	27	08/30/2010 07:57:26	08/30/2010 14:35:16	6h 37' 50"	0.344	AT502	Pole
25	20	08/30/2010 08:21:06	08/30/2010 14:51:06	6h 30' 00"	0.344	AT502	Pole
26	85	08/30/2010 09:34:31	08/30/2010 09:56:06	21' 35"	0.483	AT502	Tripod
27	84	08/30/2010 10:11:46	08/30/2010 10:31:46	20' 00"	0.382	AT502	Tripod
28	32	08/30/2010 12:47:26	08/30/2010 14:20:41	1h 33' 15"	0.692	AT502	Tripod
29	78	08/30/2010 13:28:36	08/30/2010 14:01:16	32' 40"	0.604	AT502	Tripod
30	10	08/30/2010 13:37:26	08/30/2010 14:06:16	28' 50"	0.805	AT502	Tripod
31	2	08/31/2010 06:25:16	08/31/2010 14:14:41	7h 49' 25"	0.344	AT502	Pole
32	57	08/31/2010 06:52:31	08/31/2010 14:49:51	7h 57' 20"	0.344	AT502	Pole
33	52	08/31/2010 08:23:21	08/31/2010 13:14:11	4h 50' 50"	0.344	AT502	Pole
34	80	08/31/2010 08:45:41	08/31/2010 09:08:31	22' 50"	0.880	AT502	Tripod
35	93	08/31/2010 08:51:31	08/31/2010 12:48:21	3h 56' 50"	0.344	AT502	Pole
36	15	08/31/2010 09:31:01	08/31/2010 09:55:56	24' 55"	0.837	AT502	Tripod
37	37	08/31/2010 09:45:31	08/31/2010 12:17:16	2h 31' 45"	0.798	AT502	Tripod
38	41	08/31/2010 10:15:31	08/31/2010 10:37:31	22' 00"	0.798	AT502	Tripod
39	17	08/31/2010 10:35:36	08/31/2010 10:59:16	23' 40"	0.774	AT502	Tripod
40	21	08/31/2010 11:32:26	08/31/2010 12:01:31	29' 05"	0.942	AT502	Tripod
41	65	08/31/2010 11:34:01	08/31/2010 12:00:01	26' 00"	0.687	AT502	Tripod
42	64	08/31/2010 12:55:16	08/31/2010 13:20:11	24' 55"	0.850	AT502	Tripod
43	91	08/31/2010 13:48:56	08/31/2010 14:08:51	19' 55"	0.845	AT502	Tripod
44	2	09/01/2010 06:28	09/01/2010 15:27	8h 59' 15"	0.344	AT502	Pole
45	13	09/01/2010 06:56	09/01/2010 15:55	8h 58' 20"	0.344	AT502	Pole
46	11	09/01/2010 08:19	09/01/2010 08:41 2	1' 35"	0.688	AT502	Tripod
47	9	09/01/2010 09:04	09/01/2010 09:26 2	1' 35"	0.860	AT502	Tripod
48	20	09/01/2010 12:06	09/01/2010 14:45	2h 39' 25"	0.344	AT502	Pole
49	62	09/01/2010 12:32	09/01/2010 13:02	29' 55"	0.742	AT502	Tripod
50	2	09/02/2010 07:46	09/02/2010 13:00	5h 14' 05"	0.344	AT502	Pole
51	20	09/02/2010 08:24	09/02/2010 12:23	3h 59' 15"	0.344	AT502	Pole
52	52	09/02/2010 08:39	09/02/2010 12:11	3h 31' 40"	0.344	AT502	Pole
53	93	09/02/2010 09:01	09/02/2010 11:50	2h 48' 55"	0.344	AT502	Pole
54	23	09/02/2010 10:16	09/02/2010 10:52	36' 35"	1.020	AT502	Tripod
55	2	09/03/2010 07:02	09/03/2010 16:29	9h 27' 00"	0.344	AT502	Pole
56	14	09/03/2010 07:37	09/03/2010 12:48	5h 10' 45"	0.344	AT502	Pole
57	48	09/03/2010 07:47	09/03/2010 15:31	7h 43' 50"	0.344	AT502	Pole
58	95	09/03/2010 08:17	09/03/2010 10:34	2h 17' 35"	0.344	AT502	Pole

	Station No.	Start date & time	End date & time	Duration		Height	Setup
59	16	09/03/2010 09:04	09/03/2010 13:18	4h 13' 25"	0.344	AT502	Pole
60	31	09/03/2010 09:41	09/03/2010 15:34	5h 52' 25"	0.344	AT502	Pole
61	42	09/03/2010 10:12	09/03/2010 14:12	3h 59' 30"	0.344	AT502	Pole
62	72	09/03/2010 11:55	09/03/2010 14:57	3h 02' 15"	0.344	AT502	Pole
63	35	09/03/2010 13:49	09/03/2010 14:29	39' 55"	0.344	AT502	Pole
64	2	09/04/2010 06:46	09/04/2010 16:43	9h 56' 15"	0.344	AT502	Pole
65	20	09/04/2010 07:30	09/04/2010 16:04	8h 33' 55"	0.344	AT502	Pole
66	52	09/04/2010 08:17	09/04/2010 15:48	7h 31' 10"	0.344	AT502	Pole
67	93	09/04/2010 08:52	09/04/2010 15:08	6h 15' 45"	0.344	AT502	Pole
68	30	09/04/2010 09:47	09/04/2010 11:20	1h 32' 35"	0.993	AT502	Tripod
69	1	09/04/2010 10:30	09/04/2010 12:36	2h 06' 15"	0.736	AT502	Tripod
70	22	09/04/2010 10:55	09/04/2010 13:12	2h 17' 30"	0.612	AT502	Tripod
71	82	09/04/2010 12:17	09/04/2010 14:02	1h 45' 20"	0.344	AT502	Pole
72	71	09/04/2010 12:54	09/04/2010 13:46	52' 25"	0.843	AT502	Tripod
73	87	09/04/2010 13:28	09/04/2010 15:02	1h 34' 05"	0.604	AT502	Tripod
74	38	09/04/2010 14:08	09/04/2010 14:34	26' 25"	0.344	AT502	Pole
75	82	09/04/2010 14:09	09/04/2010 14:51	41' 50"	0.344	AT502	Pole
76	14	09/05/2010 06:49	09/05/2010 16:26	9h 37' 25"	0.344	AT502	Pole
77	2	09/05/2010 07:14	09/05/2010 16:01	8h 47' 25"	0.344	AT502	Pole
78	28	09/05/2010 07:53	09/05/2010 15:28	7h 34' 10"	0.344	AT502	Pole
79	52	09/05/2010 08:23	09/05/2010 15:00	6h 36' 55"	0.344	AT502	Pole
80	93	09/05/2010 08:48	09/05/2010 14:35	5h 46' 30"	0.344	AT502	Pole
81	46	09/05/2010 09:46	09/05/2010 10:03	16' 40"	0.344	AT502	Pole
82	53	09/05/2010 10:27	09/05/2010 11:30	1h 02' 25"	0.344	AT502	Pole
83	8	09/05/2010 10:51	09/05/2010 11:36	44' 55"	0.344	AT502	Pole
84	90	09/05/2010 13:45	09/05/2010 14:30	44' 55"	0.344	AT502	Pole
85	2	09/06/2010 06:48	09/06/2010 15:34	8h 46' 10"	0.344	AT502	Pole
86	52	09/06/2010 07:34	09/06/2010 14:49	7h 14' 30"	0.344	AT502	Pole
87	93	09/06/2010 08:22	09/06/2010 14:25	6h 02' 50"	0.344	AT502	Pole
88	65	09/06/2010 09:54	09/06/2010 12:25	2h 31' 15"	0.880	AT502	Tripod
89	36	09/06/2010 10:41	09/06/2010 11:15	33' 50"	0.849	AT502	Tripod
90	84	09/06/2010 10:47	09/06/2010 13:52	3h 05' 20"	0.443	AT502	Tripod
91	45	09/06/2010 11:50	09/06/2010 13:35	1h 44' 50"	0.898	AT502	Tripod
92	37	09/06/2010 13:12	09/06/2010 13:28	15' 05"	1.133	AT502	Tripod
93	2	09/07/2010 07:01	09/07/2010 14:44	7h 43' 35"	0.344	AT502	Pole
94	20	09/07/2010 07:42	09/07/2010 15:03	7h 20' 50"	0.344	AT502	Pole
95	52	09/07/2010 08:00	09/07/2010 15:15	7h 15' 10"	0.344	AT502	Pole
96	89	09/07/2010 09:14	09/07/2010 14:10	4h 55' 55"	0.344	AT502	Pole
97	86	09/07/2010 09:47	09/07/2010 12:14	2h 26' 15"	0.344	AT502	Pole
98	43	09/07/2010 10:34	09/07/2010 11:37	1h 02' 50"	1.193	AT502	Tripod
99	61	09/07/2010 12:34	09/07/2010 13:51	1h 17' 15"	0.344	AT502	Pole
100	60	09/07/2010 12:58	09/07/2010 13:31	33' 30"	0.344	AT502	Pole
101	67	09/08/2010 06:28	09/08/2010 13:48	7h 19' 55"	1.258	AT502	Tripod
102	68	09/08/2010 06:44	09/08/2010 08:31	1h 46' 15"	0.344	AT502	Pole
103	2	09/08/2010 06:49	09/08/2010 13:09	6h 20' 10"	0.344	AT502	Pole
104	69	09/08/2010 06:54	09/08/2010 08:26	1h 32' 30"	0.344	AT502	Pole
105	92	09/08/2010 07:31	09/08/2010 08:07	35' 45"	0.825	AT502	Tripod
106	70	09/08/2010 08:48	09/08/2010 09:11	22' 40"	0.835	AT502	Tripod
107	55	09/08/2010 09:00	09/08/2010 12:54	3h 54' 30"	0.885	AT502	Tripod
108	14	09/08/2010 09:32	09/08/2010 13:33	4h 01' 05"	0.344	AT502	Pole
109	79	09/08/2010 09:44	09/08/2010 12:22	2h 38' 15"	1.146	AT502	Tripod
110	95	09/08/2010 10:03	09/08/2010 14:05	4h 01' 20"	0.344	AT502	Pole
111	56	09/08/2010 11:10	09/08/2010 12:28	1h 17' 50"	1.165	AT502	Tripod
112	2	09/09/2010 07:02	09/09/2010 16:04	9h 01' 40"	0.344	AT502	Pole
113	89	09/09/2010 07:50	09/09/2010 14:49	6h 58' 35"	0.344	AT502	Pole
114	63	09/09/2010 08:42	09/09/2010 14:59	6h 16' 55"	0.344	AT502	Pole
115	59	09/09/2010 09:16	09/09/2010 10:06	50' 20"	0.857	AT502	Tripod
116	57	09/09/2010 09:25	09/09/2010 15:11	5h 45' 45"	0.344	AT502	Pole
117	44	09/09/2010 10:58	09/09/2010 15:27	4h 28' 40"	0.344	AT502	Pole
118	66	09/09/2010 11:30	09/09/2010 12:39	1h 08' 40"	0.344	AT502	Pole
119	25	09/09/2010 13:52	09/09/2010 14:27	35' 40"	0.344	AT502	Pole
120	2	09/10/2010 06:57	09/10/2010 15:44	8h 46' 55"	0.344	AT502	Pole

	Station No.	Start date & time	End date & time	Duration		Height	Setup
121	20	09/10/2010 07:54	09/10/2010 14:48	6h 53' 25"	0.344	AT502	Pole
122	28	09/10/2010 11:30	09/10/2010 11:53	22' 35"	0.344	AT502	Pole
123	28	09/10/2010 12:04	09/10/2010 14:23	2h 19' 15"	0.344	AT502	Pole
124	39	09/10/2010 12:16	09/10/2010 14:58	2h 41' 40"	0.893	AT502	Tripod
125	78	09/10/2010 13:26	09/10/2010 14:20	53' 35"	0.837	AT502	Tripod
126	10	09/10/2010 13:32	09/10/2010 14:15	42' 55"	0.958	AT502	Tripod
127	32	09/10/2010 13:59	09/10/2010 14:17	17' 20"	0.843	AT502	Tripod
128	2	09/11/2010 06:45	09/11/2010 16:21	9h 36' 05"	0.344	AT502	Pole
129	14	09/11/2010 07:19	09/11/2010 07:42	23' 55"	0.344	AT502	Pole
130	33	09/11/2010 07:21	09/11/2010 07:42	21' 20"	1.206	AT502	Tripod
131	31	09/11/2010 08:26	09/11/2010 15:25	6h 58' 55"	0.344	AT502	Pole
132	18	09/11/2010 09:06	09/11/2010 10:32	1h 26' 35"	0.769	AT502	Tripod
133	72	09/11/2010 09:33	09/11/2010 13:40	4h 06' 25"	0.344	AT502	Pole
134	58	09/11/2010 10:08	09/11/2010 12:54	2h 45' 50"	0.514	AT502	Tripod
135	45	09/11/2010 11:49	09/11/2010 12:53	1h 03' 30"	0.921	AT502	Tripod
136	37	09/11/2010 12:20	09/11/2010 12:36	15' 45"	0.888	AT502	Tripod
137	54	09/11/2010 14:56	09/11/2010 15:26	29' 10"	1.091	AT502	Tripod
138	2	09/12/2010 06:49	09/12/2010 16:02	9h 13' 40"	0.344	AT502	Pole
139	14	09/12/2010 07:15	09/12/2010 15:35	8h 20' 05"	0.344	AT502	Pole
140	28	09/12/2010 08:15	09/12/2010 14:51	6h 35' 45"	0.344	AT502	Pole
141	11	09/12/2010 08:52	09/12/2010 09:13	21' 20"	0.858	AT502	Tripod
142	9	09/12/2010 09:41	09/12/2010 10:02	20' 50"	0.977	AT502	Tripod
143	70	09/12/2010 11:04	09/12/2010 11:52	48' 30"	0.839	AT502	Tripod
144	2	09/15/2010 06:30:06	09/15/2010 16:05:26	9h 35' 20"	0.344	AT502	Pole
145	57	09/15/2010 07:10:36	09/15/2010 16:26:11	9h 15' 35"	0.344	AT502	Pole
146	48	09/15/2010 08:44:31	09/15/2010 14:51:16	6h 06' 45"	0.344	AT502	Pole
147	16	09/15/2010 09:53:51	09/15/2010 12:41:31	2h 47' 40"	0.344	AT502	Pole
148	42	09/15/2010 10:46:26	09/15/2010 13:30:56	2h 44' 30"	0.344	AT502	Pole
149	83	09/15/2010 11:17:01	09/15/2010 14:03:01	2h 46' 00"	0.344	AT502	Pole
150	2	09/18/2010 06:39:06	09/18/2010 16:38:16	9h 59' 10"	0.344	AT502	Pole
151	28	09/18/2010 07:19:46	09/18/2010 14:36:11	7h 16' 25"	0.344	AT502	Pole
152	20	09/18/2010 07:50:21	09/18/2010 15:23:11	7h 32' 50"	0.344	AT502	Pole
153	52	09/18/2010 08:14:21	09/18/2010 15:39:51	7h 25' 30"	0.344	AT502	Pole
154	2	09/19/2010 06:58:06	09/19/2010 15:08:01	8h 09' 55"	0.344	AT502	Pole
155	2	09/20/2010 06:02:06	09/20/2010 15:57:06	9h 55' 00"	0.344	AT502	Pole
156	28	09/20/2010 06:57:46	09/20/2010 15:24:26	8h 26' 40"	0.344	AT502	Pole
157	52	09/20/2010 07:31:36	09/20/2010 14:49:51	7h 18' 15"	0.344	AT502	Pole
158	82	09/20/2010 07:48:56	09/20/2010 14:07:16	6h 18' 20"	0.344	AT502	Pole
159	76	09/20/2010 08:55:21	09/20/2010 09:15:21	20' 00"	0.595	AT502	Tripod
160	88	09/20/2010 09:52:51	09/20/2010 11:07:46	1h 14' 55"	0.625	AT502	Tripod
161	71	09/20/2010 10:11:26	09/20/2010 12:34:41	2h 23' 15"	0.835	AT502	Tripod
162	22	09/20/2010 10:38:26	09/20/2010 11:15:01	36' 35"	0.711	AT502	Tripod
163	30	09/20/2010 11:40:21	09/20/2010 14:21:36	2h 41' 15"	0.968	AT502	Tripod
164	7	09/20/2010 12:10:16	09/20/2010 14:37:16	2h 27' 00"	0.781	AT502	Tripod
165	73	09/20/2010 13:07:21	09/20/2010 13:23:36	16' 15"	0.622	AT502	Tripod
166	12	09/20/2010 13:50:21	09/20/2010 15:00:41	1h 10' 20"	1.238	AT502	Tripod
167	2	09/21/2010 06:31:26	09/21/2010 15:55:11	9h 23' 45"	0.344	AT502	Pole
168	29	09/21/2010 07:31:06	09/21/2010 15:23:26	7h 52' 20"	0.344	AT502	Pole
169	94	09/21/2010 08:18:51	09/21/2010 11:49:36	3h 30' 45"	0.344	AT502	Pole
170	20	09/21/2010 08:53:56	09/21/2010 15:08:51	6h 14' 55"	0.344	AT502	Pole
171	24	09/21/2010 09:10:46	09/21/2010 10:21:31	1h 10' 45"	0.344	AT502	Pole
172	52	09/21/2010 09:19:11	09/21/2010 14:54:31	5h 35' 20"	0.344	AT502	Pole
173	93	09/21/2010 09:55:26	09/21/2010 14:20:21	4h 24' 55"	0.344	AT502	Pole
174	74	09/21/2010 10:52:06	09/21/2010 12:34:36	1h 42' 30"	0.344	AT502	Pole
175	38	09/21/2010 13:24:16	09/21/2010 14:41:11	1h 16' 55"	0.344	AT502	Pole
176	50	09/21/2010 13:41:56	09/21/2010 13:59:26	17' 30"	0.344	AT502	Pole
177	2	09/22/2010 06:43:01	09/22/2010 09:39:16	2h 56' 15"	0.344	AT502	Pole
178	2	09/23/2010 06:32:16	09/23/2010 14:31:21	7h 59' 05"	0.344	AT502	Pole
179	52	09/23/2010 07:22:26	09/23/2010 13:26:56	6h 04' 30"	0.344	AT502	Pole
180	72	09/23/2010 08:05:41	09/23/2010 12:46:56	4h 41' 15"	0.344	AT502	Pole
181	35	09/23/2010 08:34:46	09/23/2010 11:38:06	3h 03' 20"	0.344	AT502	Pole
182	83	09/23/2010 09:28:21	09/23/2010 10:48:21	1h 20' 00"	0.344	AT502	Pole

Station No.		*Start date & time*	*End date & time*	*Duration*		*Height*	*Setup*
183	42	09/23/2010 10:03:51	09/23/2010 11:13:56	1h 10' 05"	0.344	AT502	Pole
184	58	09/23/2010 12:07:21	09/23/2010 12:28:16	20' 55"	0.417	AT502	Tripod
185	2	09/24/2010 06:24:46	09/24/2010 14:52:51	8h 28' 05"	0.344	AT502	Pole
186	63	09/24/2010 12:51:01	09/24/2010 14:26:56	1h 35' 55"	0.344	AT502	Pole
187	25	09/24/2010 13:29:01	09/24/2010 13:52:26	23' 25"	0.344	AT502	Pole
188	2	09/25/2010 06:41:21	09/25/2010 15:41:26	9h 00' 05"	0.344	AT502	Pole
189	2	09/26/2010 06:29:16	09/26/2010 16:48:46	10h 19' 30"	0.344	AT502	Pole
190	2	09/27/2010 06:47:46	09/27/2010 13:38:51	6h 51' 05"	0.344	AT502	Pole
191	3	09/28/2010 06:27:56	09/28/2010 16:25:11	9h 57' 15"	0.344	AT502	Pole
192	67	09/29/2010 07:18:26	09/29/2010 14:39:11	7h 20' 45"	1.380	AT502	Tripod
193	4	09/29/2010 07:59:51	09/29/2010 17:24:36	9h 24' 45"	0.344	AT502	Pole
194	44	09/29/2010 08:30:41	09/29/2010 13:55:51	5h 25' 10"	0.344	AT502	Pole
195	79	09/29/2010 09:12:41	09/29/2010 12:20:06	3h 07' 25"	1.221	AT502	Tripod
196	48	09/29/2010 10:00:06	09/29/2010 13:03:21	3h 03' 15"	0.344	AT502	Pole
197	5	09/30/2010 06:29:21	09/30/2010 16:06:21	9h 37' 00"	0.344	AT502	Pole
198	63	09/30/2010 06:52:56	09/30/2010 15:46:11	8h 53' 15"	0.344	AT502	Pole
199	89	09/30/2010 07:06:51	09/30/2010 15:35:16	8h 28' 25"	0.344	AT502	Pole
200	61	09/30/2010 07:25:36	09/30/2010 15:20:31	7h 54' 55"	0.344	AT502	Pole
201	86	09/30/2010 07:43:21	09/30/2010 15:07:01	7h 23' 40"	0.344	AT502	Pole
202	6	10/01/2010 06:28	10/01/2010 15:58	9h 30' 25"	0.344	AT502	Pole
203	86	10/01/2010 07:18	10/01/2010 15:07	7h 49' 00"	0.344	AT502	Pole
204	43	10/01/2010 11:14	10/01/2010 12:51	1h 37' 00"	1.014	AT502	Tripod

NERC GEF

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