The Aurora 1989

R. J. Livesey

This report summarizes observations of the aurora collected in 1989 from members and correspondents of the Aurora Section.

A report of the Aurora Section *Director R. J. Livesey*

Observers

Land observers

Abbott, Adam, Andersen, Anderson, Arnott, Aszódy, Barbour, Basingthwaighte, Baum, Bilbe, Bishop, Blandford, Bone, Bonsor, Boschat, Boyko, Brausch, Brill, Buscinski, Cartwright, Chambers, Chaplain, Collins, Cooper, Davies A. R., Davies H. J., Dempster, Dougherty, Dunlop, Duthie, Eberst, Eddy, Ellis, Ferrier, Fletcher, Ford, Francis, Fraser J., Fraser K., Fraser R., Frydman, Gash, Gavine, Gélinas, Girard, Graham, Green, Greenward, Ham, Hands, Hansen, Hapwood, Hardgrave, Hartridge, Hatch, Hay, Haymes, Healy, Heath, Hedger, Heely, Henriksen, Hirsch, Hopwood, Hukkanen, Ingram, Irons, Jääskelainen, Jahn, Jones, Jyuäskylä, Kaila, Kaposuar, Kelly, Kiernan, Kinnunen, Könnyü, Koscien, Kota, Lang, Laukkanen, Lenham, Leslie, Lewis, Livesey R., Livesey T., Livingstone, Lockley, Lohvinenko, Lubbock, Luukkonen, Macnicholl, Magiorosi, Makela, Markham, Martin, McBeath, McCall, McDowall, McEwan, McWilliam, Middlemist, Miles D., Miles H., Miszer, Mitton, Moffat, Mogyorosi, Molnar, Morrison, Moseley, Murphy, Murray, Nightingale, Northcott, Olesen, Oliver, O'Neill, Panther, Papp, Paterson, Pearce, Pekkola, Pettitt, Phillips, Powell, Quinn, Rajala, Ramsay, Reid, Relf, Ropeleswki, Ruonala, Ruoskanen, Rutherford, Salaman, Scollay, Shepherd, Sidney, Simmons, Smith, Smithies, Spalding, Stapleton, Steele, Steven, Strickland, Swan, Szalma, Szarka, Szöllösi, Taylor, Thompson, Tweddle, Vincent, Waldron, Ward, Waterman, Wayne, Webberley, Weiszt, West, Whipps, Wikholm, Willmott, Woodin, Young, Zselye.

Land observing groups

Junior Astronomical Society Aurora Section, Norwegian Astronomical Society Solar Section, Royal New Zealand Astronomical Society Aurora Section, The Astronomer Aurora Observers, Ursa Astronomical Society, Aurora Section, of Finland.

British merchant ships, weathership, fishery protection vessels and research ships

Act 7, Alliance, Atlantic Link, Auckland Star, Authenticity, Baltic Link, Blue Stream, British Ranger, Canmore Europe, Canopus, Charles Darwin, City of Edinburgh, City of Manchester, Corystes, Cumulus, Direct Key, English Star, Esso Fife, Fleetwave, Ironbridge, John Biscoe, Lackenby, Lampas, Liverpool Star, London Spirit, Luminetta, Matco Clyde, Maersk Commando, Mount Eland, Norna, Norrisia, OOCL Challenge, Remuerra Bay, Resolution Bay, Scamper Universal, Scottish Star, Selectivity, Sentis, Shetland Service, Snowdon, Sulisker, Union Endevour, Vigilant, Westra.

Magnetic observers

Hawkins, Hopwood, Lewis, Livesey, Owen, Pettitt, Smillie, Soper, Wright.

Radio aurora observers and data reporters

Ham, Hopwood, Hunter, Smillie, Stapleton, Steven.

Professional datas centres

Academy of Athens, French National Institute for Space Sciences at St Maur des Fosses, Geomagnetism Research Unit of the British Geological Survey at Edinburgh, The Institute for Geophysics at Göttingen, NOAA Environmental Laboratories at Boulder, The Rutherford Appleton Laboratory at Chilton.

The observations

The distribution of visual auroral observations received is shown in Table 1. The code denoting the regions of observation and the code indicating the maximum auroral activity in each region are given in the notes to Table 1. The date given is the date of commencement and termination of the night of the aurora. The daily magnetic index Ap is given for the previous day, the day of commencement and day of termination of the auroral night. The minimum geomagnetic latitude at which the aurora was seen anywhere and also in the UK are also given. The high frequency with which the aurora is seen in North Dakota by Jay Brausch has influenced the frequency with which maglat 57° appears in the record, while in the latter end of the year, some observations from around maglat 45° in Hungary recorded the mid-Europe red aurora.

In Table 2 are listed the dates on which the planetary magnetic index averaged a value of 5 or more during any 3-hour period in the 24-hour day. This is an index of disturbance to the geomagnetic field. In Table 3 are

Table 1. Reported location and maximum strength of auroral activity in the northern hemisphere in 1989.

Date of event night	*No. of observers*	*Geomagnetic index Ap on day*			*Location and maximum strength of aurora*	*Minimum geomagnetic latitude*	
		Before	*Start*	*Finish*		*Total*	*UK only*
Jan 3/4	2	6	4	9	NS(1), F(2)		60
4/5	6	4	9	33	ND(5), S(5), E(4)	56	56
5/6	8	9	33	10	L(5), NS(5), F(3)		60
6/7	1	33	10	10	NS(2)		62
8/9	3	10	17	16	L(1), NS(5)		61
9/10	1	17	16	12	NS(1)		61
10/11	1	16	12	37	L(1)		63
11/12	16	12	37	20	ND(5), NS(5), F(5)	57	60
12/13	2	37	20	11	NS(1)		61
13/14	2	20	11	14	NS(5)		61
15/16	9	14	38	43	S(5), F(5)	57	59
16/17	12	38	43	28	S(5), F(5)	57	59
17/18	2	43	28	15	ND(3), K(5)	57	61
20/21	2	7	45	28	F(4)	60	–
21/22	1	45	28	30	NS(5)		61
27/28	1	10	12	13	ND(4)	57	–
28/29	2	12	13	10	F(4)		60
29/30	1	13	10	12	ND(4)	57	–
30/31	2	10	12	32	NS(4)		60
31/01	10	12	32	29	ND(5), L(2), NS(5)	57	60
Feb 1/2	14	32	29	21	ND(5), S(6)	57	59
2/3	12	29	21	44	ND(1), W(1), S(5)	57	57
3/4	7	21	44	24	ND(4), NS(5), F(4)	57	61
4/5	3	44	24	22	ND(1), NS(1)	57	61
5/6	4	24	22	23	NS(4), F(5)	57	60
6/7	2	22	23	25	ND(1), F(4)	57	61
7/8	5	23	25	14	ND(4), NS(2), F(4)	57	60
8/9	2	25	14	19	ND(4), NS(2)	57	61
9/10	4	14	19	21	ND(4), L(1), F(5)	57	61
11/12	6	12	10	14	ND(4), NS(2), F(4)	57	60
12/13	1	10	14	21	NS(4)		62
15/16	2	14	14	17	S(4)		59
16/17	2	14	17	5	NS(4), F(4)		60
20/21	2	9	21	11	W(1), F(3)		61
28/01	1	6	13	12	L(1)		63
Mar 1/2	1	13	12	25	NS(1)		61
2/3	2	12	25	37	W(5), L(1)		63
3/4	3	25	37	13	L(1), NS(1)		61
4/5	1	37	13	30	NS(2)		61
5/6	1	13	30	24	L(1)		63
6/7	4	30	24	18	L(1), NS(3), F(4)		61
7/8	1	24	18	24	L(1)		63
8/9	14	18	24	31	S(6)		59
9/10	6	24	31	19	L(1), S(5)		59
10/11	2	31	19	17	NS(5)		61

Table continues on next page

Notes to Table 1

Maximum auroral activity at given location

1 Glow or unspecified auroral light or patch.
2 Homogenious arc or homogenious band.
3 Rayed arc or rayed band or rayed veil.
4 Ray bundles.
5 Active forms, pulsating or flickering light.
6 Coronal rayed structures at magnetic zenith.
7 All sky auroral coverage.

Planetery index Ap

Gives measure of magnetic disturbance on day preceding, day of commencement and day of end of aurorally active night.
Ap 0–10 Quiet
10–20 Minor storm
20–50 Storm
50–80 Severe storm
80–400 increasingly very severe storm

Locations at which aurora observed

C	Canada	**NA**	North Atlantic
DT	Detroit	**NE**	North England
E	England	**NM**	North America
F	Finland	**NS**	North Scotland
H	Hungary	**Q**	Quebec
HNS	Halifax, Nova Scotia	**S**	Scotland
IR	Ireland	**W**	Winnipeg
L	Weatherstation Lima		

Geomagnetic latitude
Most southerly geomagnetic latitude at which aurora seen
Total = All observations if less than UK
UK only = Great Britain and Irish observations.

Table 1 continued

Date of event night	*No. of observers*	*Geomagnetic index Ap on day*			*Location and maximum strength of aurora*	*Minimum geomagnetic latitude*	
		Before	*Start*	*Finish*		*Total*	*UK only*
Mar 11/12	5	19	17	23	L(1), S(3)		59
12/13	4	17	23	246	NA(6), IR(1), NS(2), F(4)		57
13/14	116	23	246	158	C(4), HNS(7), DT(4), S(7), E(7), Fr(4), Caribbean(4)	15	54
14/15	11	246	158	49	IR(4), L(6), NS(7), DM(4), S(4)	56	56
15/16	1	158	49	50	S(4)	59	
16/17	5	49	50	34	W(6), S(5), F(3)		59
20/21	1	55	14	22	NS(4)		61
22/23	3	22	39	36	NS(5)		61
24/25	2	36	16	10	L(2), NS(1)		62
25/26	4	16	10	14	NS(5), F(6)		61
26/27	2	10	14	44	NS(5)		61
27/28	4	14	44	39	F(4)	57	–
28/29	7	44	39	71	S(5), F(5)		59
29/30	5	39	71	47	S(6), F(5)	57	59
30/31	14	71	47	52	W(6), S(5), F(6)	57	59
31/01	14	47	52	42	L(1), S(5), F(6)		58
Apr 1/2	6	52	42	26	ND(3), L(1), NS(5), F(6)	57	61
2/3	5	42	26	21	NA(1), L(1), F(6)		61
3/4	13	26	21	46	ND(4), S(5), F(6)	57	59
4/5	10	21	46	42	ND(3), W(6), S(4), F(6)	57	59
5/6	2	46	42	14	F(5)		61
6/7	3	42	14	27	NS(1), F(4)		61
7/8	4	14	27	20	ND(3), L(1), E(5)		56
8/9	1	27	20	15	NS(2)		61
10/11	1	15	8	14	NS(1)		61
12/13	1	14	6	17	ND(1)	57	–
14/15	5	17	24	27	ND(5), W(6), IR(4), S(5)	57	57
16/17	2	27	20	10	S(3), F(6)		59
17/18	1	20	10	10	F(4)	61	–
22/23	12	7	7	12	NA(5)		66
23/24	2	7	12	8	S(2)		59
24/25	5	12	8	34	S(4)		59
25/26	25	8	34	78	IR(4), S(6), E(5), F(6), W(6)		54
26/27	7	34	76	49	W(1), IR(4), S(6)		57
27/28	9	76	49	39	W(6), IR(5), S(5)		57
28/29	2	49	39	28	ND(5), L(1)	57	63
29/30	2	39	28	17	ND(1), NS(1)	57	61
May 1/2	1	17	10	18	W(5)		59
2/3	1	10	18	12	NS(1)		61
3/4	1	18	12	20	NS(2)		61
4/5	5	12	20	44	ND(5), L(1), S(5)	57	59
5/6	4	20	44	14	ND(4), W(5), L(1), NS(1)	57	59
6/7	1	44	14	46	ND(5)	57	–
22/23	1	8	12	47	ND(4)	57	–
24/25	1	47	68	24	ND(5)	57	–
26/27	1	24	17	16	W(5)	59	–
31/01	1	9	13	11	ND(1)	57	–
Jun 1/2	1	13	11	19	ND(1)	57	–
2/3	1	11	19	14	W(6)	59	–
Jun 6/7	1	7	11	34	ND(5)	57	–
7/8	2	11	34	23	ND(3), W(5)	57	–
8/9	1	34	23	34	ND(3)	57	–
9/10	2	23	34	78	ND(5), W(6)	57	–
13/14	2	12	16	50	ND(4), W(6)	57	–
14/15	1	16	50	37	ND(5)	57	–
21/22	1	28	4	5	HNS(2)	57	–
28/29	1	6	7	13	ND(4)	57	–
29/30	1	7	13	10	ND(4)	57	–
Jul 5/6	1	3	15	11	ND(1)	57	–
6/7	1	15	11	8	ND(5)	57	–
9/10	1	4	6	11	NS(6)		61
12/13	1	4	3	7	ND(5)	57	–
13/14	1	3	7	4	NS(2)		61
15/16	1	4	6	2	NS(2)		61
Aug 1/2	1	4	6	6	ND(5)	57	–
2/3	1	6	6	5	ND(3)	57	–

Table continues on next page

Table 1 continued

Date of event night	*No. of observers*	*Geomagnetic index Ap on day*			*Location and maximum strength of aurora*	*Minimum geomagnetic latitude*	
		Before	*Start*	*Finish*		*Total*	*UK only*
Aug 4/5	1	5	8	2	L(1)		63
5/6	2	8	2	8	L(1), NS(1)		61
7/8	1	8	9	7	ND(1)	57	–
8/9	1	9	7	10	L(1)		63
9/10	8	7	10	41	ND(1), Q(4), W(7), S(5), F(2)	57	59
10/11	2	10	41	25	ND(1), L(4)	57	63
11/12	3	41	25	8	ND(5), L(1), NS(4)	57	61
12/13	2	25	8	9	ND(5), L(1)	57	63
14/15	10	9	55	77	ND(5), W(7), L(4), IR(5), S(6), E(5)	57	58
15/16	8	55	77	26	S(5), NE(4), F(6)		58
16/17	2	77	26	34	NS(2)		61
19/20	1	29	14	26	ND(1)	57	–
21/22	2	26	21	12	ND(3), F(6)	57	62
22/23	1	21	12	28	ND(5)	57	–
23/24	3	12	28	6	NS(5)		61
24/25	1	28	6	5	NS(1)		61
25/26	3	6	5	6	ND(3), NS(1)	57	61
26/27	2	5	6	26	ND(5), S(2)	57	61
27/28	9	6	26	22	S(5), NE(5)		58
28/29	12	26	22	28	ND(6), HNS(4), S(6), DM(4)		56
29/30	4	22	58	17	ND(5), W(2), NS(1)	57	59
31/01	2	17	6	8	NS(1), F(5)		60
Sep 3/4	4	8	8	30	ND(3), DT(5), Q(4), E(4)	54	56
4/5	4	8	30	21	ND(5), W(5), S(1), F(3)	57	59
5/6	1	30	21	12	F(2)		62
6/7	1	21	12	22	NS(1)		61
7/8	2	12	22	16	ND(3), F(2)	57	62
8/9	1	22	16	11	F(6)		62
9/10	3	16	11	10	ND(3), W(5), F(6)	57	59
11/12	1	10	3	12	ND(4)	57	–
13/14	1	12	9	5	ND(3)	57	–
15/16	6	5	42	24	ND(6), S(6)	57	59
17/18	2	24	7	52	ND(5), IR(6)	57	57
Sep 18/19	19	7	52	70	ND(6), DT(6), IR(6), S(7), E(3), F(6)	57	57
20/21	1	70	6	8	NS(1)		61
21/22	1	6	8	23	ND(3)	57	–
22/23	6	8	23	4	S(4), F(5)	57	61
24/25	1	4	7	5	NA(3)	57	–
25/26	2	7	5	54	ND(3), W(6)	57	–
26/27	19	5	54	8	ND(5), S(7), E(7), DM(6), F(4)		55
27/28	2	54	8	8	S(5), F(4)	59	61
28/29	1	8	8	8	NS(1)		61
29/30	1	8	8	12	ND(1)	57	–
30/01	8	8	12	13	ND(5), S(4)	57	59
Oct 2/3	1	13	9	12	ND(1)	57	–
3/4	3	9	12	6	ND(1), W(5), NA(2)	57	59
4/5	4	12	6	5	F(7)	58	–
5/6	3	6	5	10	ND(4), F(4)	57	–
6/7	6	5	10	12	ND(4), IR(1), 5(1), S(1), F(5)	57	57
7/8	3	10	12	9	NS(3), F(6)	59	61
8/9	1	12	9	11	NS(3)		61
12/13	1	7	8	1	NS(1)		61
16/17	1	4	10	12	ND(5)	57	–
17/18	1	10	12	17	ND(3)	57	–
18/19	1	12	17	24	ND(5)	57	–
19/20	1	17	24	112	ND(5)	57	–
20/21	21	24	112	146	ND(5), W(7), S(7), D(7), H(4)	46	55
21/22	36	112	146	51	ND(5), S(7), E(5)		55
22/23	21	146	51	22	ND(5), S(4), E(1), F(4), L(1)	57	56
23/24	4	51	22	17	ND(5), NS(5)	57	61
24/25	5	22	17	23	ND(5), NA(1), L(1), NS(1), F(5)	57	59
25/26	5	17	23	24	HNS(2), NA(3), NS(5)	56	61
26/27	15	23	24	17	L(4), NS(6), S(4), F(5)	57	59
27/28	1	24	17	9	F(4)	59	–
29/30	3	9	13	23	ND(5), W(3), NS(1)	57	61
30/31	3	13	23	14	ND(5), NS(1)	57	61
31/01	1	23	14	8	NS(1)		61

Table continues on next page

Table 1 continued

Date of event night	No. of observers	Geomagnetic index Ap on day Before	Start	Finish	Location and maximum strength of aurora	Minimum geomagnetic latitude Total	UK only
Nov 1/2	4	14	8	21	NS(3), S(1)		59
2/3	6	8	21	26	NS(5), S(4), E(4)		59
3/4	3	21	26	28	L(1), NS(1) E(4)		59
4/5	7	26	28	19	S(4)		59
5/6	6	28	19	11	ND(1), NS(4), S(3)	57	59
6/7	3	19	11	19	ND(5), L(1), E(1)	57	58
7/8	2	11	19	15	NS(2)		61
8/9	3	19	15	25	S(2)		59
17/18	25	5	109	45	ND(4), W(3), HNS(6), IR(4), S(6), E(6), D(7), H(6), F(3)	46	52
23/24	1	6	6	8	NS(1)		61
24/25	4	6	8	2	NS(1), H(3)	46	61
25/26	2	8	2	11	L(1), NS(1)		61
26/27	13	2	11	16	S(4), H(1)	46	59
27/28	2	11	16	28	ND(1), NS(1)	57	61
28/29	3	16	28	19	ND(1), NS(3)	57	60
29/30	5	28	19	20	ND(3), NS(5)	57	61
Nov 30/01	1	19	20	38	ND(5)	57	–
Dec 1/2	10	20	38	22	ND(5), S(5), E(5)	54	57
2/3	2	38	22	26	L(1), SE(1)		54
3/4	1	22	26	31	ND(1)	57	–
4/5	3	26	31	14	IR(1), E(4), D(4)		55
5/6	1	31	14	5	NS(1)		61
7/8	1	5	10	6	L(1)		63
14/15	2	7	12	10	S(2), E(1)		55
17/18	1	16	11	7	NE(2)		57
18/19	1	11	7	6	NS(1)		61
21/22	2	6	8	26	ND(1), NS(1)	57	61
22/23	5	8	26	15	ND(4), S(2)	57	59
24/25	1	15	20	16	ND(5)	57	–
26/27	9	16	22	25	ND(5), S(5)	57	59
27/28	6	22	25	10	ND(1), S(5)	57	59
28/29	1	25	10	50	NS(7)		61
29/30	5	10	50	30	L(4), NS(7), H(4)	47	60
30/31	1	50	30	35	ND(5)	57	–
31/01	1	30	35	16	ND(5)	57	–

Table 2. Dates on which the planetary magnetic index Kp equalled or exceeded 5 in any period of 3 hours in the 24-hour day.

Jan	5, 11, 15, 16, 17, 20, 22, 31
Feb	1, 2, 3
Mar	2, 3, 5, 8, 9, 12, 13, 14, 15, 16, 17, 18, 19, 22, 23, 24, 27, 28, 29, 30, 31
Apr	1, 2, 4, 5, 14, 15, 16, 25, 26, 27, 28, 29
May	4, 5, 7, 23, 24
Jun	4, 7, 8, 9, 10, 14, 15, 20
Jul	1
Aug	10, 11, 14, 15, 16, 17, 18, 20, 21, 23, 27, 28, 29
Sep	4, 5, 7, 15, 16, 18, 19, 26
Oct	19, 20, 21, 22, 23, 25, 26
Nov	2, 4, 8, 9, 13, 17, 18, 27
Dec	1, 4, 5, 22, 26, 29, 31

Table 3. Dates on which storm sudden commencements took place.

Jan	4, 5, 11, 20
Feb	–
Mar	2, 8, 13, 16, 19, 26, 27
Apr	11, 13
May	5, 7, 23
Jun	6, 8, 13
Jul	1, 17
Aug	9, 10, 14, 21, 23, 27
Sep	4, 7, 14, 18, 30
Oct	18, 20, 26
Nov	1, 8, 9, 11, 17, 27
Dec	1, 22, 29

listed the days on which a storm sudden commencement (SSC) took place, that is to say, the Earth's magnetic field was impacted by a shock wave in the solar wind. An SSC of itself does not necessarily generate visible aurora. Table 4 lists the magnetic storms themselves. Table 5 gives the dates upon which radio operators have reported radio auroral effects, principally on 50 and 144 MHz wavebands. Again, radio and visible auroral events do not necessarily coincide.

Figure 1 gives the calculated frequency, based on observations in the region of Britain, with which aurora could have been seen at the various geomagnetic latitudes given clear skies. Figure 2 is the Bartels Diagram for 1989 in which the dates of visible aurora, magnetic disturbances and radio aurora events have been plotted. The horizontal lines of 27 days each represent one revolution of the Sun such that recurrent activity on the Sun will generate geomagnetic activity on dates one below the other on the diagram.

There was considerable activity during 1989 of which

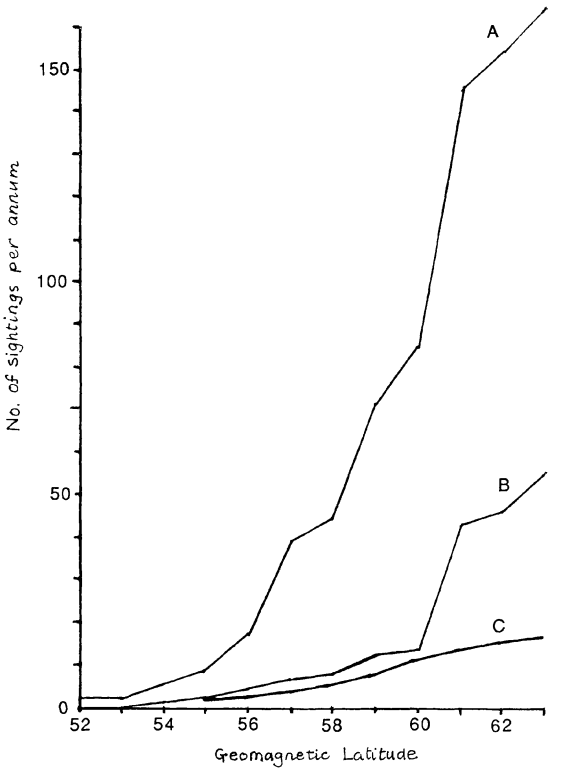

Figure 1. The visibility of aurorae in NW Europe during 1989. Number of sightings per annum is plotted as a function of geomagnetic latitude. A: all aurorae; B: quiet glows and arcs only; C: corona structures overhead in UK.

the great storm of 13/14 March was the climax. This enabled many people to see their first aurora in southern England. Such has been the interest generated that the number of reports received has been greatly increased. To put the data into perspective, the annual frequency of geomagnetic activity, which is not biased by the availability of observers and the effects of cloud cover, is compared with the calculated annual frequency of auroral events for the period since 1977. It will be evident that the 1989 was perhaps not as active in low latitude storms as might have been expected.

The Great Storm of 13/14 March

Figure 3 shows the reported limit of visibility of the aurora obtained from ships and land observers in each hemisphere. The aurora (Figure 4) spread all over the British Isles and, at certain times, northern observers were turning south to see the show. Figure 5 is a time-latitude diagram of selected observations, and indicates the spread of the aurora over Britain. The cloud cover was variable at times. A spectacular set of drawings was received from Bob Stuart of Maes Mawr indicating overhead corona superimposed on a red east-to-west band. The rays were red at the top, some yellow, green in the middle with blue along the horizon. Many photographs were obtained by a variety of observers,

Table 4. Dates on which magnetic storms were recorded.

Jan	**11**, 15, **20**, 22, 31
Feb	1, 2, 3
Mar	2, 3, 5, 8, ***13***, ***14***, **15**, **16**, 17, 18, **19**, 22, 23, **27**, 28, **29**, **30**, 31
Apr	1, **4**, 14, 25, **26**, 27
May	**5**, 7, **23**, **24**
Jun	7, 8, **9**, **10**, 14
Jul	1
Aug	10, 11, **14**, **15**, 16, 17, 27, ***29***, 30
Sep	4, 5, 7, **15**, 16, **18**, **19**, **26**
Oct	19, ***20***, ***21***, **22**, 23
Nov	13, ***17***, **18**
Dec	1, 4, 5, 22, **29**, 31

Dates in normal type, planetary index between 5 and 6 maximum. Storm.
Dates in bold type, planetary index between 6 and 8 maximum. Severe storm.
Dates in italic bold type, planetary index in excess of 8 at maximum. Very severe storm.

many of whom were producing good pictures of the event on sighting their first ever aurora.

Observers agree that the great March aurora was in fact not as bright or as sharp as some of the later aurorae during the course of the Spring, that did not spread nor were seen so widely.

In Figure 6 is a recording of a German radio beacon transmitting on VHF which was received by Doug Smillie at Wishaw after the signals had been backscattered by the auroral ionization. The distortion of the morse signals illustrates the complexity of the auroral ionisation that imposes mutual interference on the received signal due to various backscatter paths from different parts of the ion clouds.

Discussion

Figure 7 compares the trends in auroral and magnetic activity reported since the current observing network was developed in 1976. From 1986 the change in ratios between the frequencies of auroral detection at geomagnetic latitudes 59, 60 and 61 degrees north could indicate a change in auroral activity but is more likely to reveal a change in auroral observing efficiency due to the increased number of good observers in north Scotland. Visual observations are subjective in that they are dependent upon the availability of observers and sufficiently cloud-free sky conditions. Magnetic observations used in this analysis are based on permanent observatories and thus not affected by these factors.

The trends show the current build up of auroral and magnetic activity in the present sunspot cycle. Very severe magnetic and auroral storms occur randomly through the previous and present sunspot cycles. Observers will recall the big aurora of 8/9 February 1986. Storm sudden commencements appear to relate better to the sunspot cycle than the aurorae; SSCs are not necessarily followed by an aurora. The extent of activity in the declining years of the previous sunspot cycle is apparent.

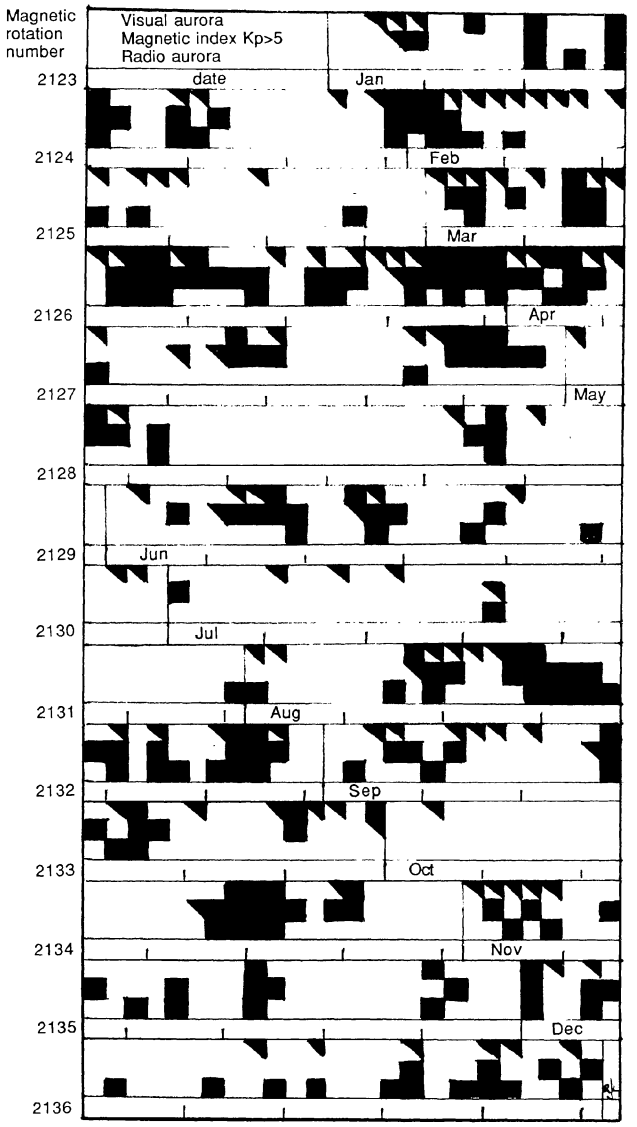

Figure 2. Bartels diagram for 1989.

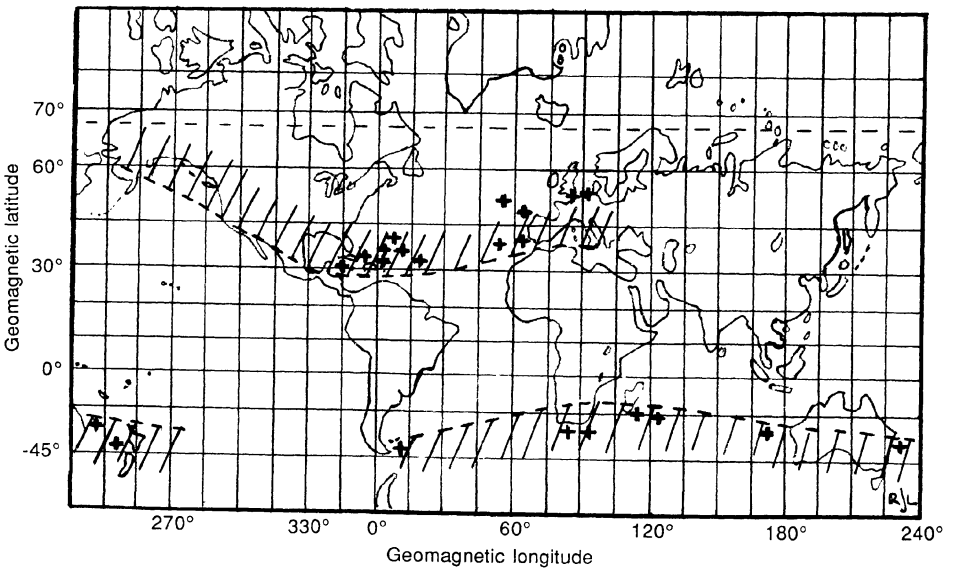

Figure 3. Known limits of auroral visibility as reported by observers on 13/14 March 1989. (+ = ship observations).

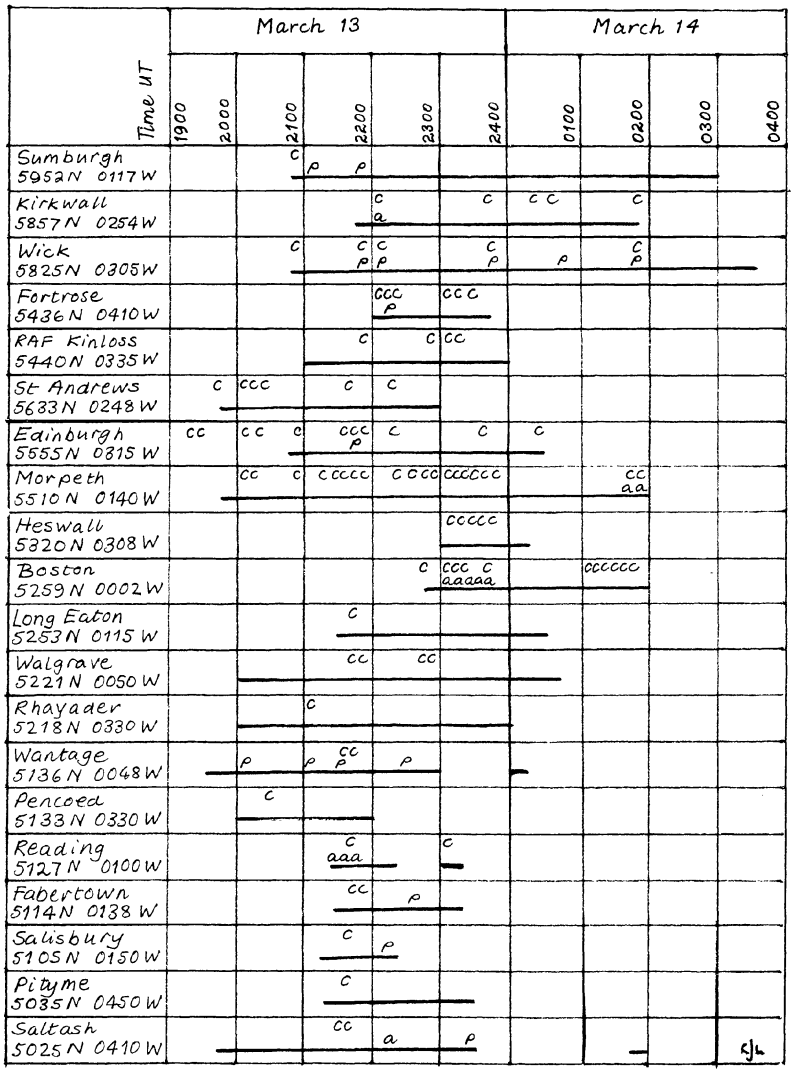

Figure 4. The aurora of 1989 March 13/14 photographed by B. Koscien of Evreux, France.

Figure 5. The great aurora of 1989 March 13/14. A selection from over 90 reports showing the location and time of overhead coronal structures. *Key:* – = extent of observations, **c** = corona, **a** = active, **p** = pulsating.

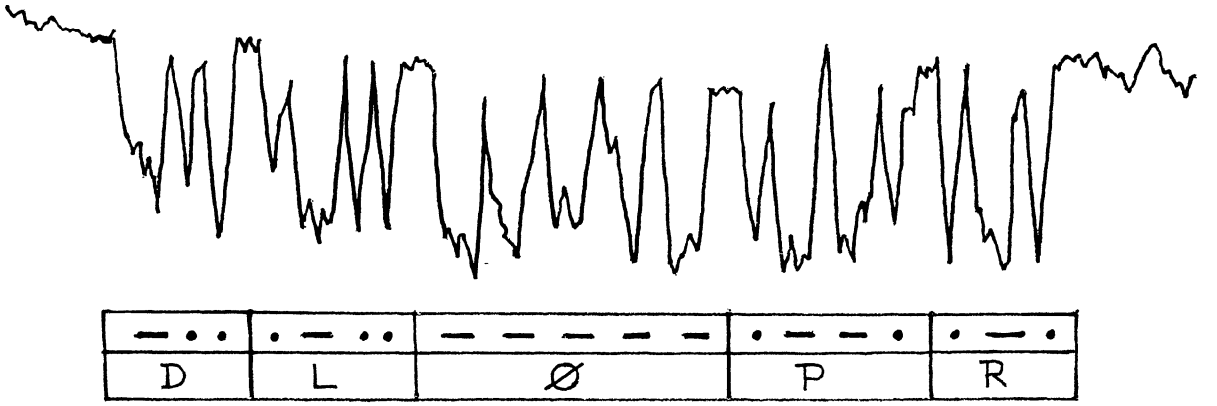

Figure 6. A record of the German radio beacon DLOPR, 144.910 MHz, 13 March 1989, received via auroral scatter by D. J. Smillie, GM4DJS at Wishaw, Lanarkshire. The uneven character, shape and amplitude is due to variation in the depth of the ionized layers in the auroral zone.

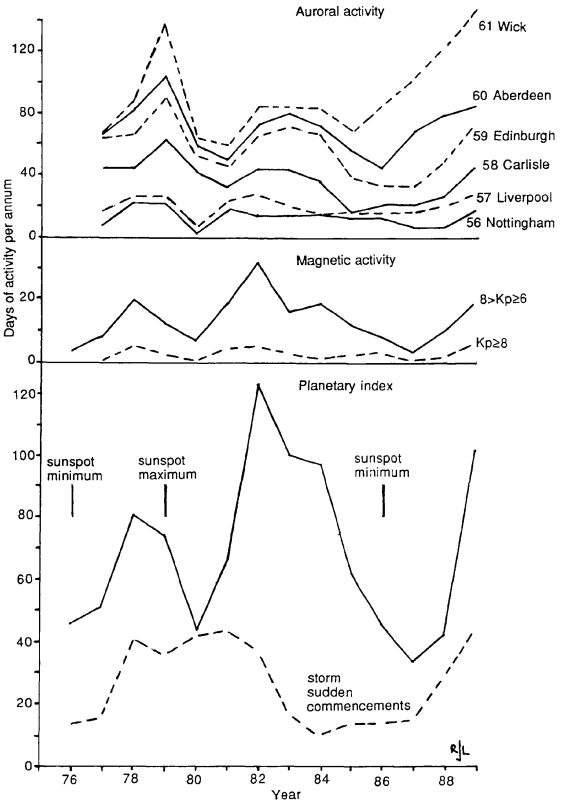

Figure 7. Auroral activity, magnetic activity and the planetary index (Kp), 1976–89. The curves for auroral activity (top) are labelled with geomagnetic latitude and typical geographical location.

Table 5. Dates on which radio operators reported aurora propagation phenomena.

Jan	11, 13, 15, 16, 20, 21, 31
Feb	2, 3, 4, 6, 12, 14, 25
Mar	3, 8, 9, 12, 13, 14, 19. 22, 23, 27, 29, 31
Apr	3, 4, 7, 23
May	7, 24
Jun	10, 14, 19, 25
Jul	17, 31
Aug	1, 8, 10, 15, 16, 17, 18, 19, 21, 23, 24, 26, 27, 28
Sep	2, 6, 15, 17, 18, 19, 26
Oct	19, 20, 21, 22
Nov	3, 5, 11, 13, 17, 26
Dec	1, 4, 7, 12, 15, 17, 21, 22, 24, 26, 27, 30

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