REPORT UAG-69

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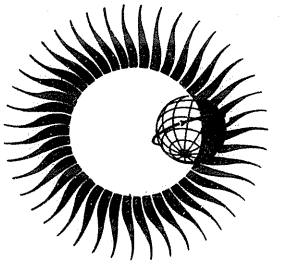
for
Solar-Terrestrial Physics

SELECTED DISTURBED D-REGION ELECTRON DENSITY PROFILES

Their relation to the undisturbed D-region



OCTOBER 1978

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WORLD DATA CENTER A
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REPORT UAG-69

SELECTED DISTURBED D-REGION ELECTRON DENSITY PROFILES

Their relation to the undisturbed D-region

by

L.F. McNamara
Ionospheric Prediction Service
Sydney, Australia

OCTOBER 1978

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SELECTED DISTURBED D-REGION ELECTRON DENSITY PROFILES
Their relation to the undisturbed D region

by

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Sydney, Australia*

ABSTRACT. A large collection of experimental D-region electron density profiles has been searched to find those profiles obtained under disturbed conditions, such as eclipses and solar flares. Where possible, each disturbed profile has been associated with a suitable reference profile corresponding to the undisturbed ionosphere, in order to determine the effect of the particular kind of disturbance. A model electron density profile corresponding to the undisturbed ionosphere has also been calculated in each case, and may be used as a reference profile when no suitable experimental profile is available. All profiles have been plotted in a self-evident format which makes it easy to see the effect of the disturbance considered.

Method

This report presents a collection of observed and model D-region electron density profiles that is designed to illustrate the effects on the profiles of various kinds of phenomena. Detailed descriptions of the phenomena are not given because these are available either in standard texts or in the journal articles from which the profiles have been extracted. The main emphasis is one of illustrating the effects on the profile of the different phenomena. References are given in Part III of McNamara [1978].

All observed profiles have been extracted by computer from the D-region electron density data base established by McNamara [1978], using the "special case parameter" associated with each profile. These parameters and the associated physical phenomena are listed in Table 1.

Table 1. Phenomena Corresponding to the "Special Case" Parameter.

Parameter	Physical Description
1	Solar eclipse
2	Solar flare
3	Solar X-ray event
4	Sudden ionospheric disturbance
5	Winter anomaly day
6	Mid-latitude particle precipitation
7	Solar proton event/solar cosmic ray event
8	Polar cap absorption
9	Auroral absorption
10	Daytime absorption event
11	Polar substorm
12	Polar radio blackout
13	Auroral arc conditions

NOTE: The descriptions are those given by the individual authors and some are equivalent or have the same causal mechanism.

Each of the observed profiles has associated with it a model profile derived from all undisturbed profiles in the complete data base [McNamara, 1979]. Many of the profiles also have associated with them a reference profile corresponding to the undisturbed ionosphere and one usually observed just before or just after the event in question.

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*Guest worker at World Data Center A for Solar-Terrestrial Physics, NOAA, Boulder, Colorado.

Consideration of each of the following diagrams must include the suitability of the reference profile and the error bars associated with each of the observed, reference and model profiles, as well as the effect of the phenomena being considered. The error bars have been discussed by McNamara [1978; 1979]. A reasonable and simple estimate is ± 0.5 in $\log_{10} N$, or $\pm 1/2$ division along the X axis of each diagram. This corresponds to a factor of 3 in density. Differences between profiles which are less than this value cannot be classed as "real". On some occasions, the model profile will agree better with the disturbed profile than with the undisturbed one. Under these circumstances the model profile should be ignored. Such failures of the model are only to be expected, especially when the differences between profiles are of the order of the error bar.

The first figure may be used to illustrate the presentation of the data. In general, there will be three profiles: an observed (disturbed) profile (O), a reference profile (R), and a model profile (M). In some cases, no suitable reference profile was available in the data base, so the observed profile can be compared only with the model profile. The reliability of the model profile is thus an important consideration.

Each observed or reference profile is identified by a unique three-digit curve identification number. In the first figure these are 947 and 948, respectively. These numbers are sufficient to extract the corresponding data from the computer files DB1 and DB3, which comprise part of the data base [McNamara, 1978], including the parameters listed at the top of the figure. These parameters give the relevant conditions of the experiment--the year, month, day, local time, monthly average sunspot number, latitude and longitude of the observing station, method of observation, and a magnetic index. The METH parameter may assume one of the following five values: (1) partial reflection; (2) rocket; (3) wave interaction; (4) LF-VLF reflection; and (5) other, e.g., incoherent scatter. The magnetic index MAG is 1 for magnetically quiet days (approximately Ap ≤ 25) and 2 for disturbed days. The parameter REF is a literature reference number, which may be used to find the corresponding journal or report reference in the computer file DB2 of the data base or in Part III of McNamara [1978]. The figure number FIG is the figure number in that reference.

The last parameter in each line is SPC, the special case parameter described in Table 1. It is zero for the reference profile. The model profile is calculated using the year, month, day, local time, sunspot number, latitude and longitude corresponding to the observed profile. The model for magnetically quiet days differs slightly from that for magnetically disturbed days. It is most likely to fail at night and at high latitudes, because the data base includes fewer undisturbed nighttime, high-latitude profiles than daytime mid- and low-latitude profiles.

The computer program DISPPLT used to prepare the data for plotting is listed in Appendix A. The actual plots were made using the software package of the Integrated Software Systems Corporation called "DISPLAA" and the program DREGPLT listed in Appendix B.

Some of the phenomena corresponding to different special case parameters have in fact the same causal mechanism. The associated plots have therefore been grouped together and described by the causal mechanism. Thus solar flare (2), solar x-ray event (3) and sudden ionospheric disturbance (4) are grouped under solar x-ray event; solar proton event (7), polar cap absorption (8) and polar radio blackout (12) are grouped under solar proton event.

Not all available plots are included, since some are very similar to each other and contain no further useful information. In some cases, consecutive plots show the time development of the event.

Acknowledgment

The plotting program DREGPLT was written and run by Marcus O. Ertle, NOAA/EDIS.

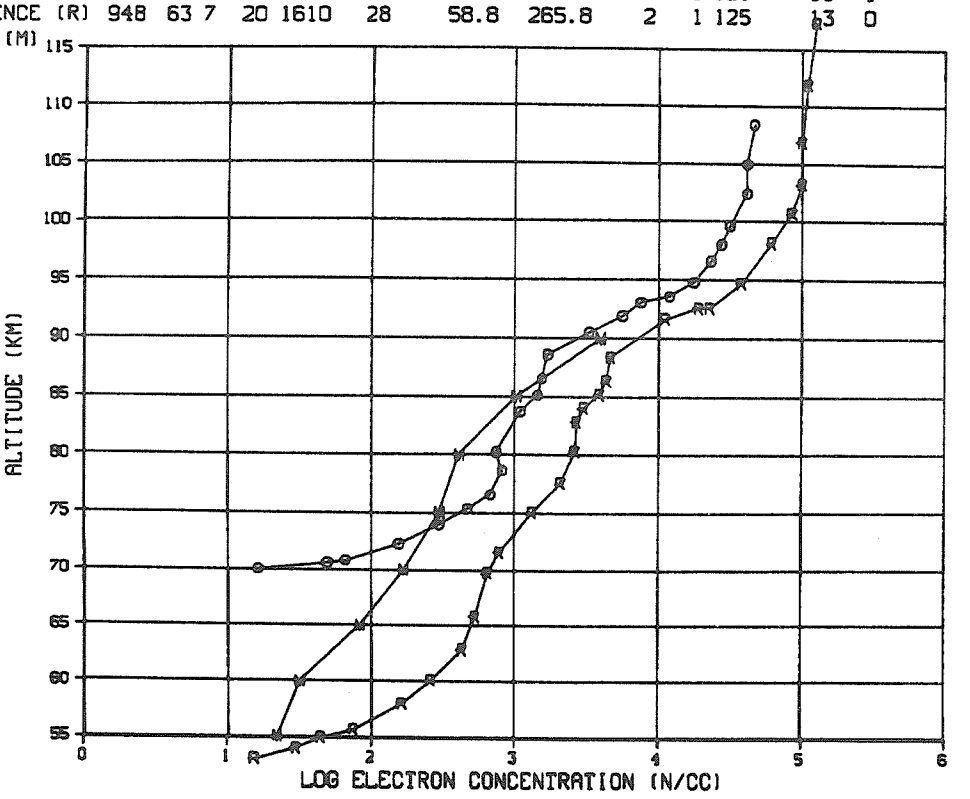
REFERENCES

McNAMARA, L.F. 1978 Ionospheric D-Region Profile Data Base--A Collection of Computer-Accessible Experimental Profiles of the D and Lower E Region. Report UAG-67, World Data Center A for Solar-Terrestrial Physics, Boulder, Colorado.

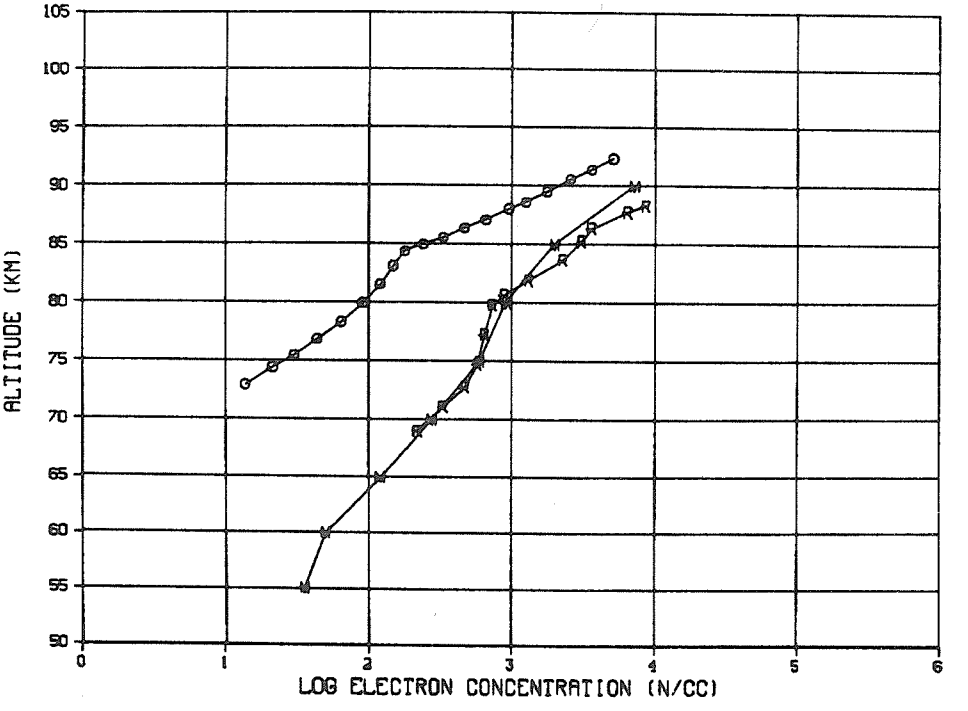
McNAMARA, L.F. 1979 Statistical Model of the D-Region. Submitted to Radio Science.

OBSERVED AND MODEL D-REGION ELECTRON DENSITY PROFILES

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	947	63	7	20	1503	28	58.8	265.8	2	1	125	13	1
REFERENCE (R)	948	63	7	20	1610	28	58.8	265.8	2	1	125	13	0
MODEL (M)													

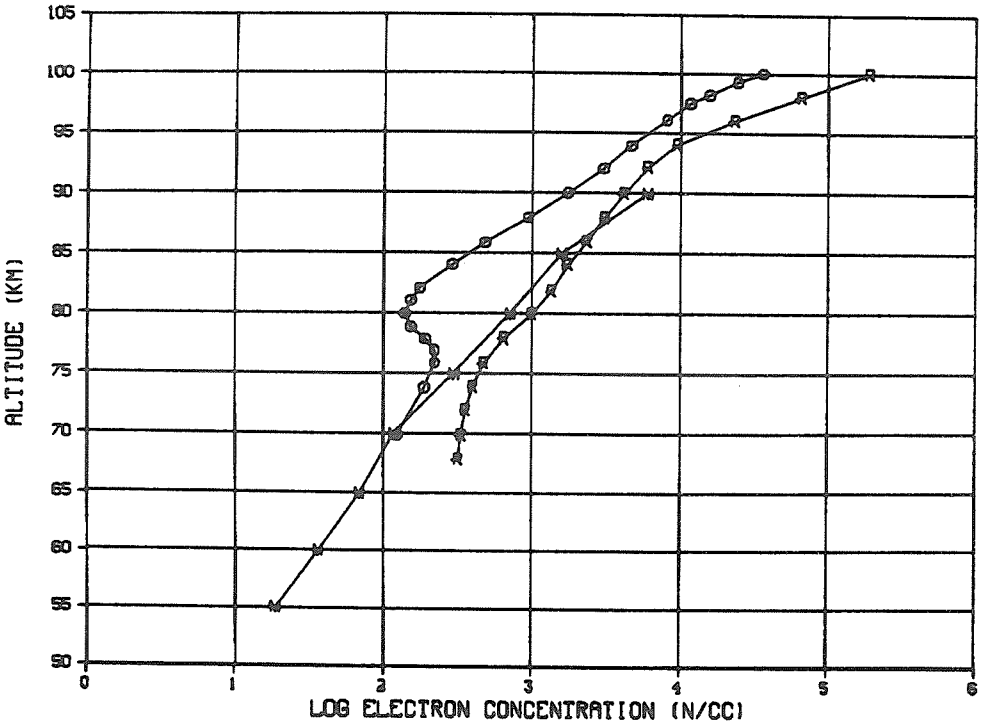


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	850	66	5	20	1045	41	36.8	21.9	2	1	78	3	1
REFERENCE (R)	234	66	5	20	1130	41	36.8	21.9	2	1	78	3	0
MODEL (M)													

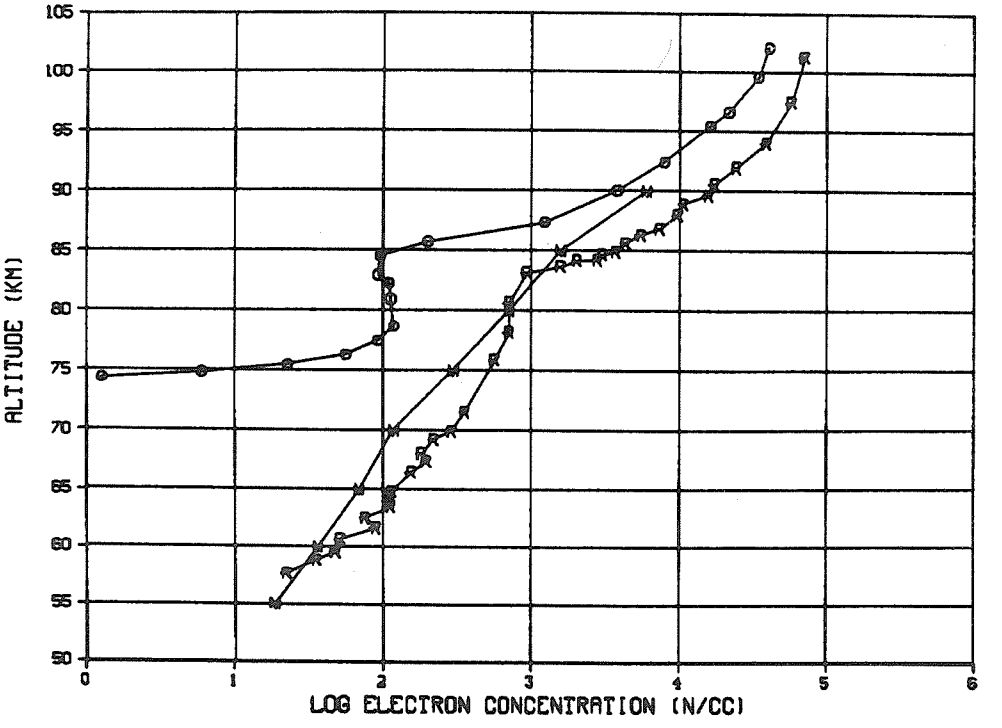


SOLAR ECLIPSE. #947 AND 850 DURING TOTALITY

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	809	66	11	12	1040	70	-32.0	308.0	1	1	155	17	1
REFERENCE (R)	808	66	11	0	1045	70	-32.0	308.0	1	1	155	17	0
MODEL (M)													

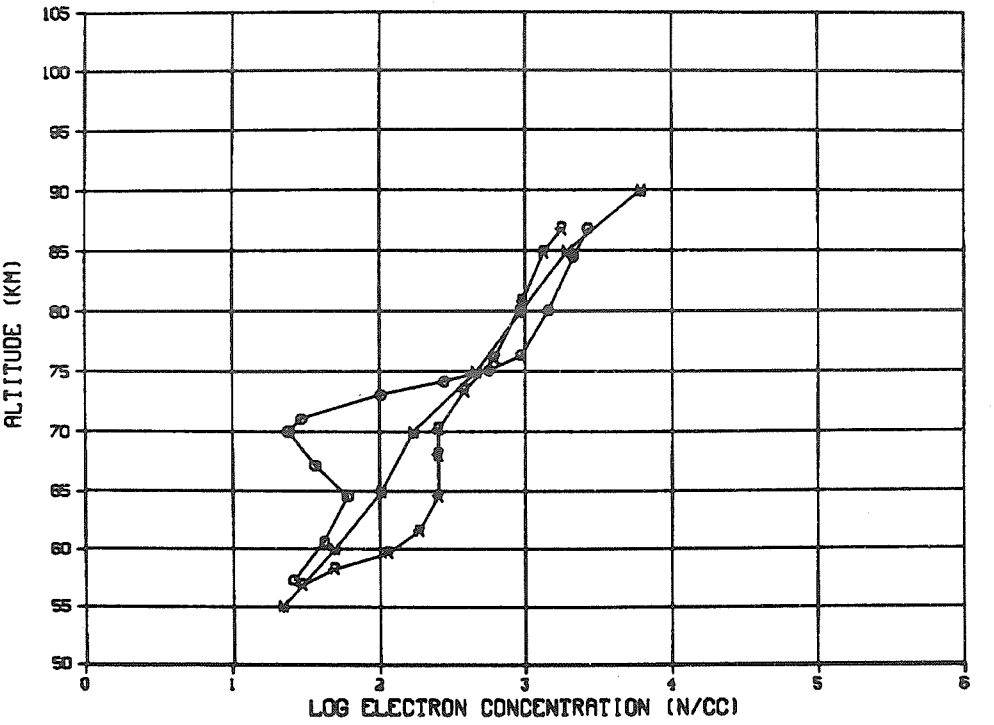


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	944	66	11	12	1040	70	-32.0	308.0	2	1	89	4	1
REFERENCE (R)	943	66	11	12	1230	70	-32.0	308.0	2	1	89	4	0
MODEL (M)													

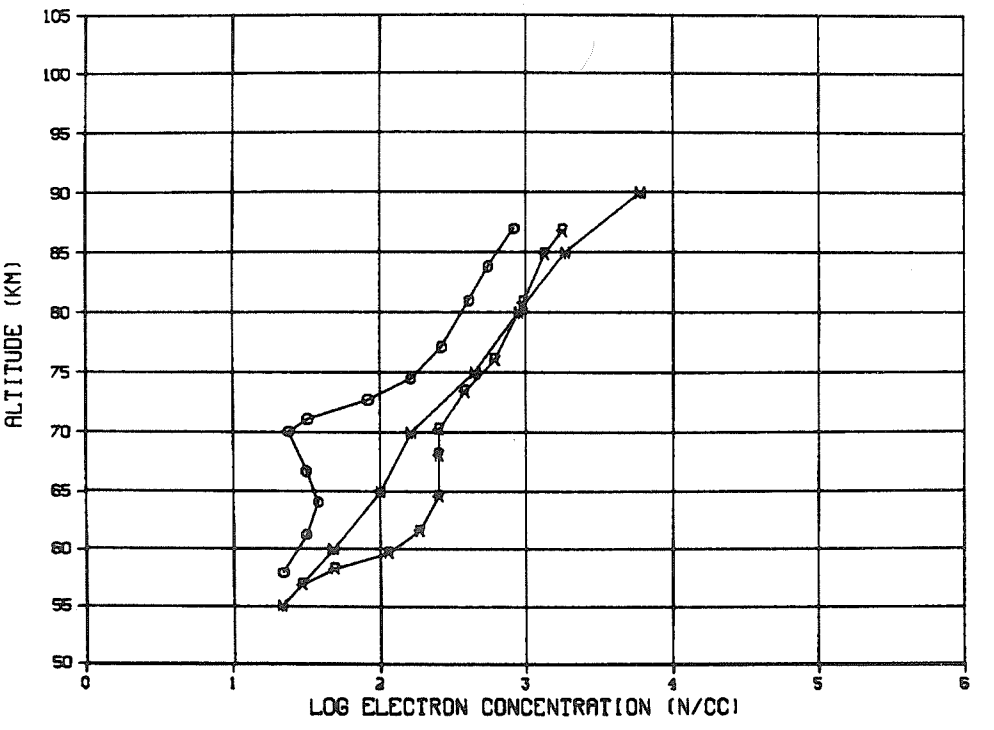


SOLAR ECLIPSE. #809 AND 944 DURING TOTALITY

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	409	70	3	7	1309	106	40.8	282.1	3	1	114	2	1
REFERENCE (R)	417	70	3	11	1310	106	40.8	282.1	3	1	114	2	0
MODEL (M)													

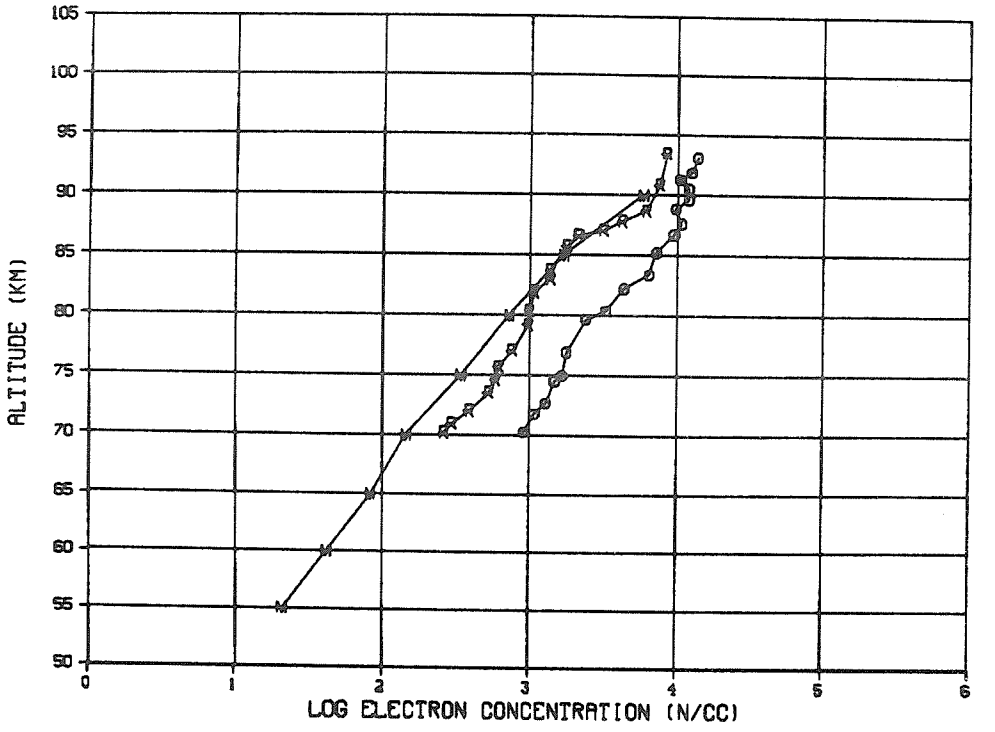


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	410	70	3	7	1328	106	40.8	282.1	3	1	114	2	1
REFERENCE (R)	417	70	3	11	1310	106	40.8	282.1	3	1	114	2	0
MODEL (M)													

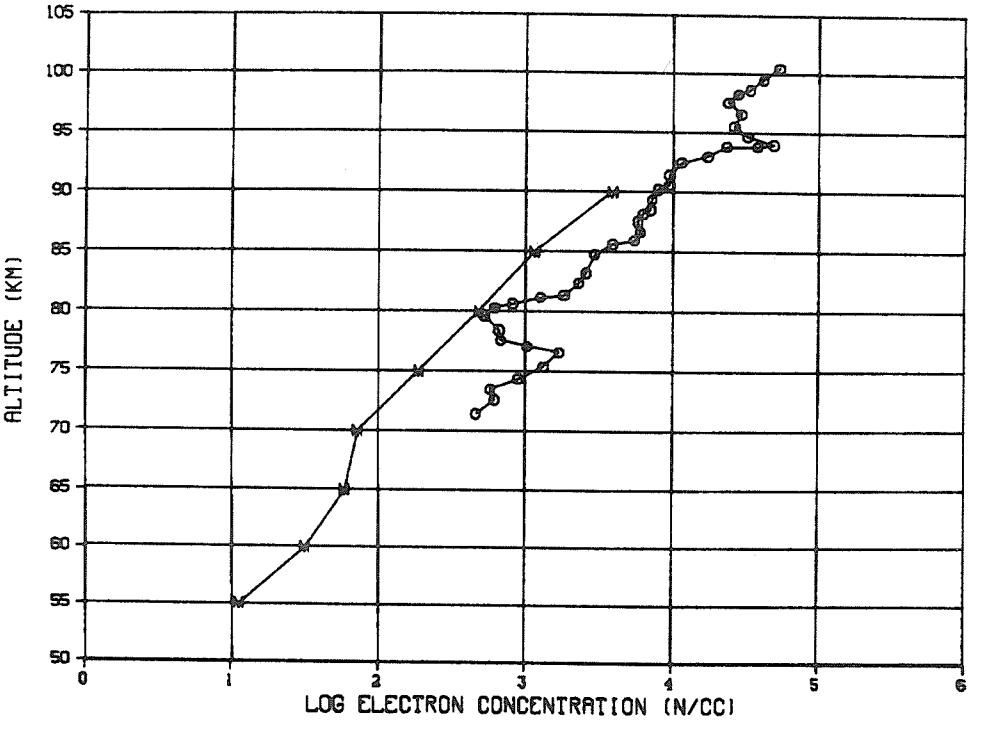


SOLAR ECLIPSE. MAXIMUM OBSERVATION 90% AT 1338 LT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	518	72	10	25	1208	61	37.1	353.3	2	1	48	4A	4
REFERENCE (R)	517	72	10	18	1200	61	37.1	353.3	2	1	48	4A	0
MODEL (M)													

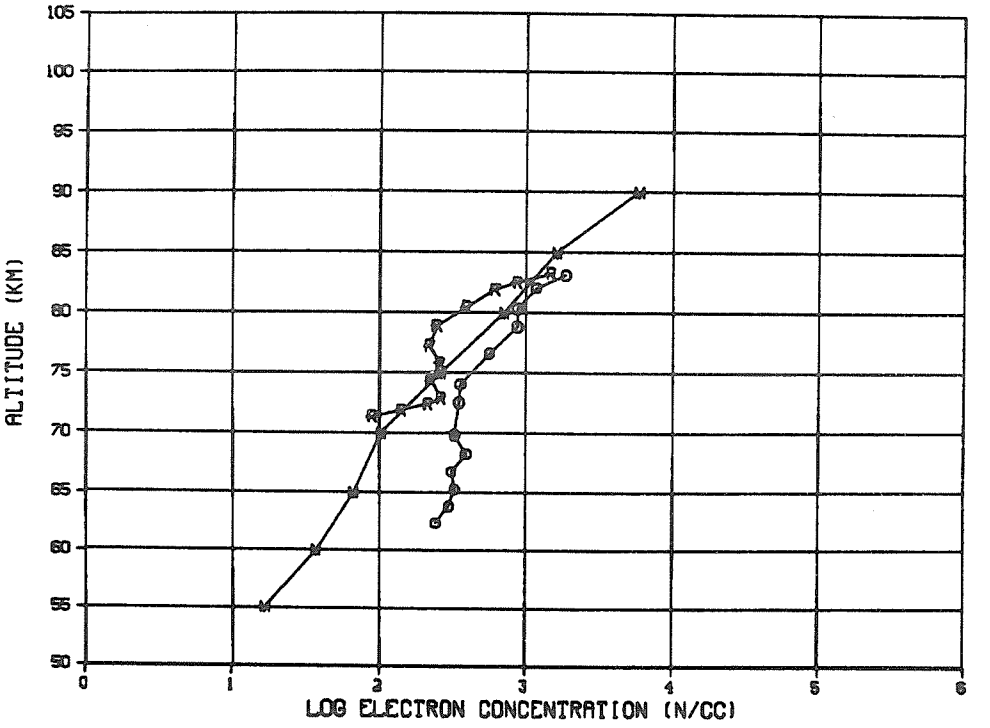


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	920	68	1	16	1514	103	37.9	284.5	2	1	2	4	3
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

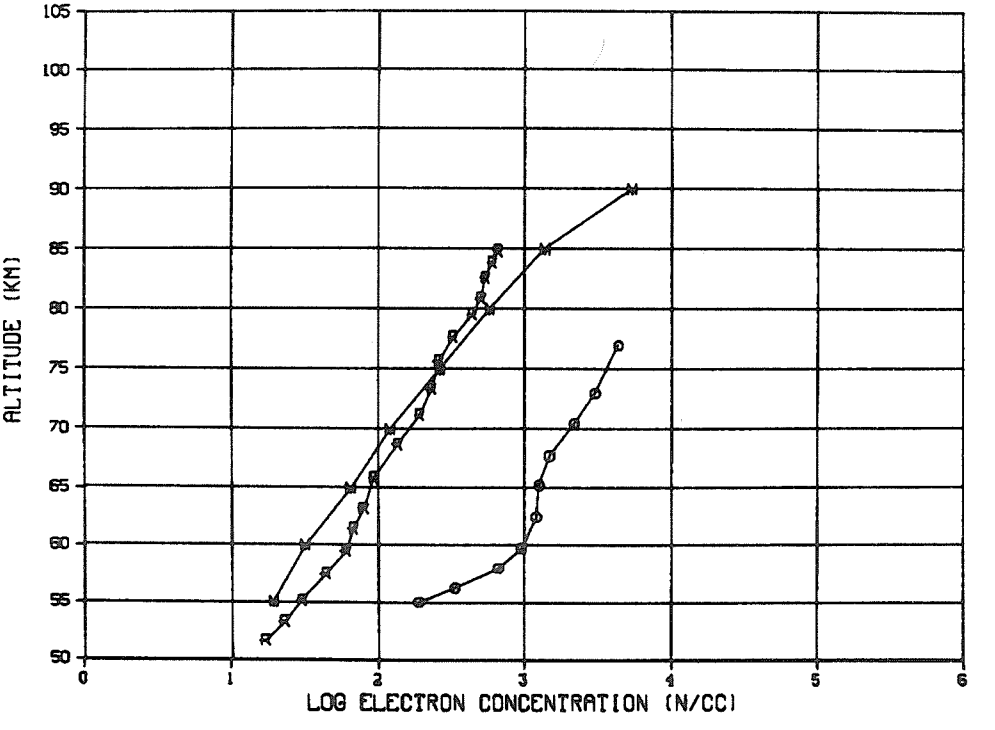


SOLAR X-RAY EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	541	72	1	19	1147	71	37.9	284.5	1	1	43	5.12	2
REFERENCE (R)	540	72	1	19	1109	71	37.9	284.5	1	1	43	5.12	0
MODEL (M)													

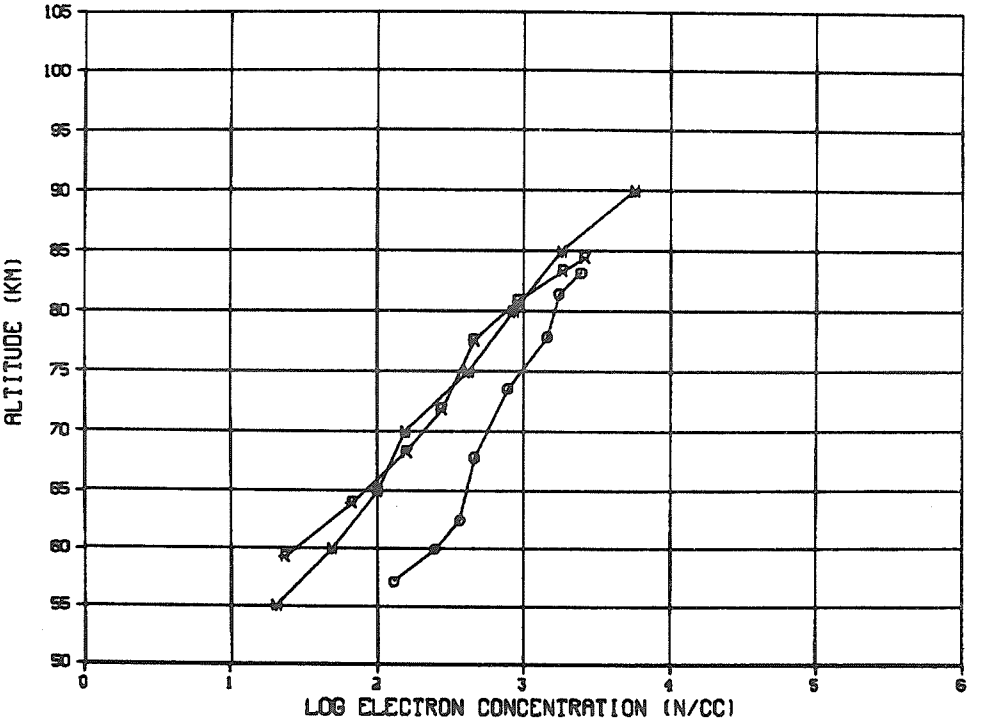


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	922	62	3	1	1147	40	45.4	284.1	1	1	14	8	4
REFERENCE (R)	54	62	3	0	1200	40	45.4	284.1	1	1	15	3.6	0
MODEL (M)													

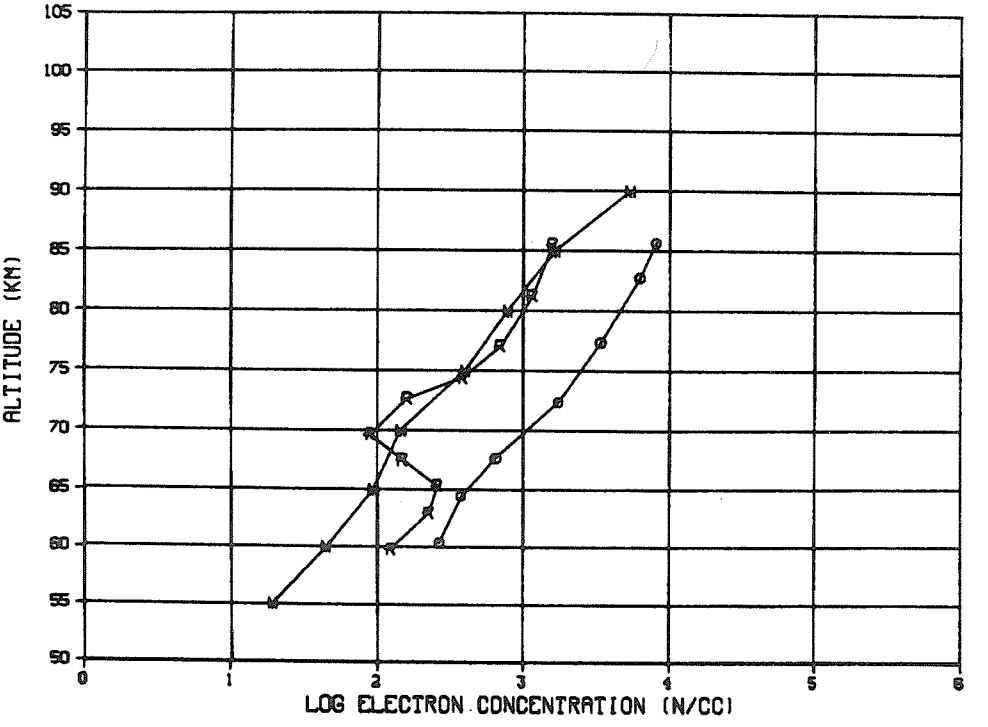


SOLAR X-RAY EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	324	68	3	25	1010	105	45.4	284.1	1	1	127	D1	2
REFERENCE (R)	323	68	3	25	945	105	45.4	284.1	1	1	127	D1	0
MODEL (M)													

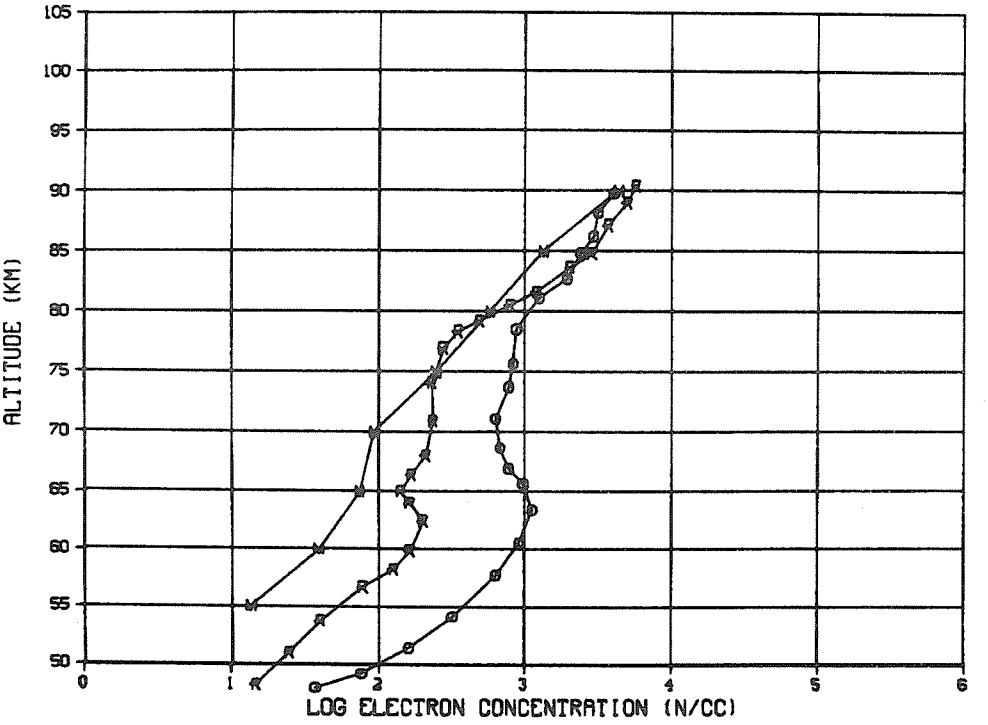


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	64	68	10	21	1239	110	40.8	282.1	3	1	115	1	2
REFERENCE (R)	63	68	10	21	1210	110	40.8	282.1	3	1	115	1	0
MODEL (M)													

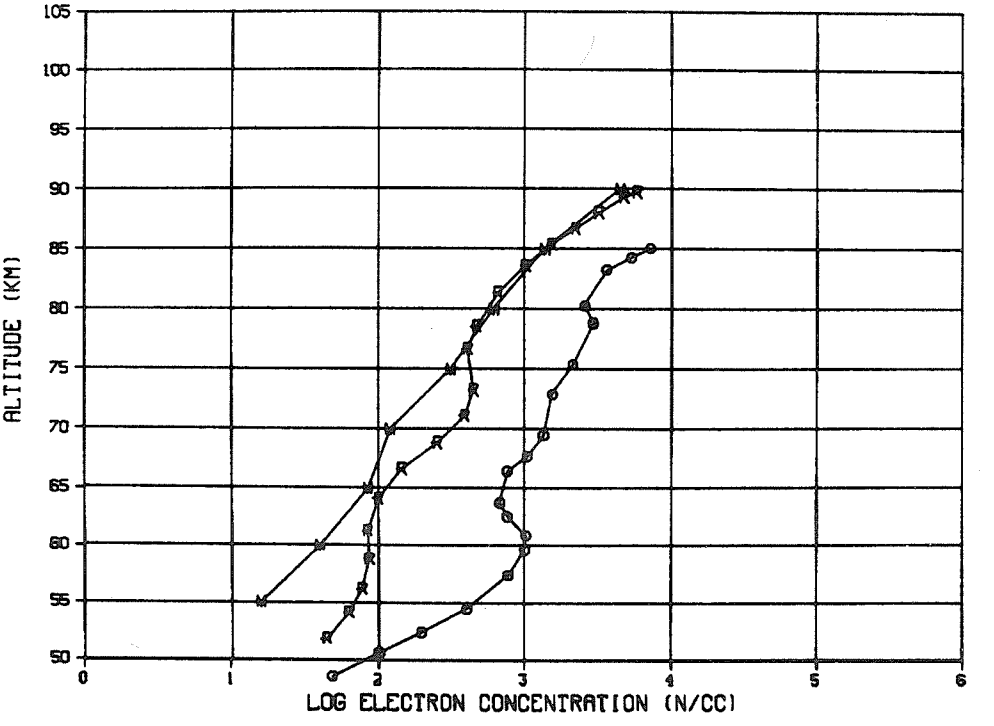


SOLAR X-RAY EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	945	69	11	18	1250	105	45.4	284.1	1	1	98	2	3
REFERENCE (R)	946	69	11	18	1430	105	45.4	284.1	1	1	98	2	0
MODEL (M)													

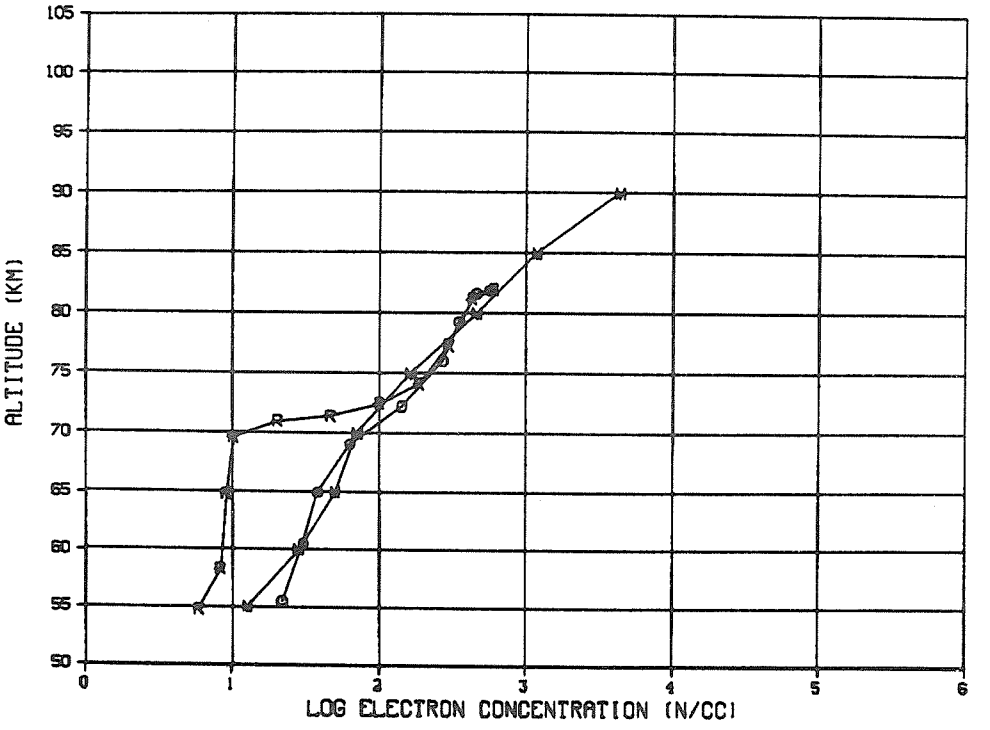


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	406	70	3	1	1009	106	45.4	284.1	1	1	98	3	3
REFERENCE (R)	405	70	3	1	1003	106	45.4	284.1	1	1	98	3	0
MODEL (M)													

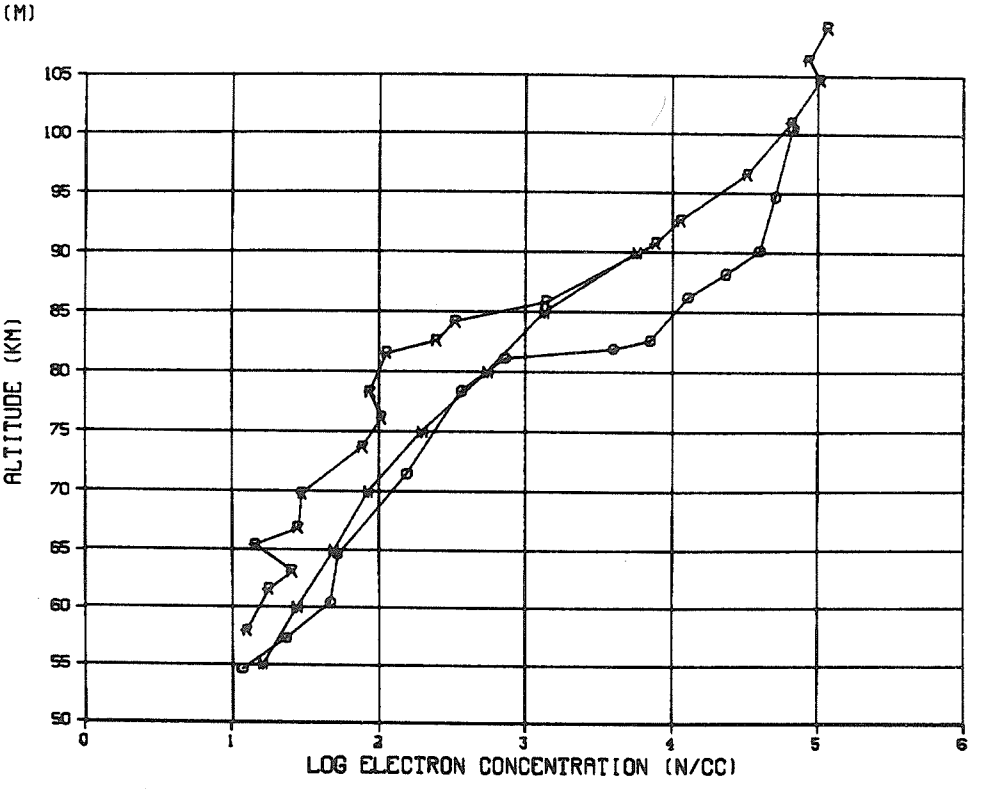


SOLAR X-RAY EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	48	61	12	18	1200	49	45.4	284.1	1	1	92	8	5
REFERENCE (R)	49	61	12	18	1200	49	45.4	284.1	1	1	92	8	0
MODEL (M)													

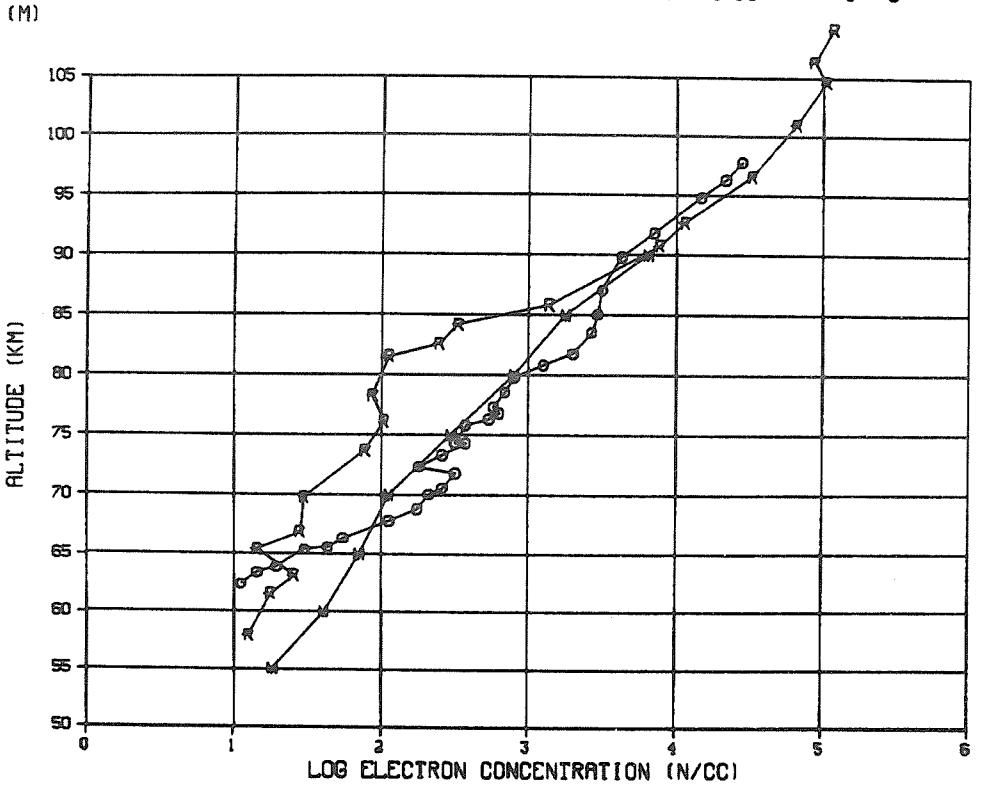


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	221	66	1	10	1200	28	37.9	284.5	2	1	90	1	5
REFERENCE (R)	220	65	12	15	1200	24	37.9	284.5	2	1	90	1	0
MODEL (M)													

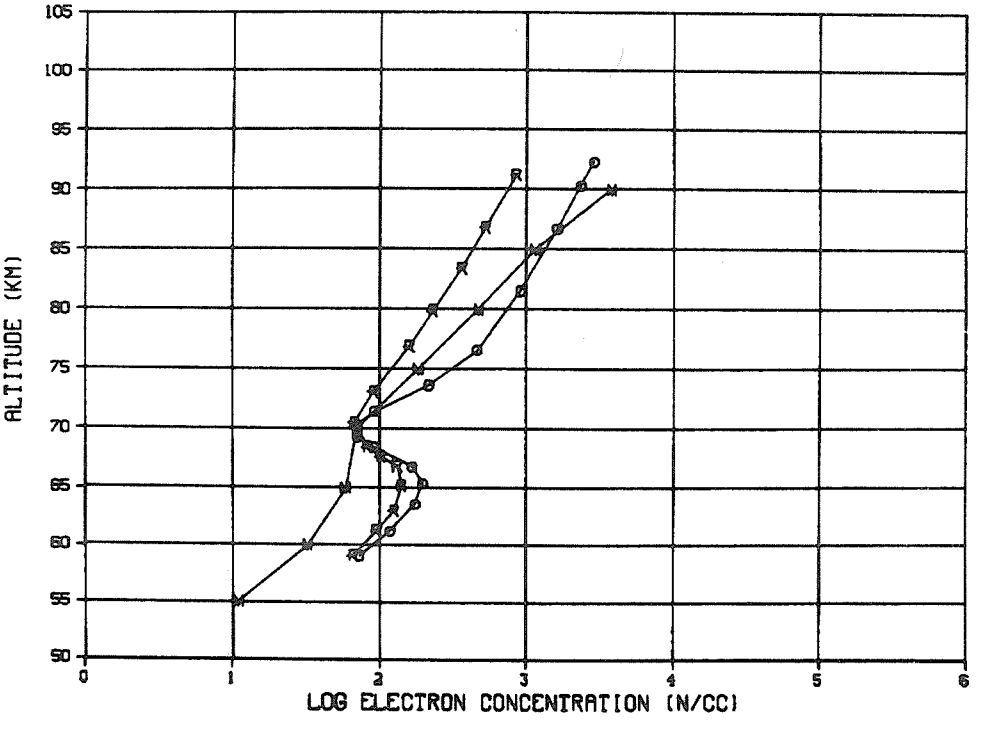


WINTER ANOMALY DAY

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	268	67	1	31	1200	75	37.9	284.5	2	1	119	3	5
REFERENCE (R)	220	65	12	15	1200	24	37.9	284.5	2	1	90	1	0
MODEL (M)													

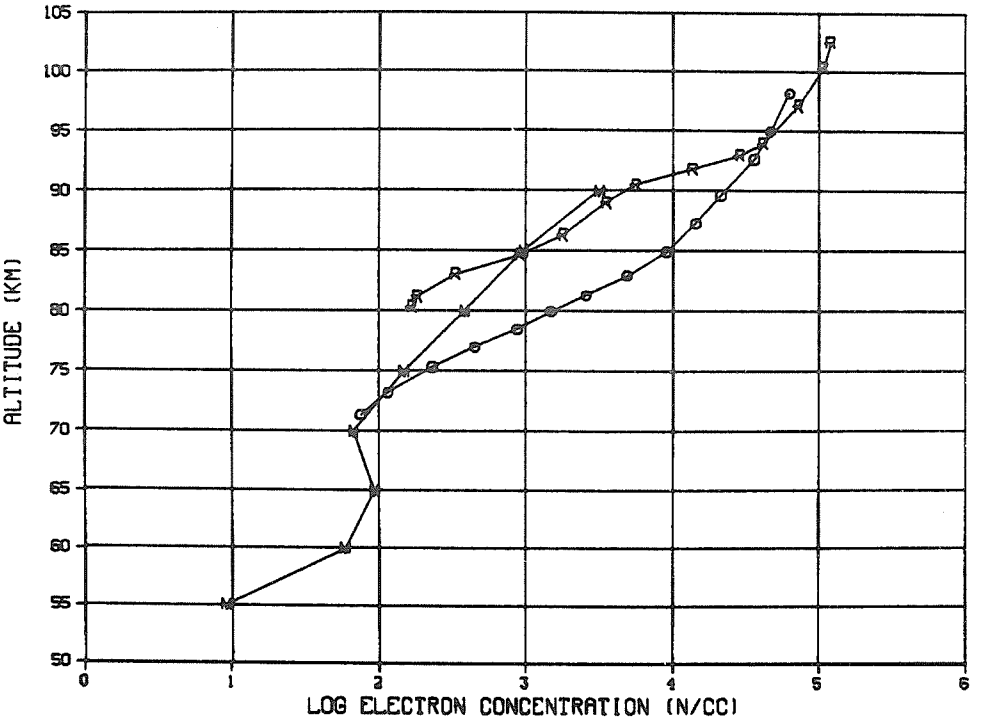


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	288	68	1	8	1500	102	40.8	282.1	3	1	116	3	5
REFERENCE (R)	287	67	12	14	900	102	40.8	282.1	3	1	116	3	0
MODEL (M)													

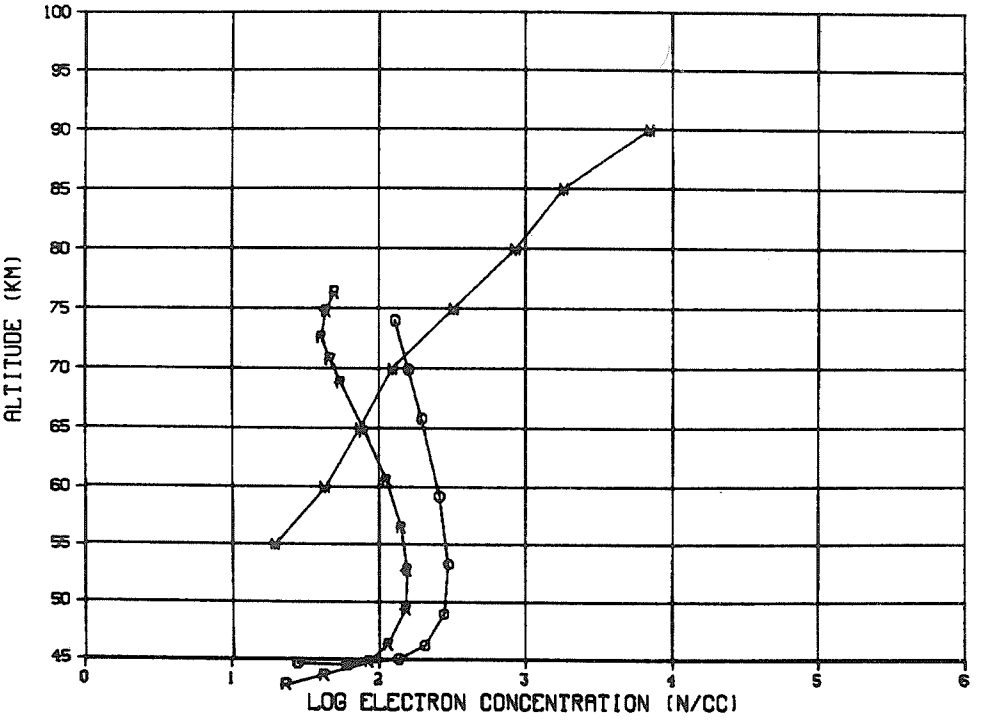


WINTER ANOMALY DAY

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	548	68	12	5	1200	110	57.2	352.7	2	1	32	1	5
REFERENCE (R)	583	71	10	14	1255	66	57.4	352.6	2	1	33	4	0
MODEL (M)													

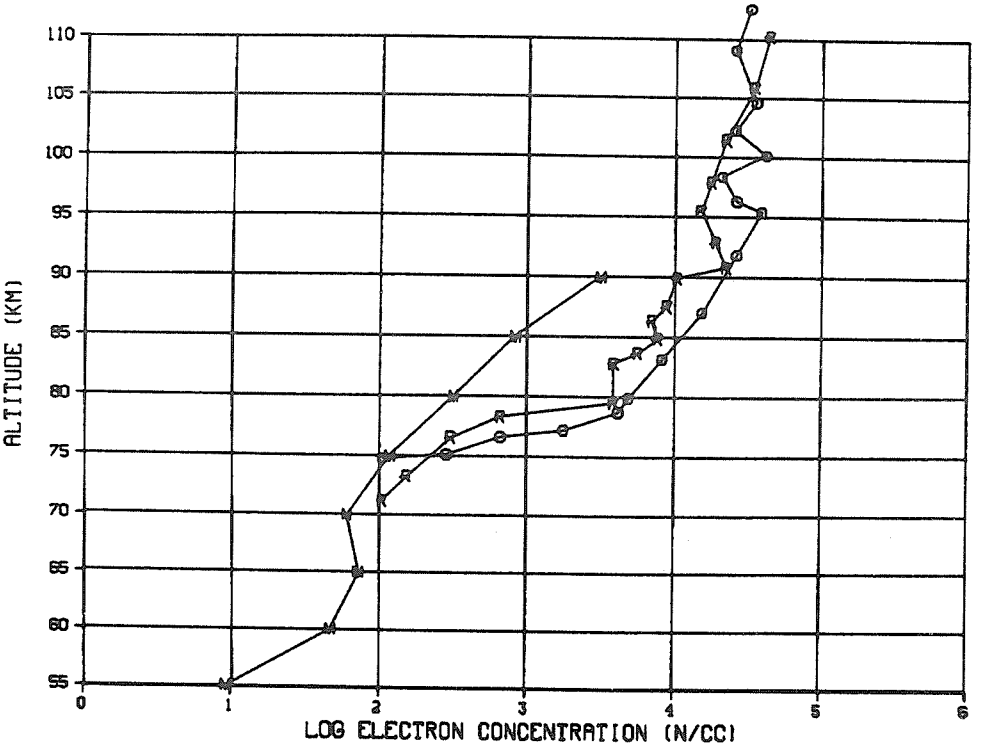


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	450	71	1	22	1200	80	32.3	253.5	2	1	96	7	5
REFERENCE (R)	451	71	2	1	1215	78	32.3	253.5	2	1	96	7	0
MODEL (M)													

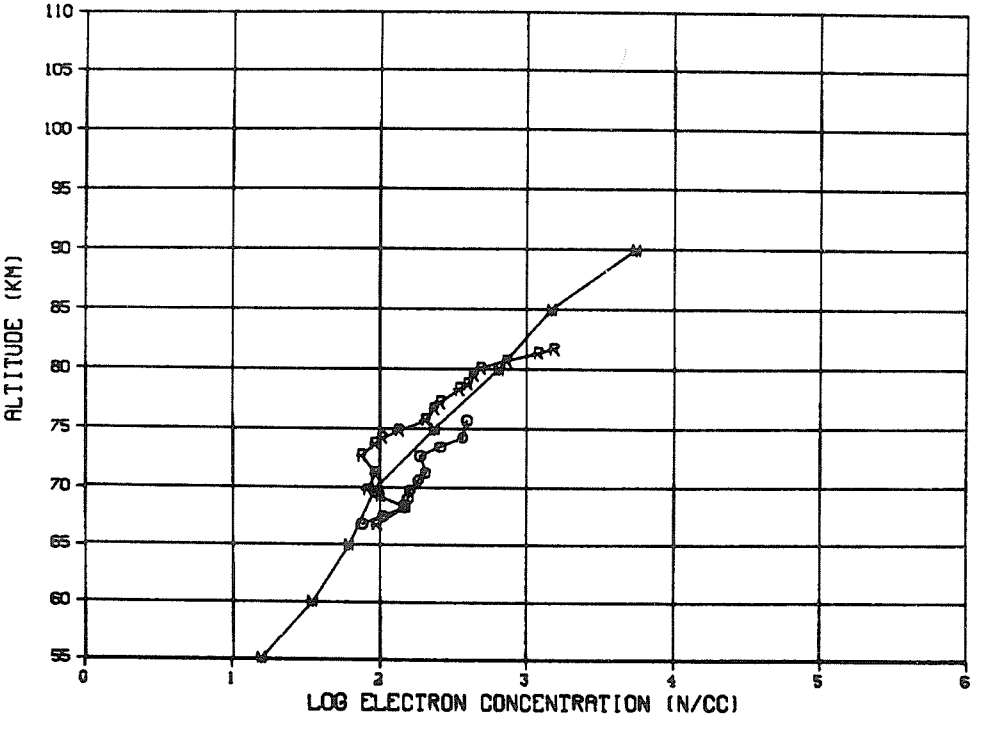


WINTER ANOMALY DAY

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	992	71	12	3	1258	69	57.2	352.9	2	1	151	2	5
REFERENCE (R)	991	71	12	1	1334	69	57.2	352.9	2	1	151	2	0
MODEL (M)													

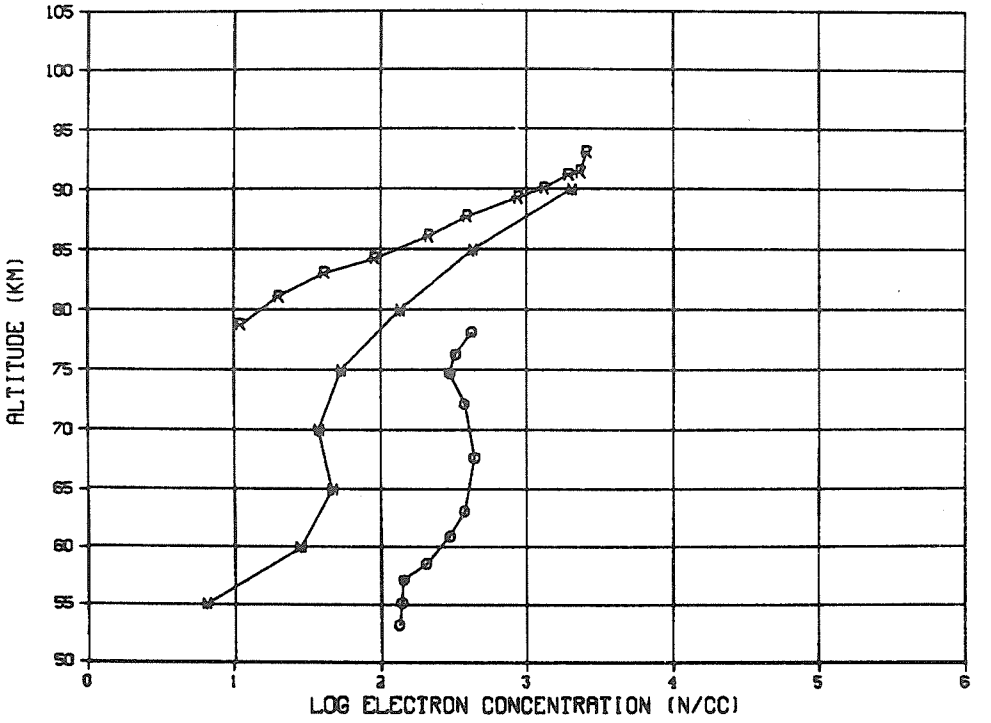


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	545	71	12	12	1200	69	37.9	284.5	1	1	43	5.7	5
REFERENCE (R)	544	71	12	9	1200	69	40.1	271.8	1	1	43	5.7	0
MODEL (M)													

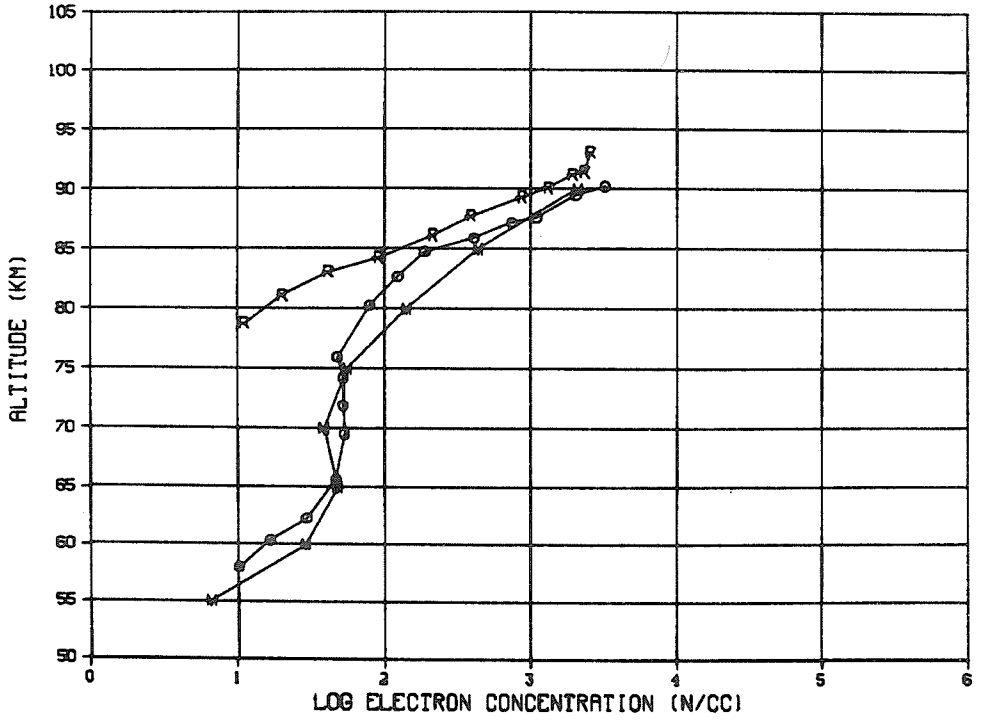


WINTER ANOMALY DAY

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	158	65	2	6	1200	12	74.7	265.1	1	1	68	2	7
REFERENCE (R)	160	65	2	11	1200	12	74.7	265.1	1	1	68	2	0
MODEL (M)													

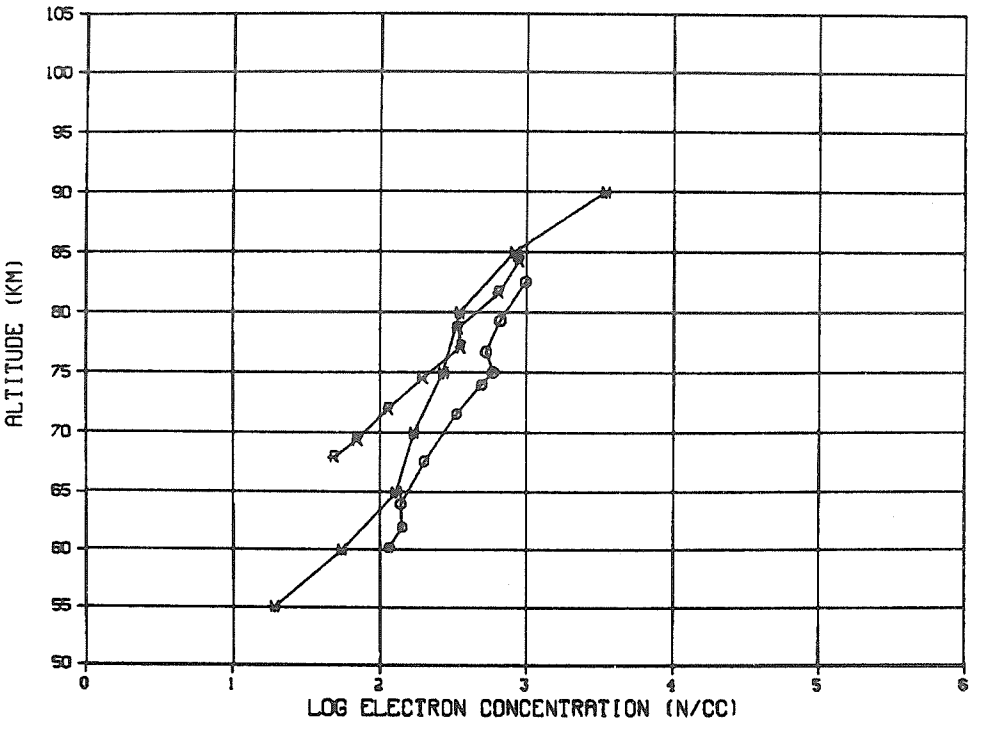


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	159	65	2	8	1200	12	74.7	265.1	1	1	68	2	7
REFERENCE (R)	160	65	2	11	1200	12	74.7	265.1	1	1	68	2	0
MODEL (M)													

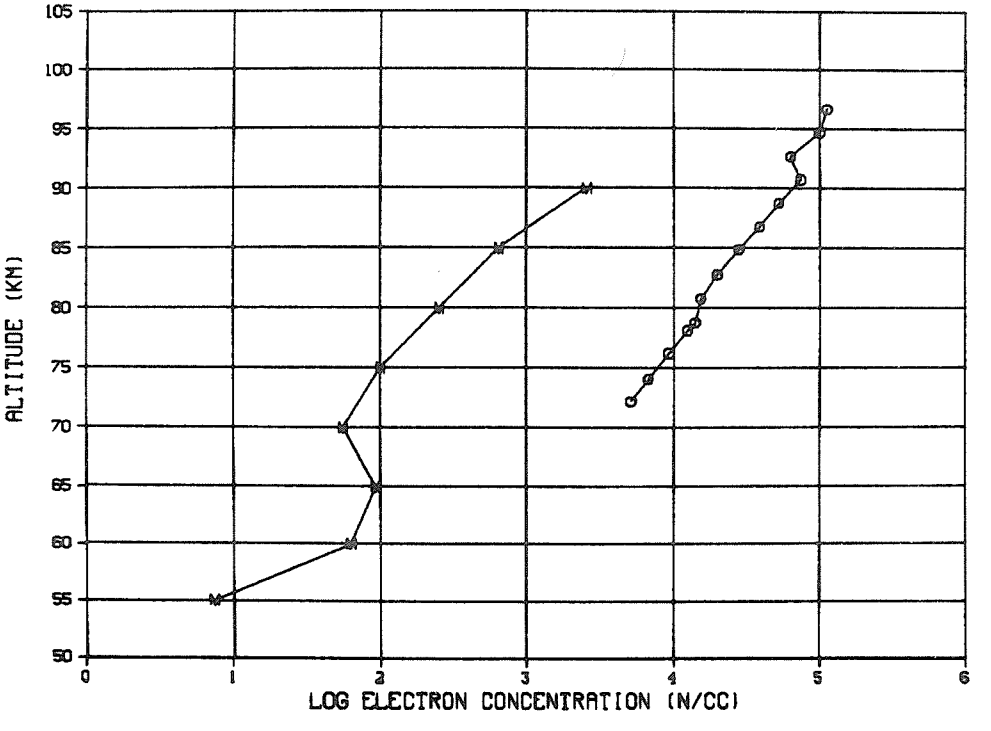


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	938	66	7	17	1200	50	74.7	265.1	1	1	68	4	7
REFERENCE (R)	250	66	7	15	1200	50	74.7	265.1	1	1	68	4	0
MODEL (M)													

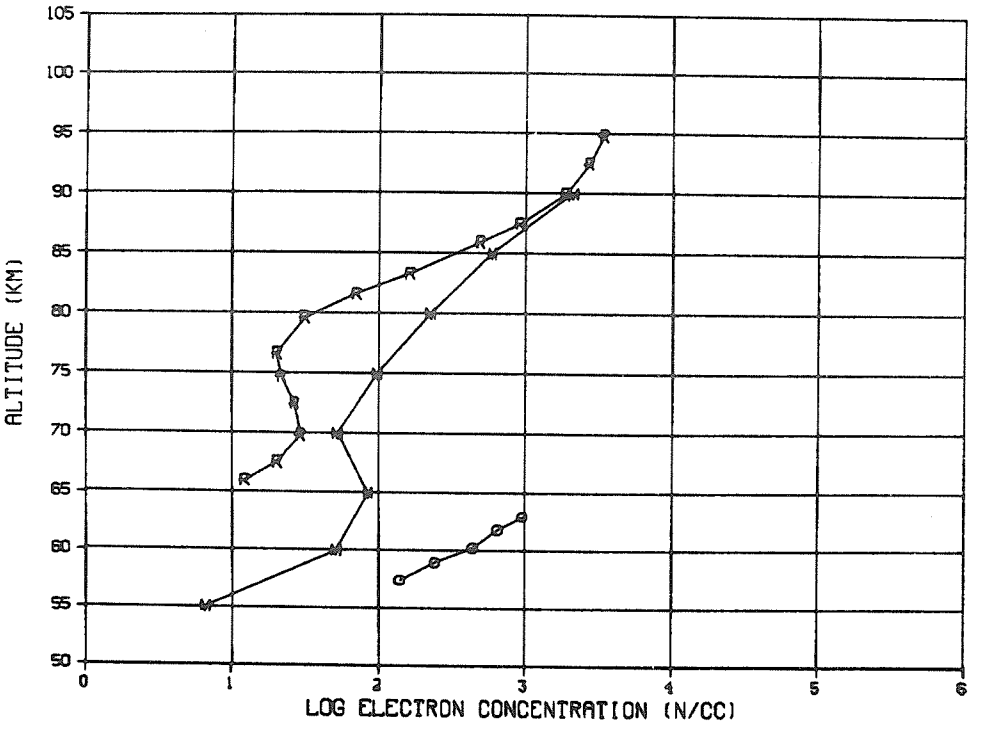


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	932	67	1	29	1030	91	-66.7	140.0	2	1	31	19.6	7
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

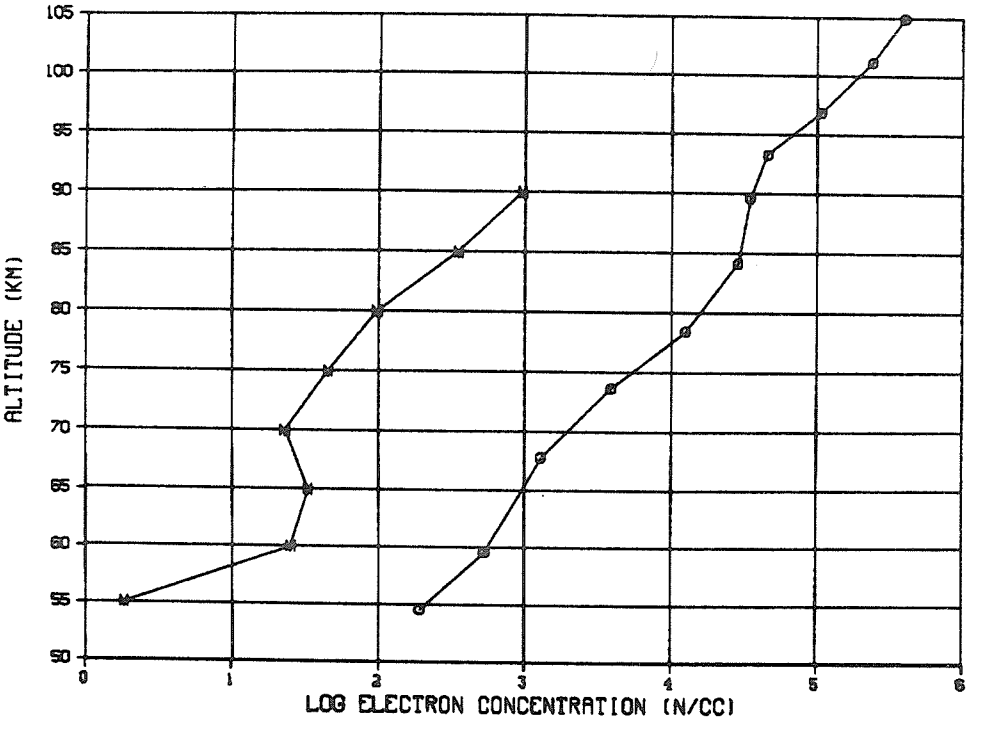


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	358	68	11	1	1200	111	74.7	265.1	1	1	27	14	7
REFERENCE (R)	354	68	10	25	1200	110	74.7	265.1	1	1	27	14	0
MODEL (M)													

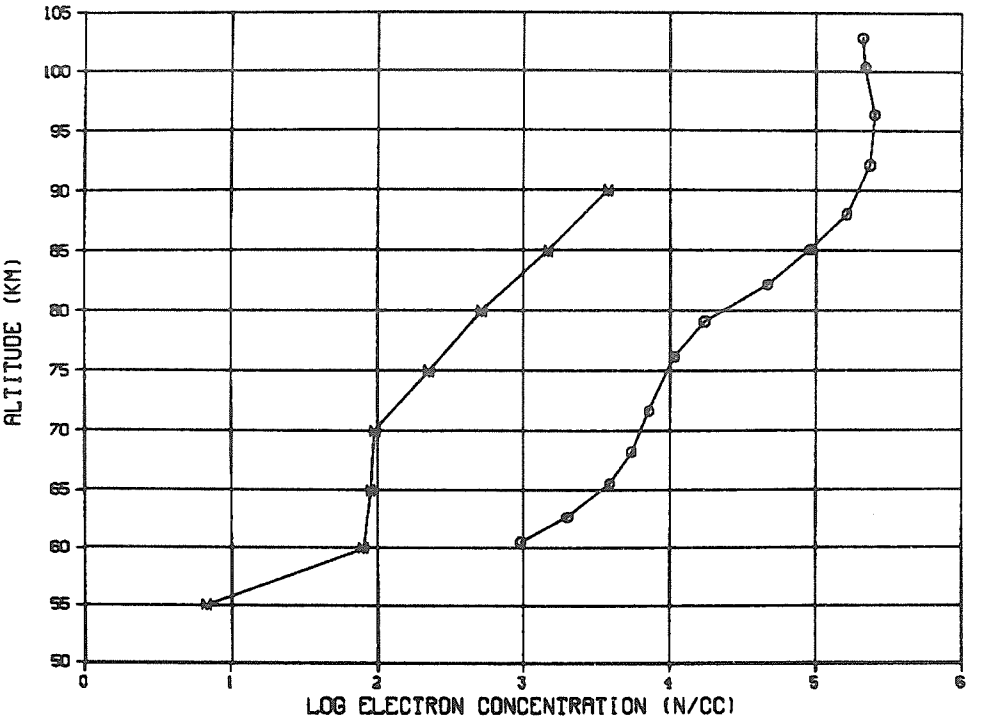


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	382	69	11	3	5	105	58.8	265.8	2	2	138	27.5	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

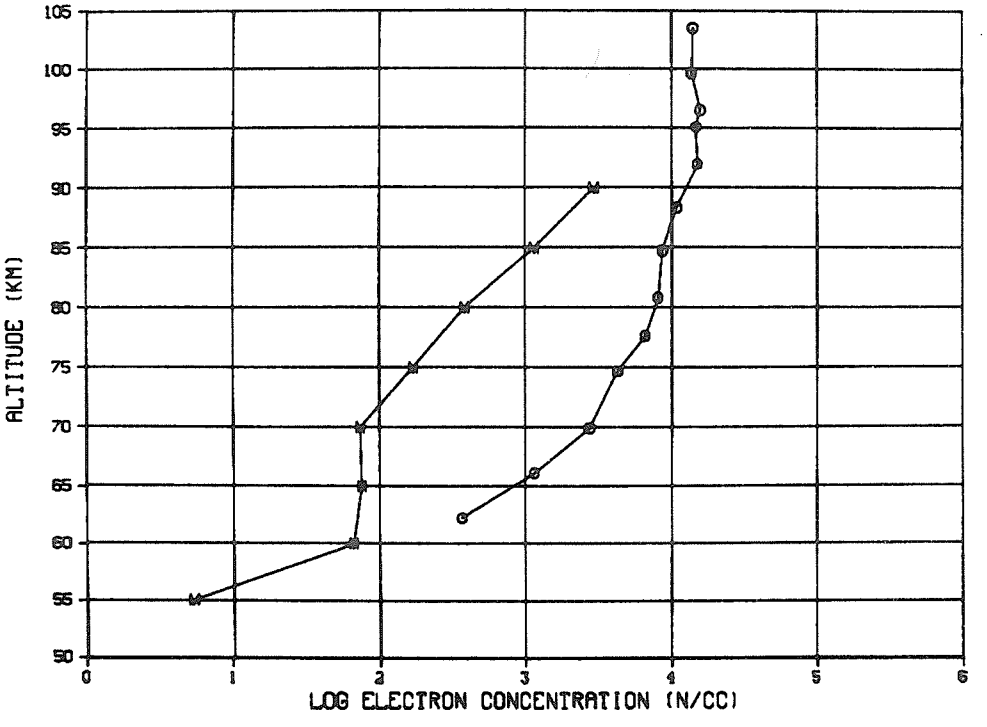


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	385	69	11	3	752	105	58.8	265.8	2	2	138	27.6	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

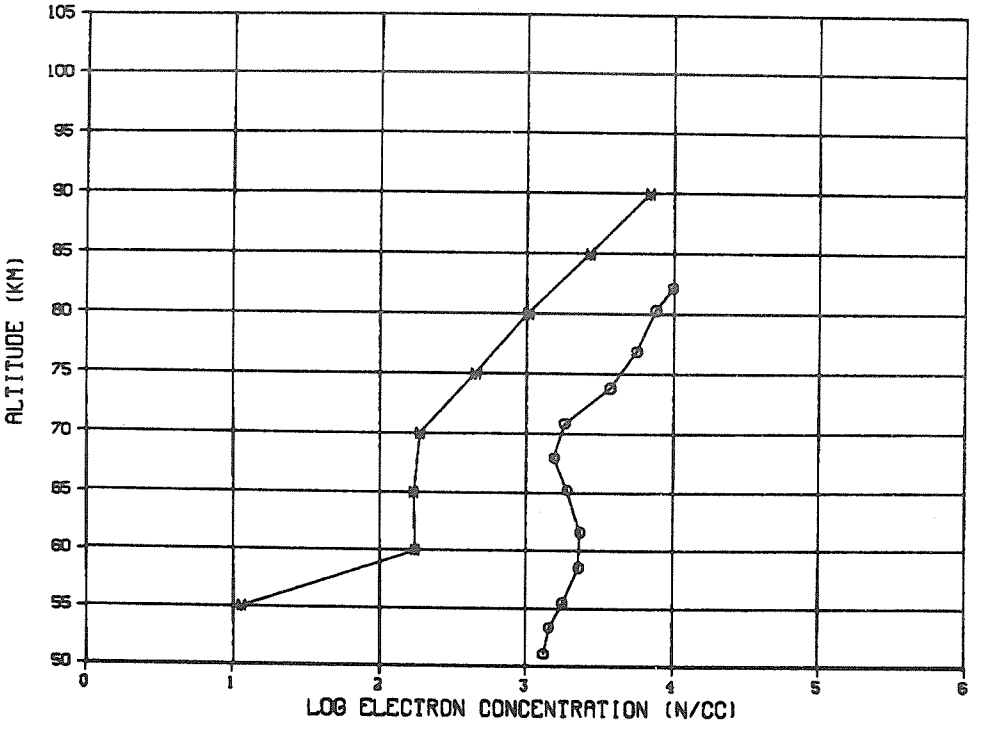


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	390	69	11	4	1708	105	58.8	265.8	2	2	138	27.8	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

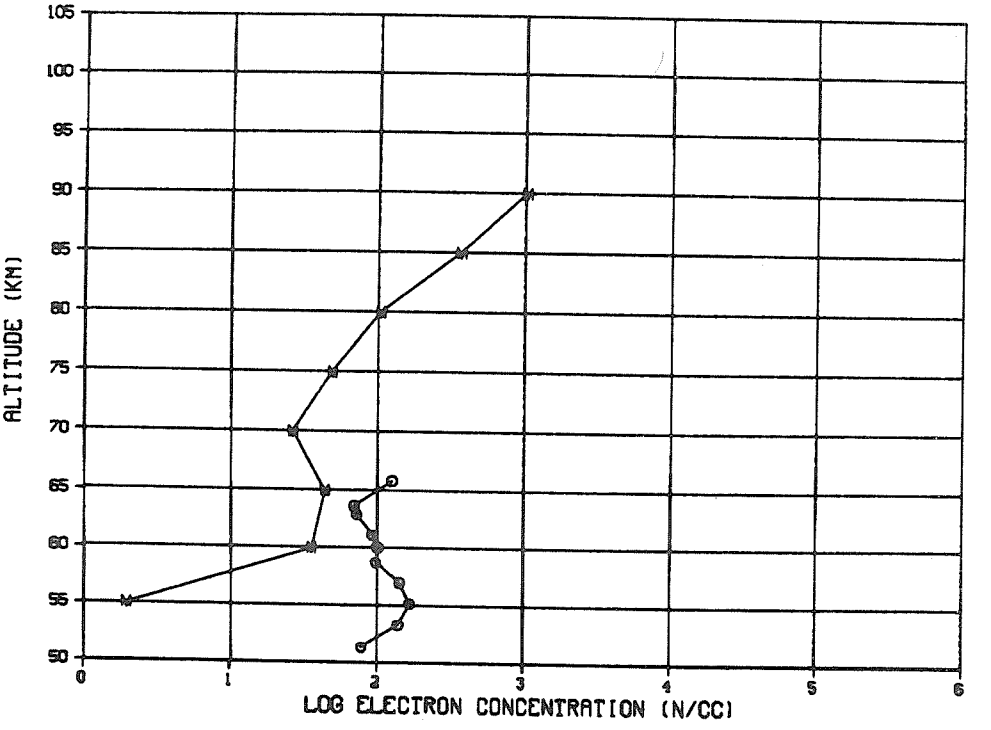


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	366	69	2	25	1521	110	50.0	15.0	2	2	78	1	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

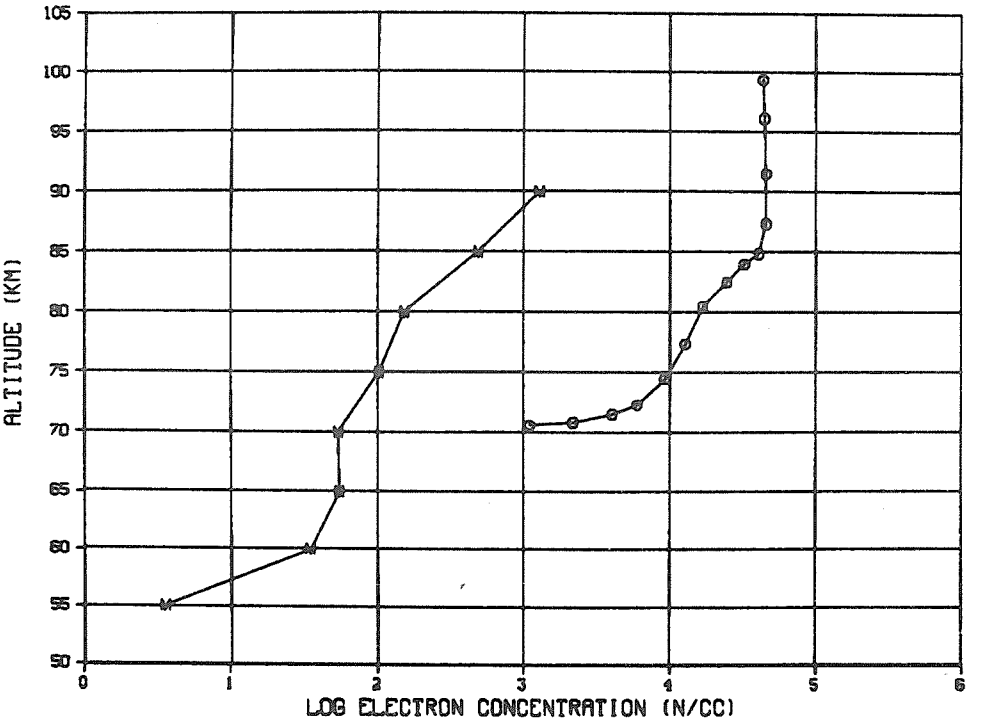


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	365	69	2	25	2237	110	50.0	15.0	2	2	78	1	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

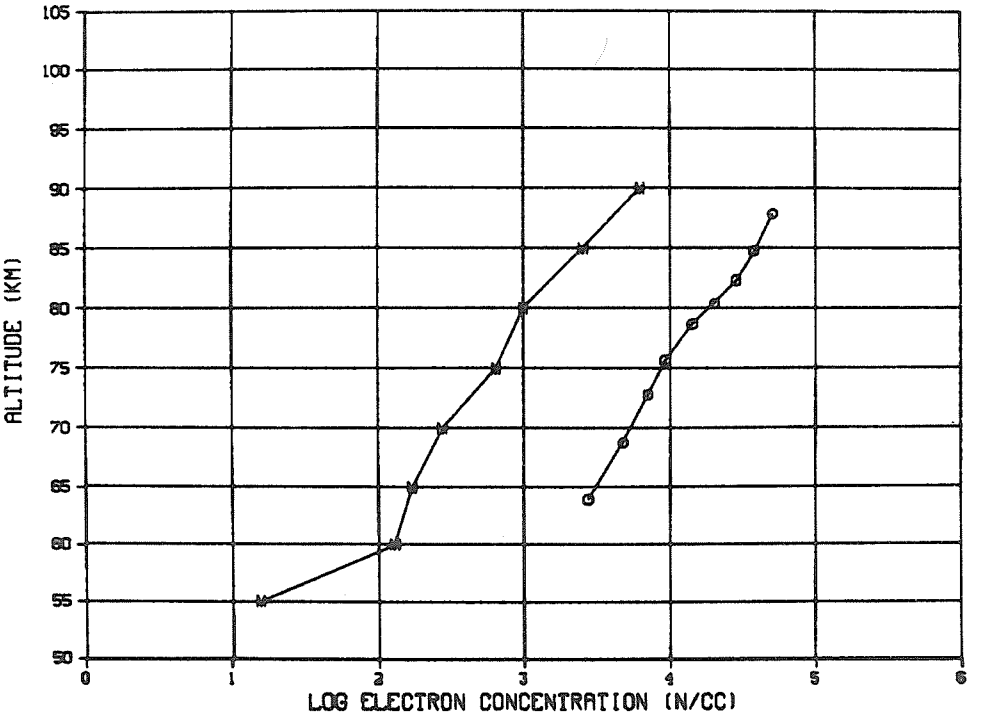


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	369	69	4	13	2319	106	58.8	265.8	2	2	94	6	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

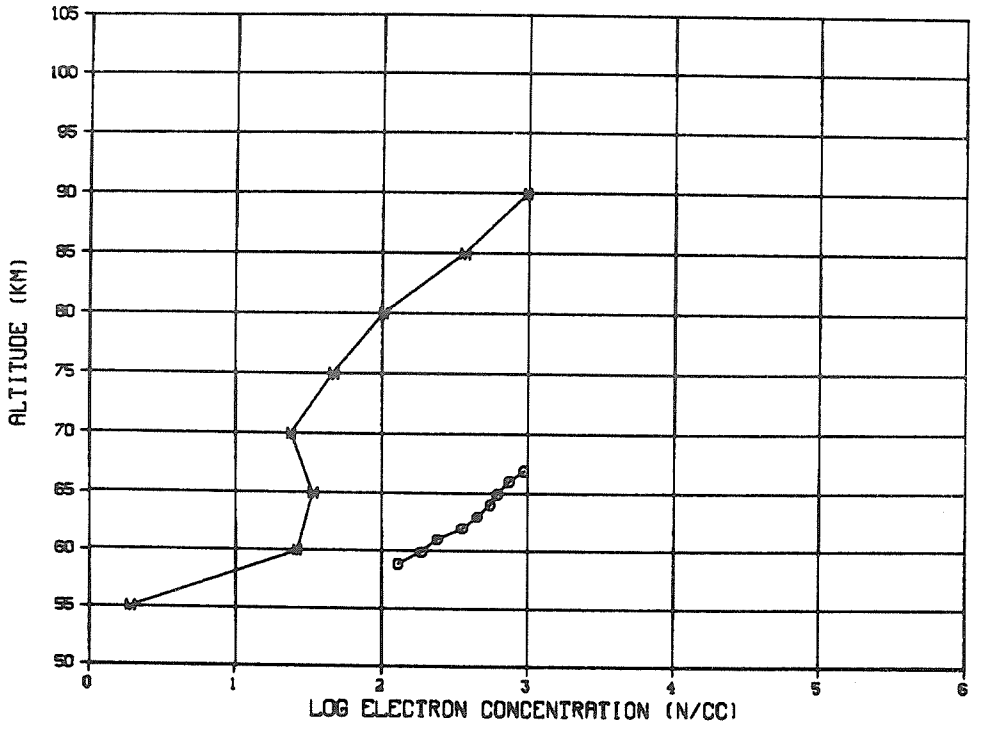


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	368	69	4	14	1528	106	58.8	265.8	2	2	94	6	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

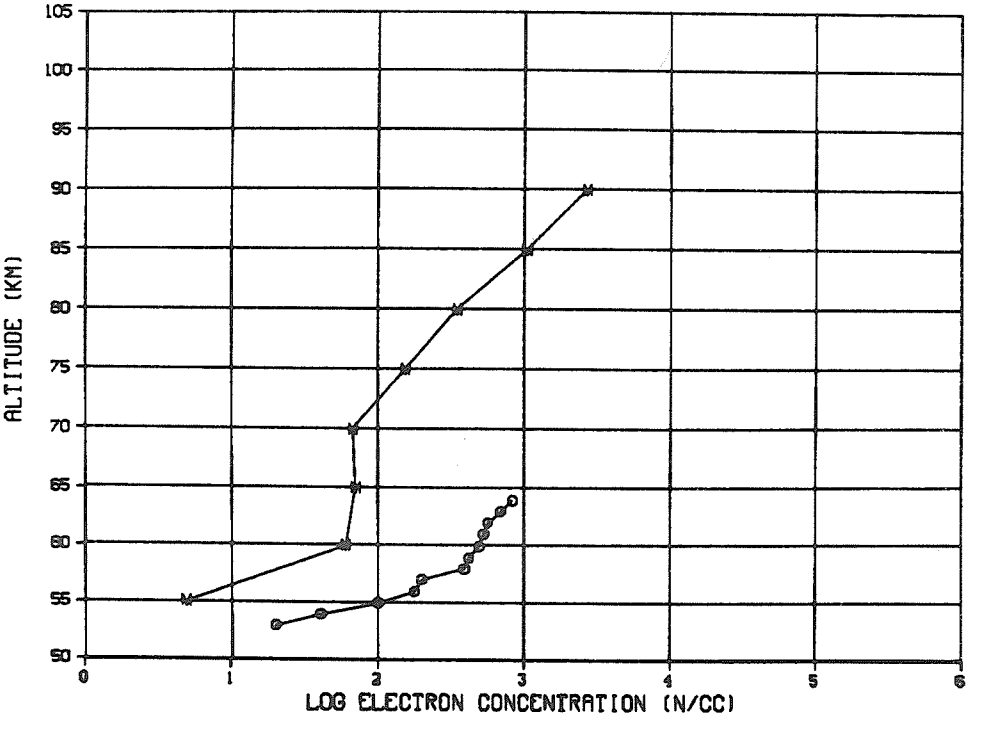


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	804	69	11	3	100	105	58.8	265.8	2	2	154	3-3	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

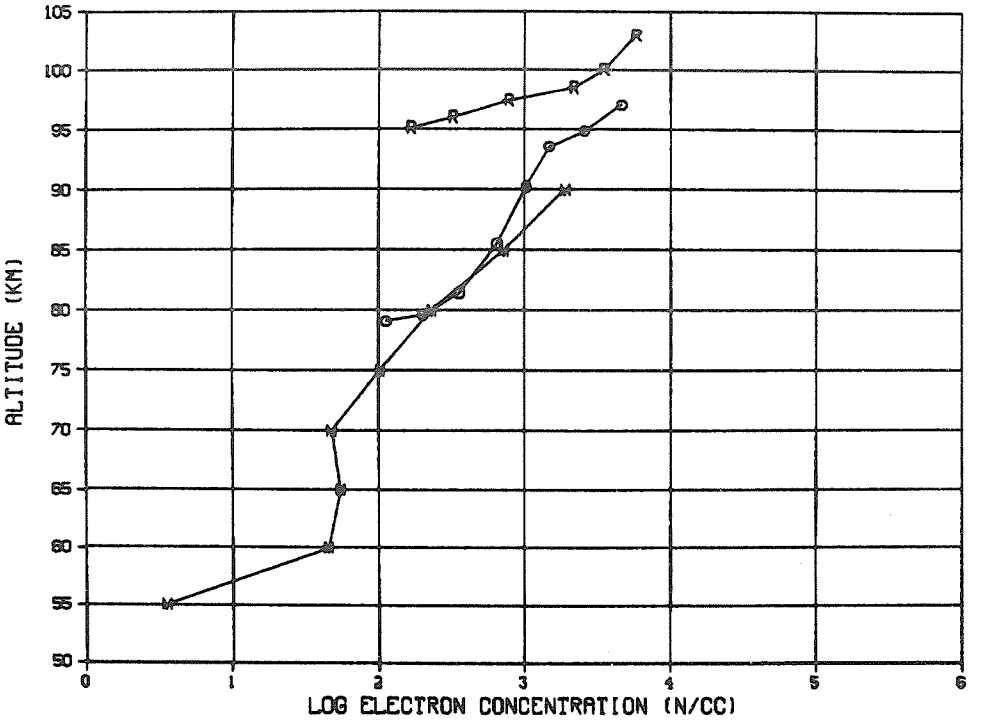


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	805	69	11	3	628	105	58.8	265.8	2	2	154	3-3	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

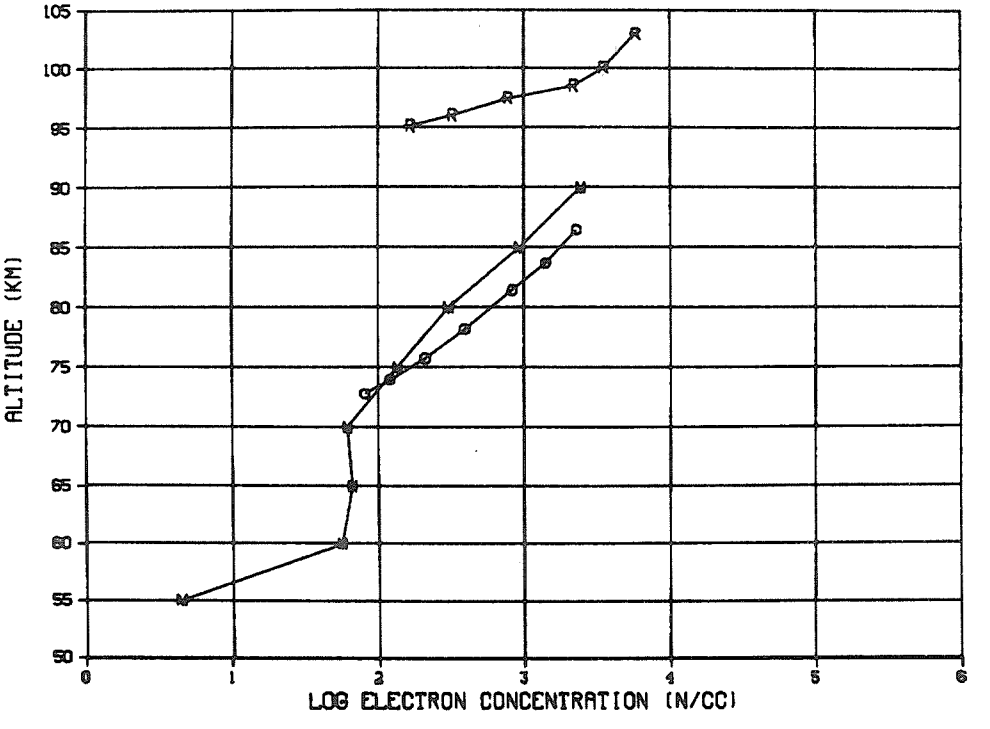


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	375	69	11	2	500	105	58.8	265.8	1	2	17	16.6	8
REFERENCE (R)	925	69	11	2	400	105	58.8	265.8	1	2	17	16.6	0
MODEL (M)													

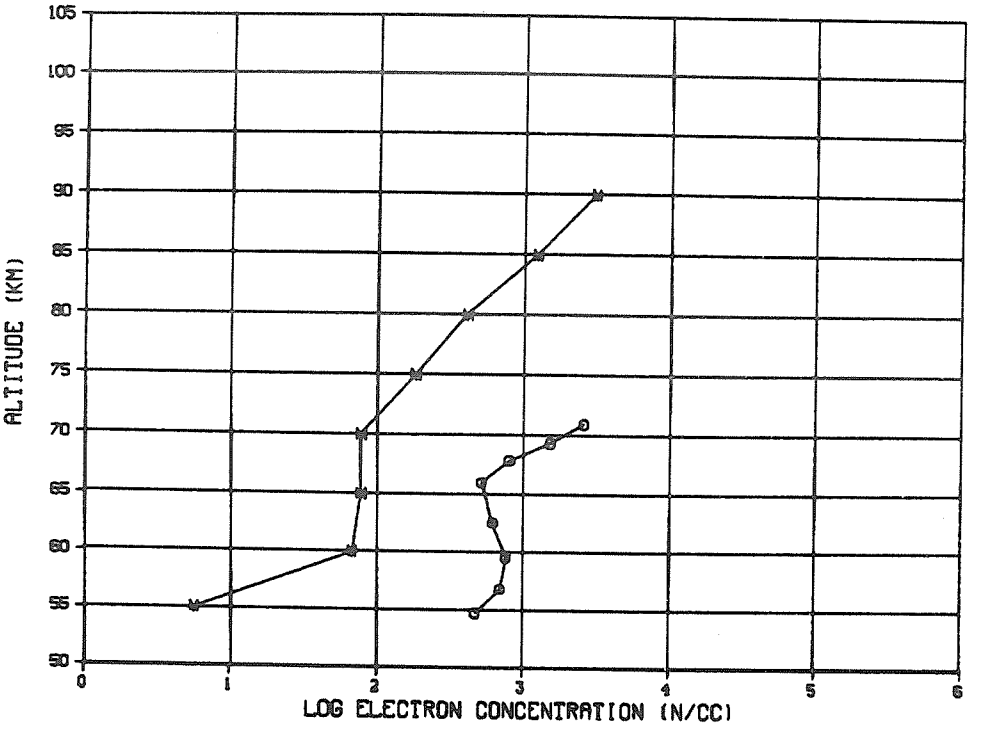


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	376	69	11	2	600	105	58.8	265.8	1	2	17	16.6	8
REFERENCE (R)	925	69	11	2	400	105	58.8	265.8	1	2	17	16.6	0
MODEL (M)													

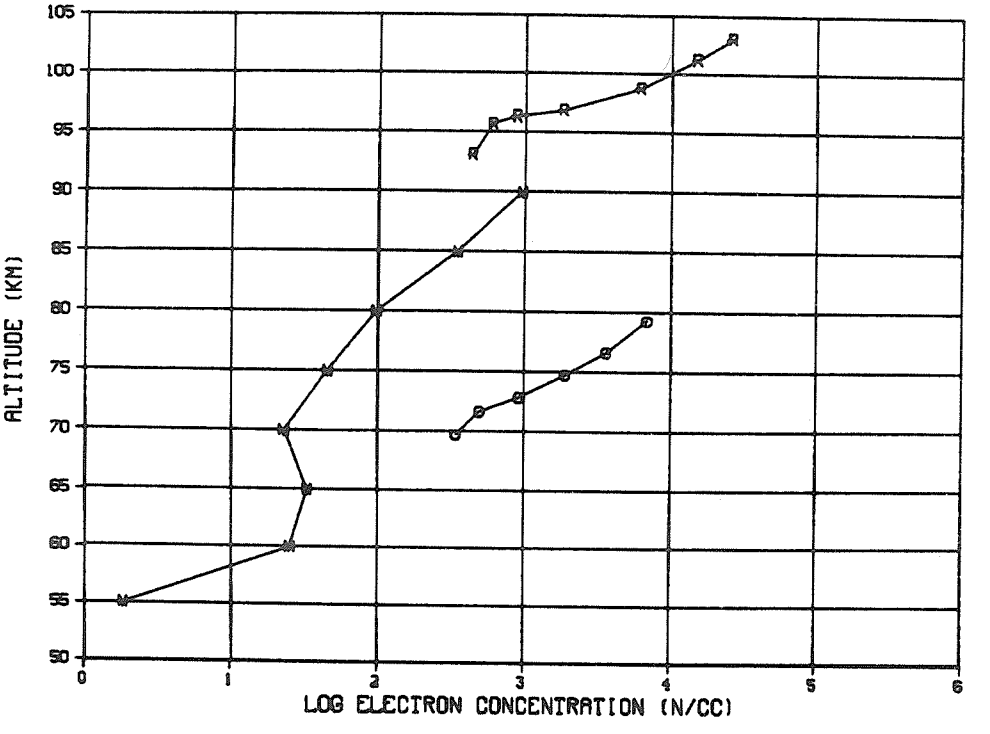


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	377	69	11	2	700	105	58.8	265.8	1	2	17	16.6	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

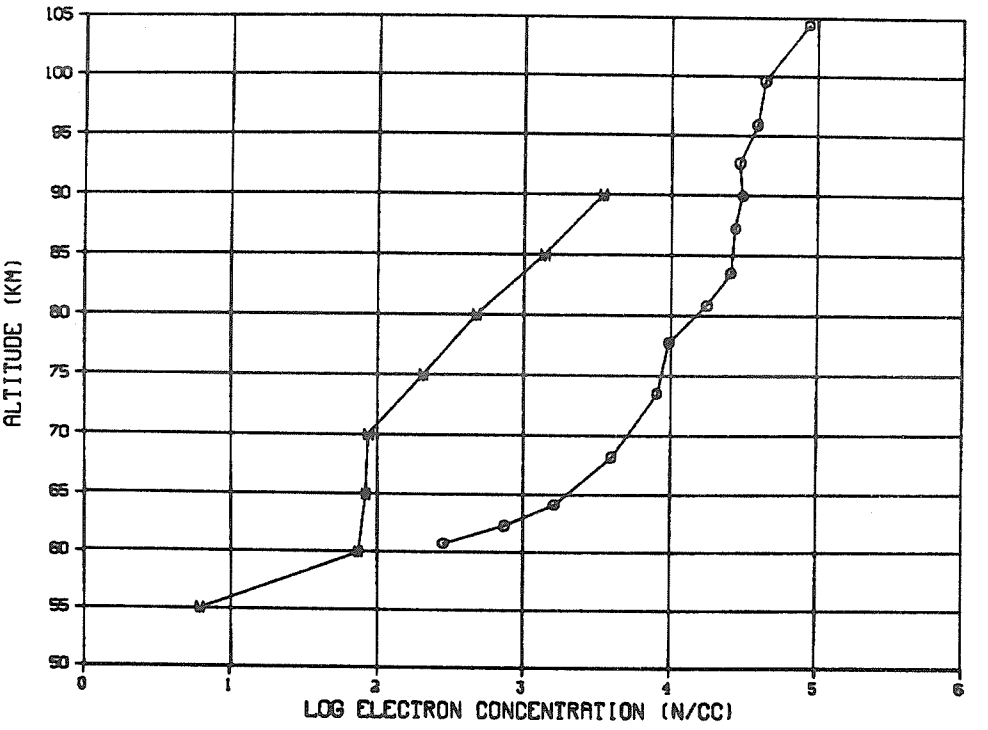


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	381	69	11	3	0	105	58.8	265.8	1	2	17	16.6	8
REFERENCE (R)	923	69	11	1	0	105	58.8	265.8	1	1	17	16.7	0
MODEL (M)													

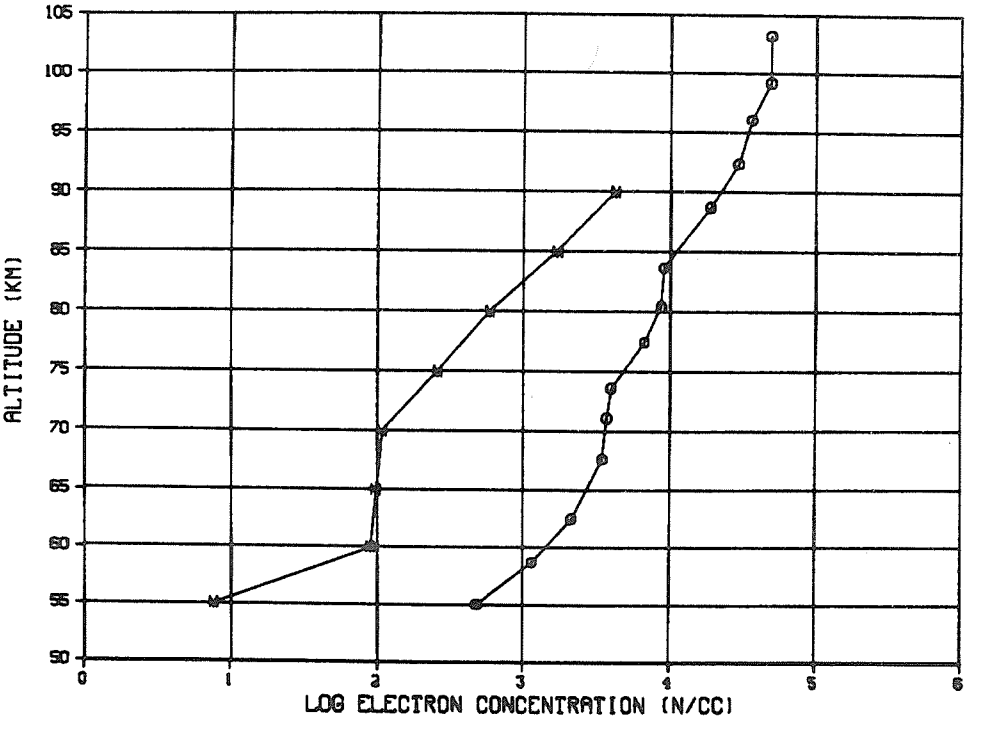


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	384	69	11	3	730	105	58.8	265.8	2	2	44	20.3	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

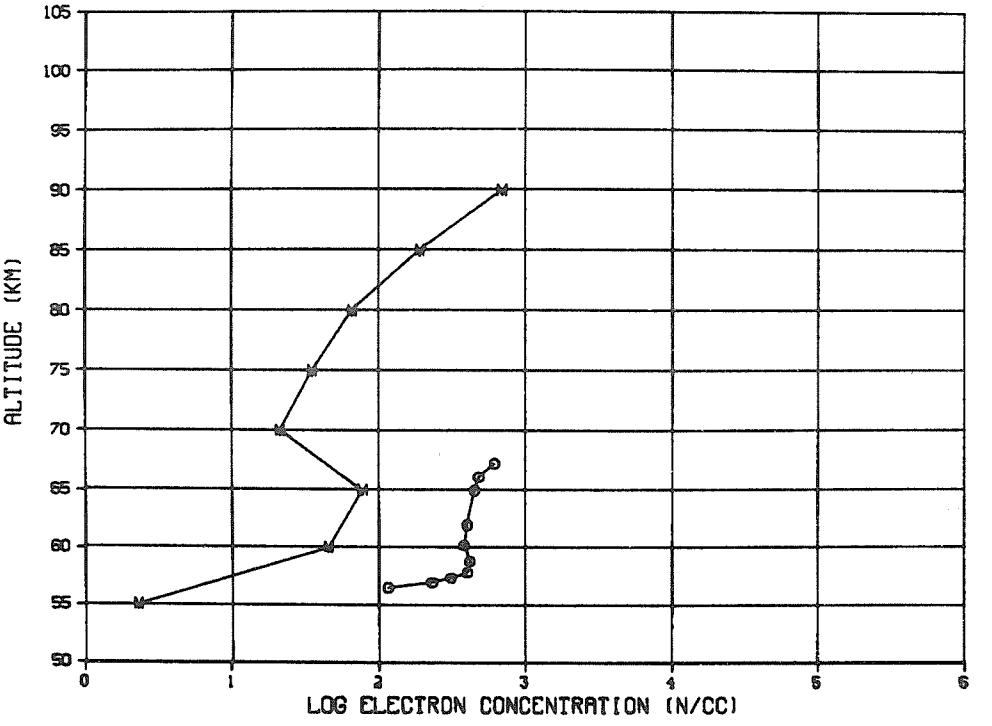


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	388	69	11	4	1530	105	58.8	265.8	2	2	44	20.6	8
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

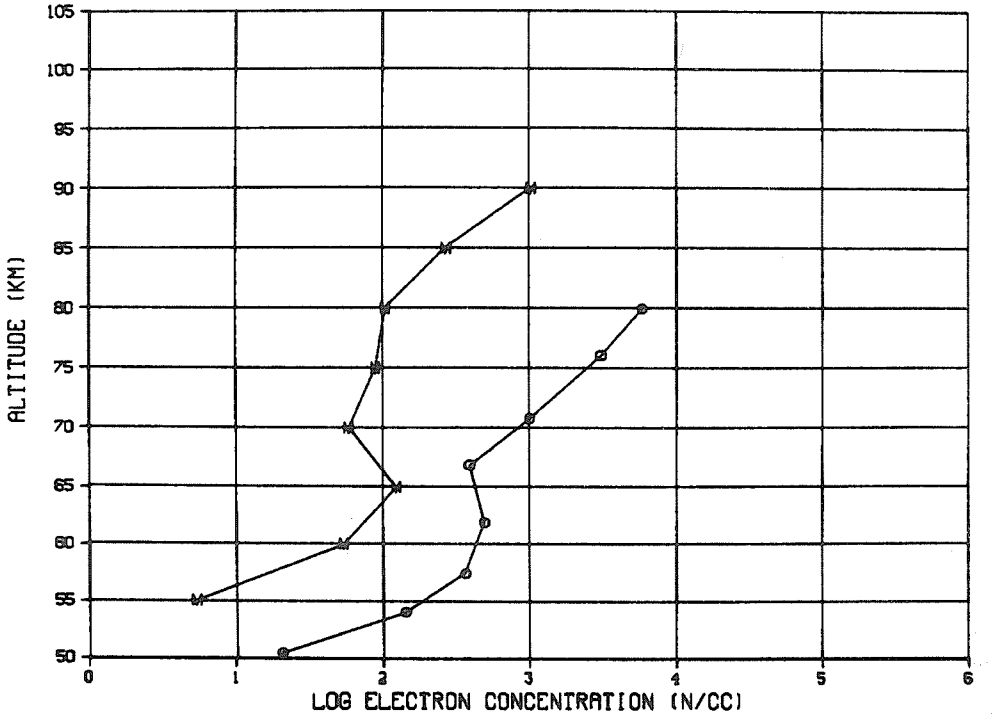


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	16	58	11	26	2100	181	69.7	19.0	3	1	72	6	12
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

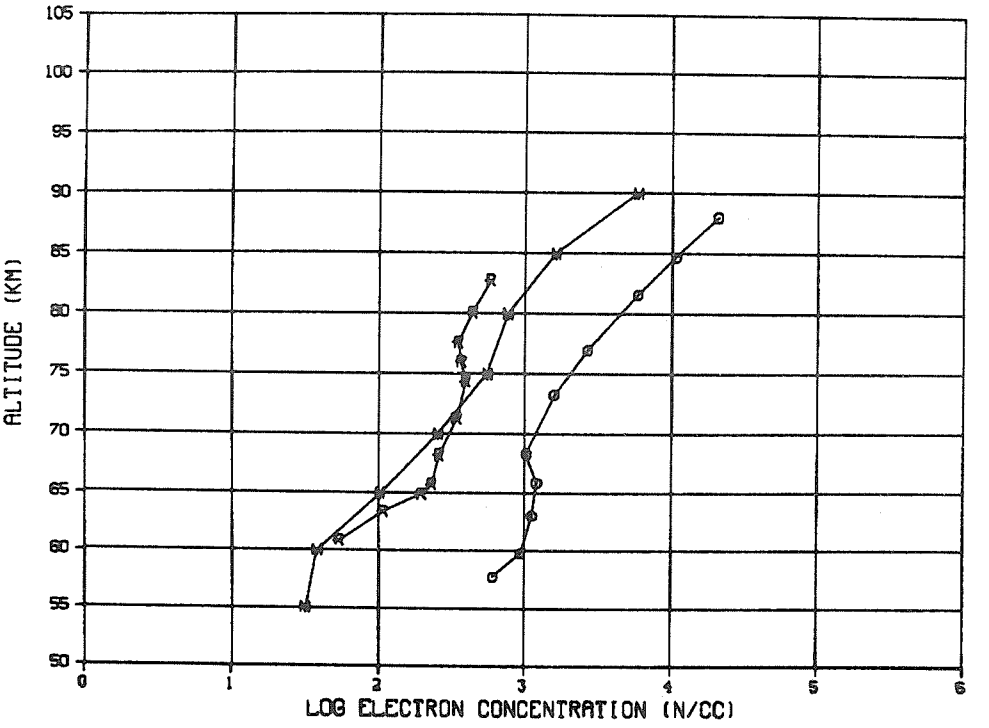


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	20	59	8	26	2120	151	69.7	19.0	3	1	72	11	12
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

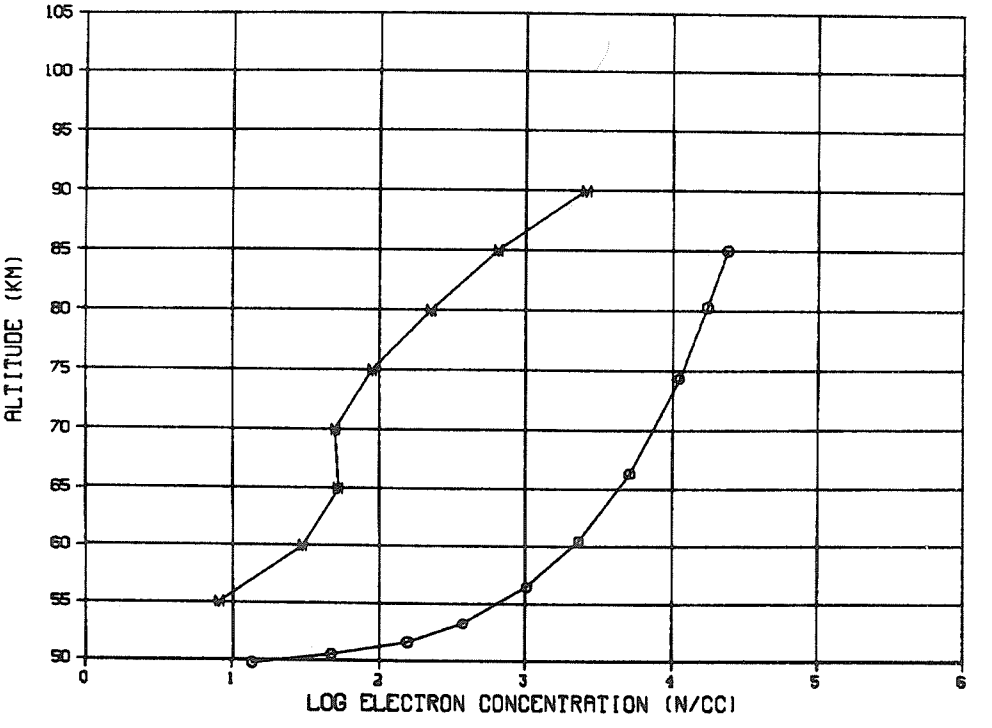


SOLAR PROTON EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	42	61	7	14	1100	53	45.4	284.1	1	1	14	9	9
REFERENCE (R)	41	61	6	0	1200	56	45.4	284.1	1	1	14	9	0
MODEL (M)													

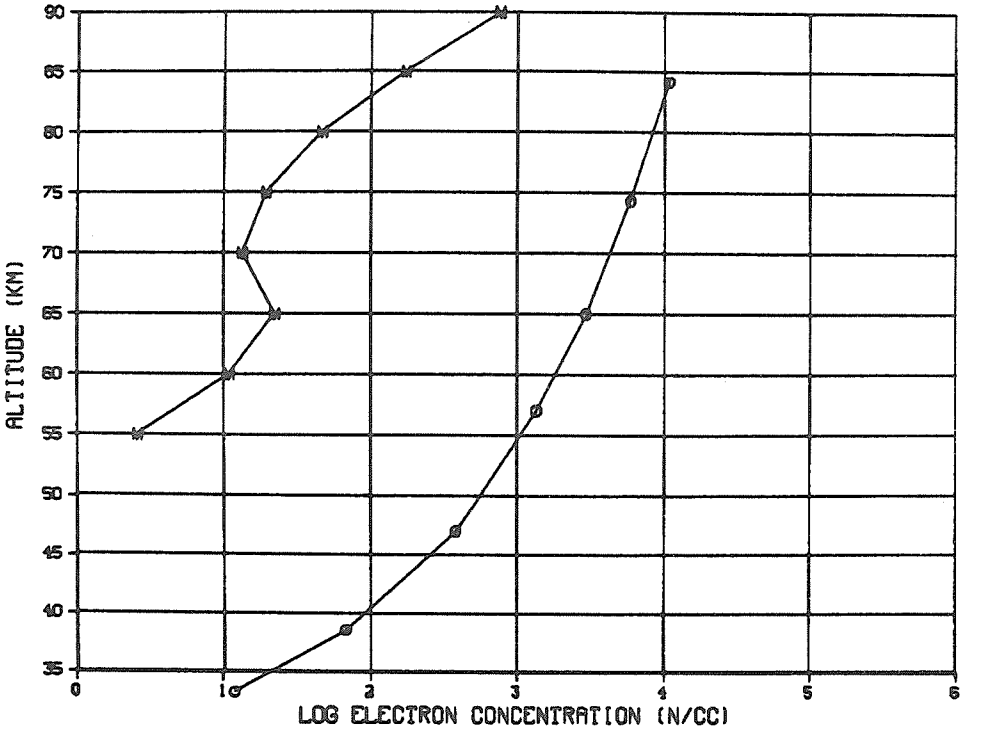


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	484	62	2	18	915	42	64.9	212.1	5	1	104	6	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

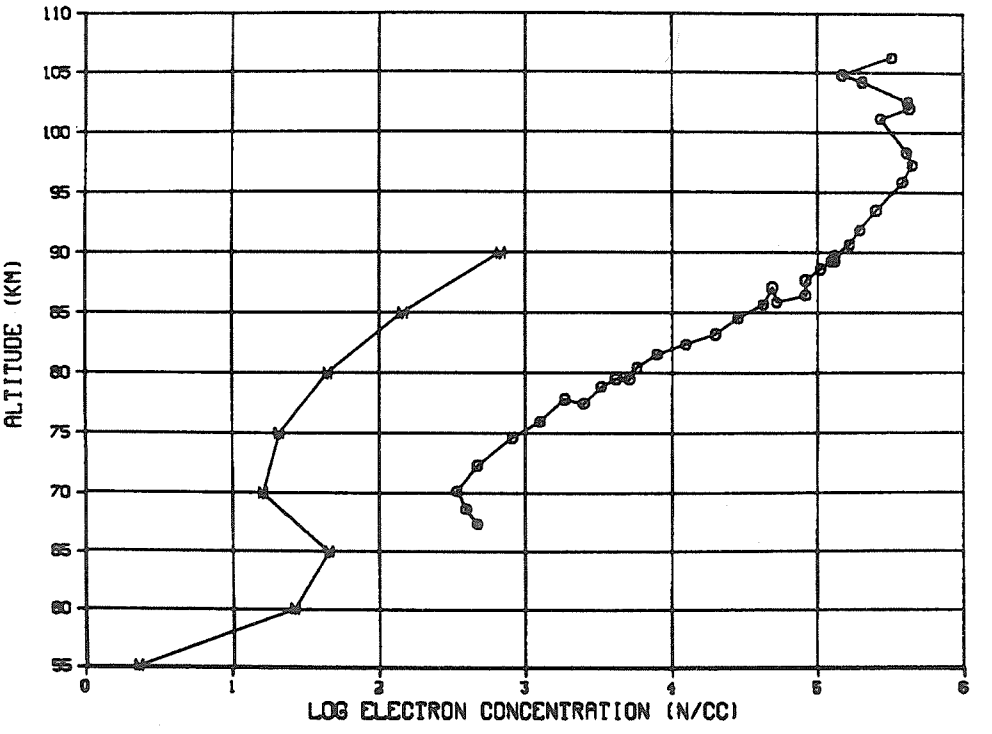


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	487	62	2	23	140	42	64.9	212.1	5	1	104	6	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

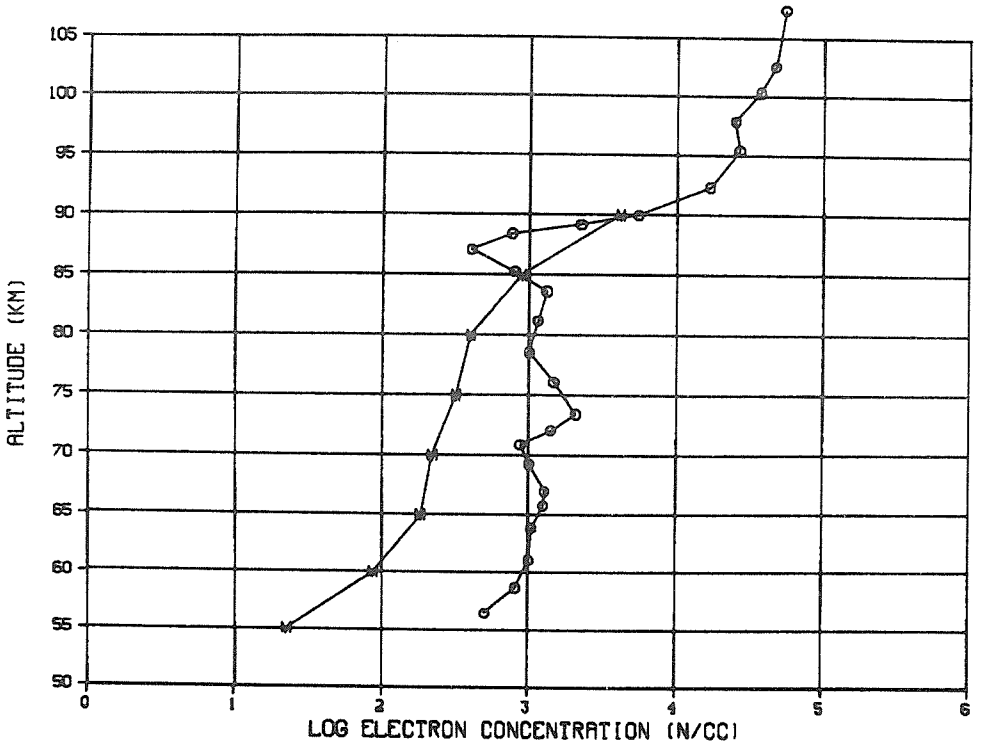


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	282	67	11	20	137	97	69.3	16.0	2	1	112	15	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

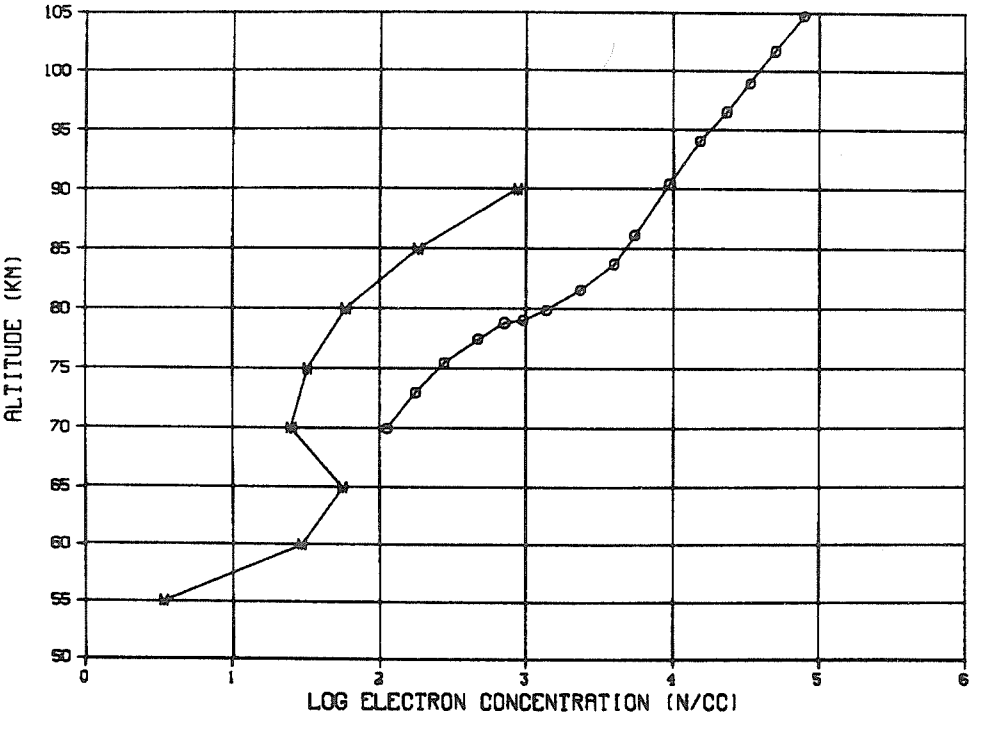


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	248	66	6	26	1200	45	69.3	16.0	2	1	112	8	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

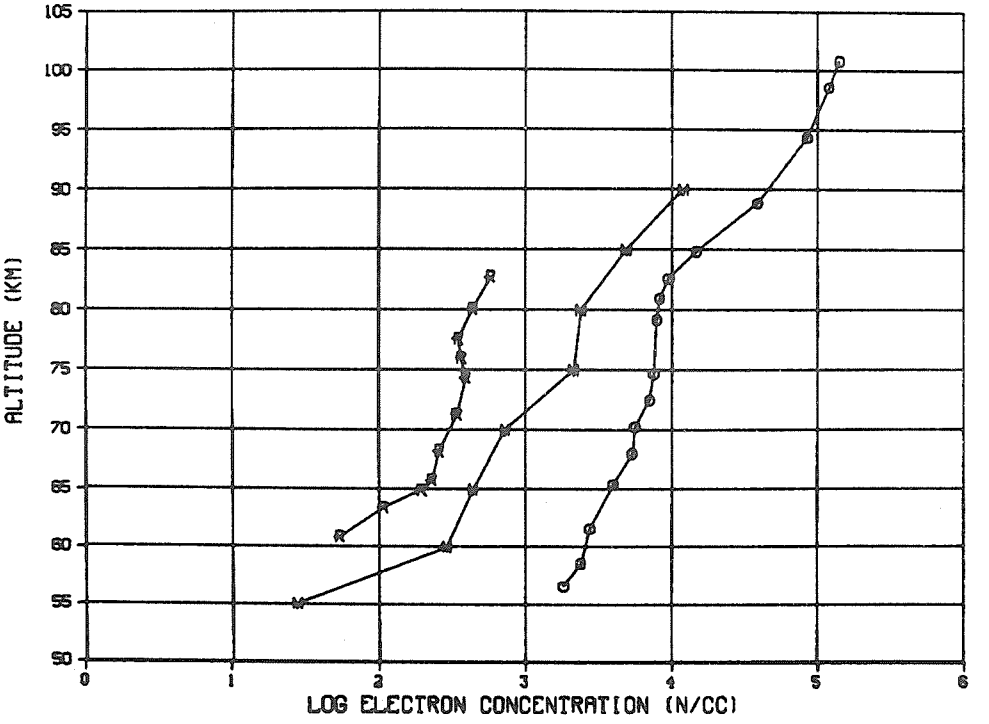


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	272	67	3	15	46	82	69.3	16.0	2	1	75	0	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

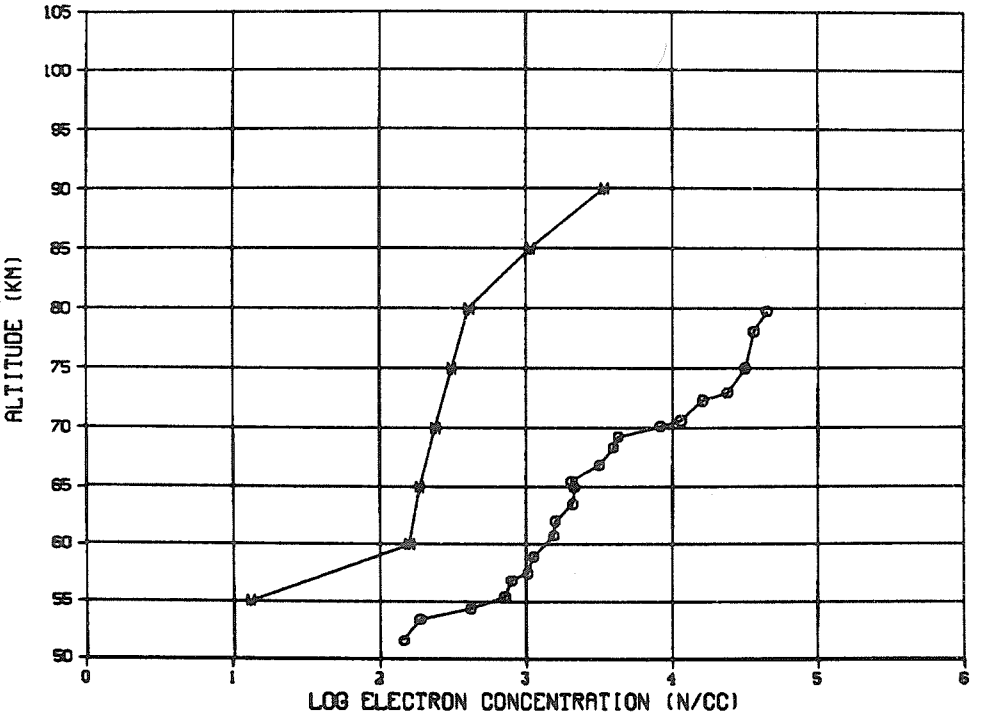


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	12	57	7	4	1216	191	58.8	265.8	2	2	14	9	9
REFERENCE (R)	41	61	6	0	1200	56	45.4	284.1	1	1	14	9	0
MODEL (M)													

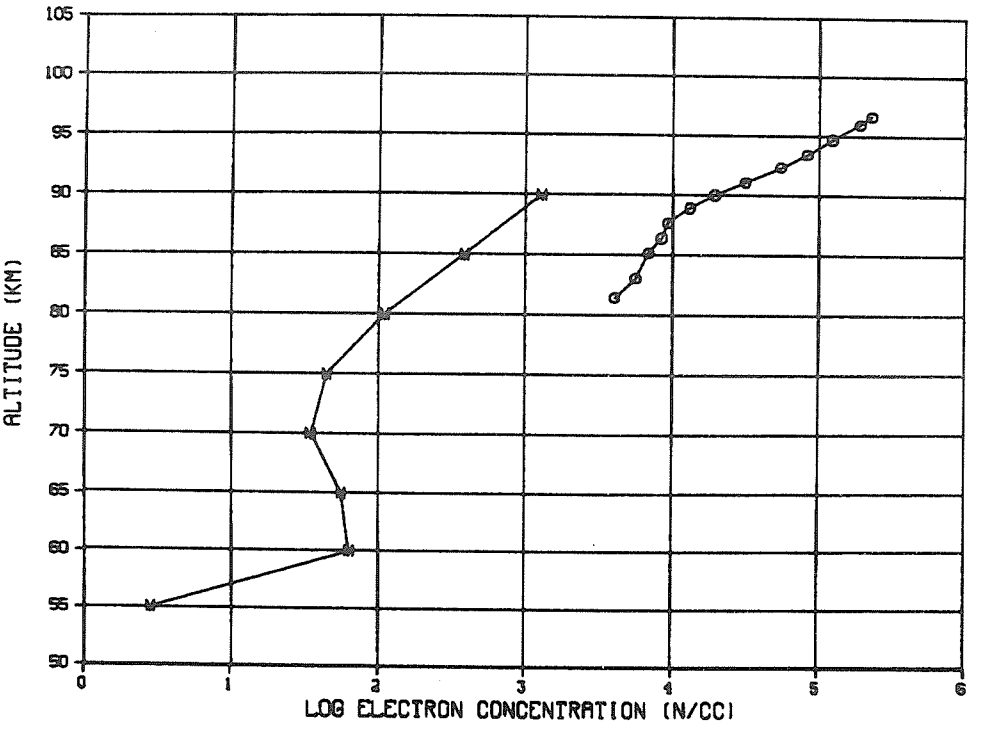


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	60	62	8	18	809	35	69.3	16.0	2	2	77	6	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

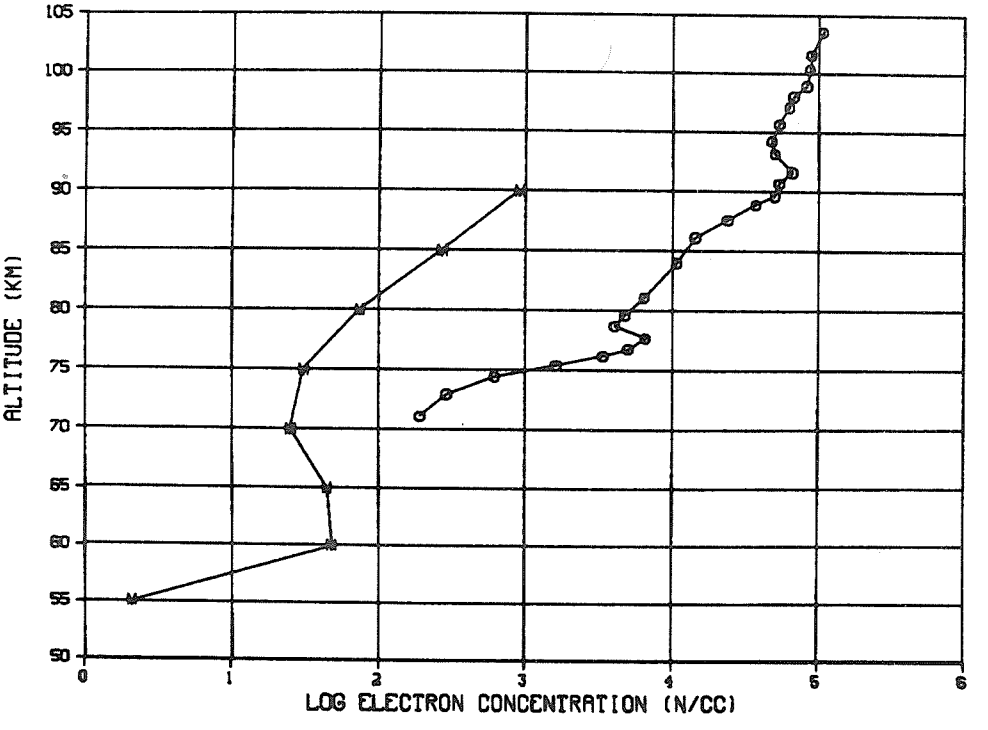


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	69	62	12	11	427	30	69.3	16.0	2	2	77	10	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

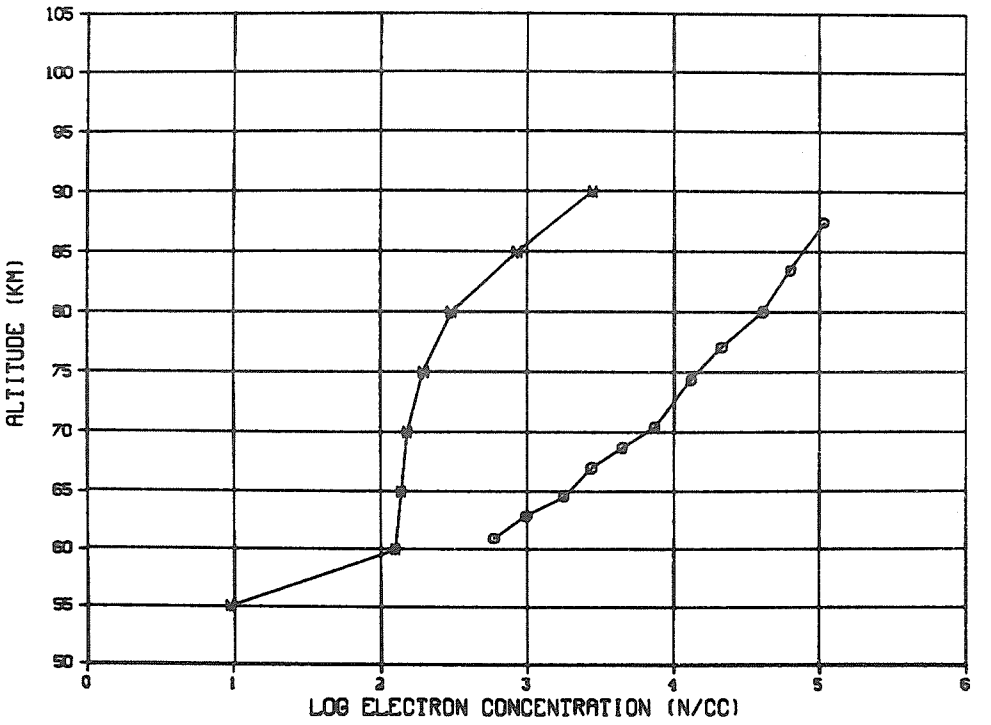


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	70	62	12	14	2152	30	69.3	16.0	2	2	77	10	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

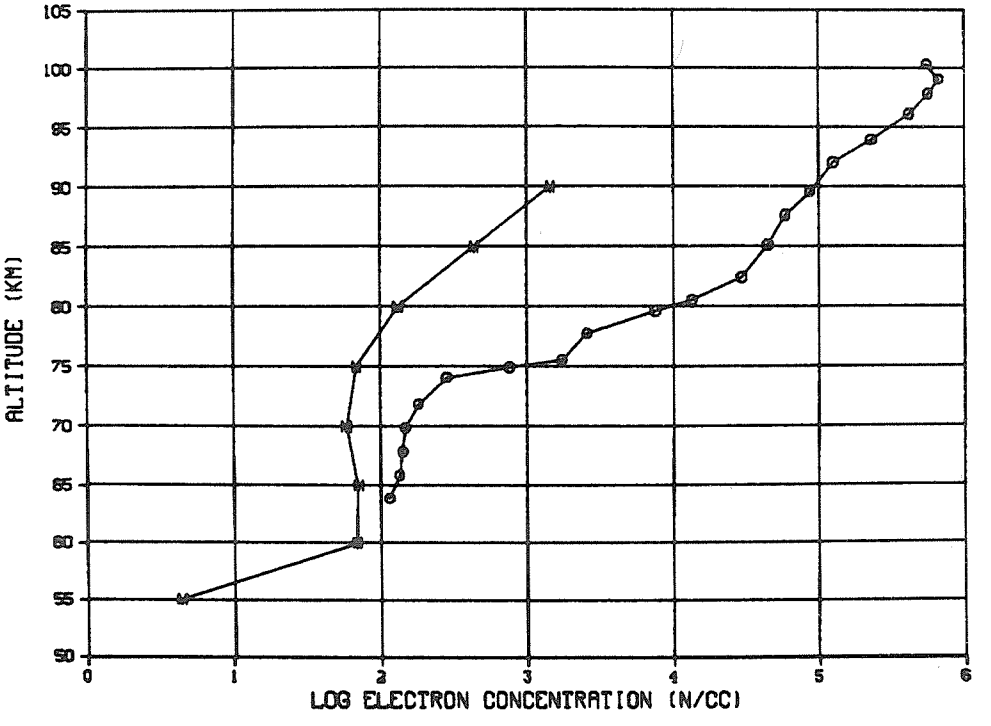


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	86	63	9	12	720	27	69.3	16.0	2	2	74	3	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

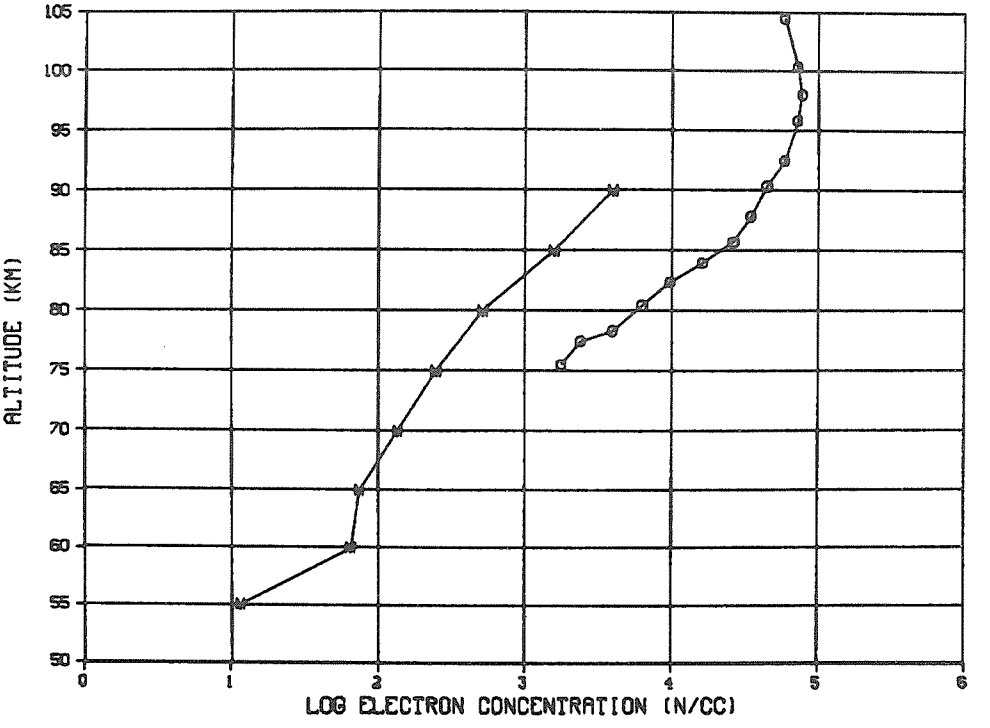


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	99	64	3	12	358	15	69.3	16.0	2	2	74	3	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

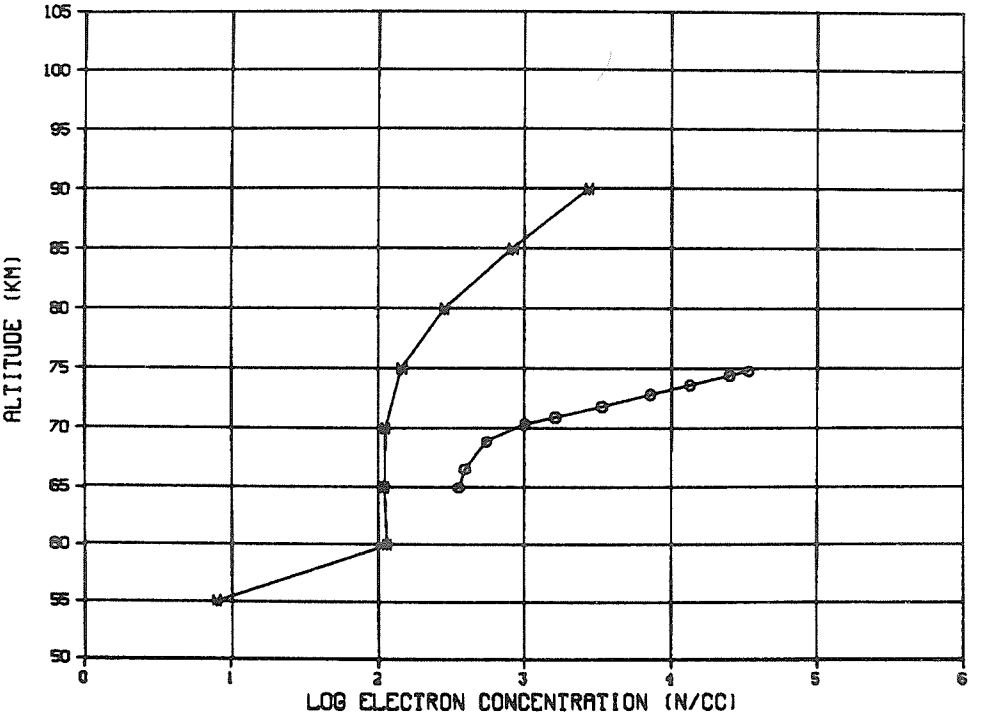


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	143	64	10	27	1200	10	58.8	265.8	2	2	140	3	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

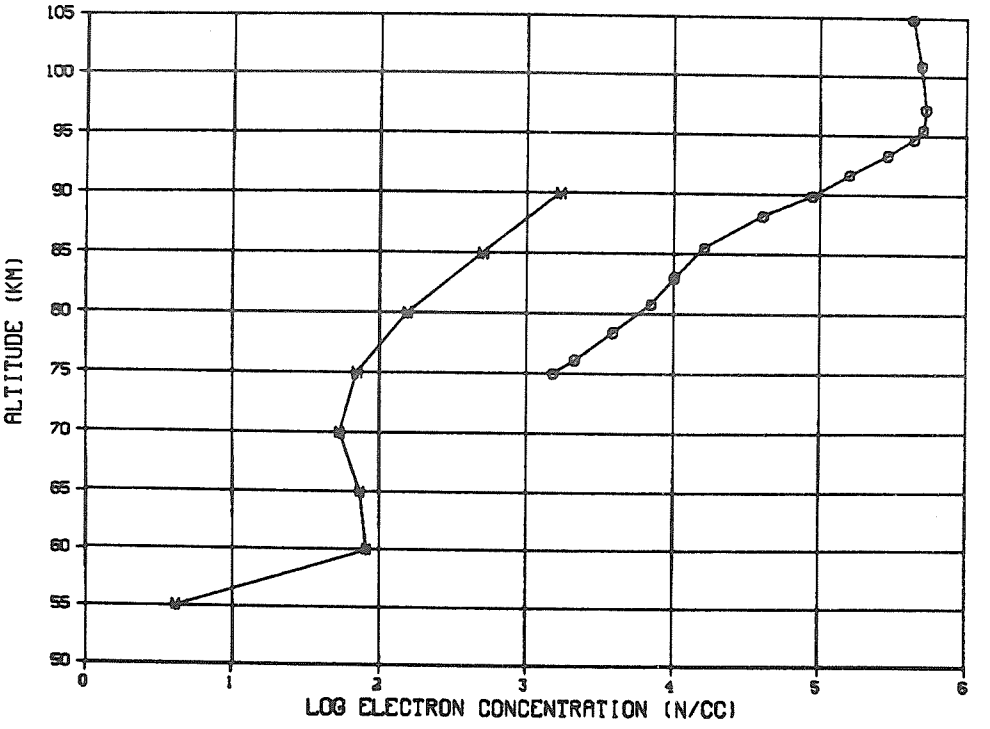


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	168	65	3	21	659	13	69.3	16.0	2	2	75	0	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

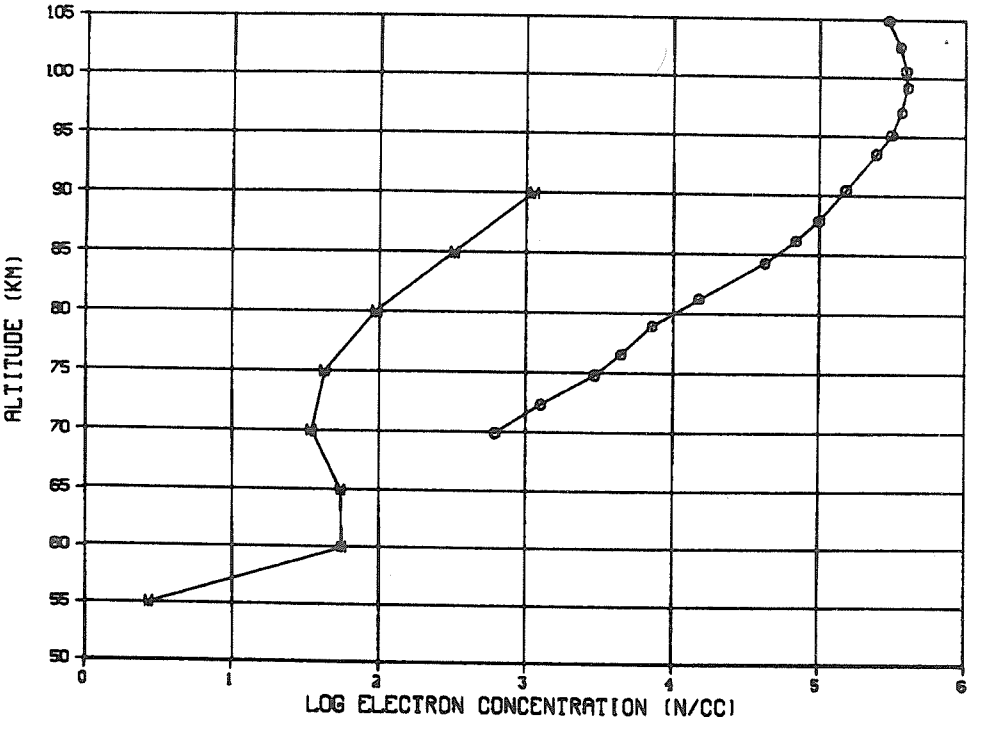


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	222	66	2	22	1929	31	69.3	16.0	2	2	75	0	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

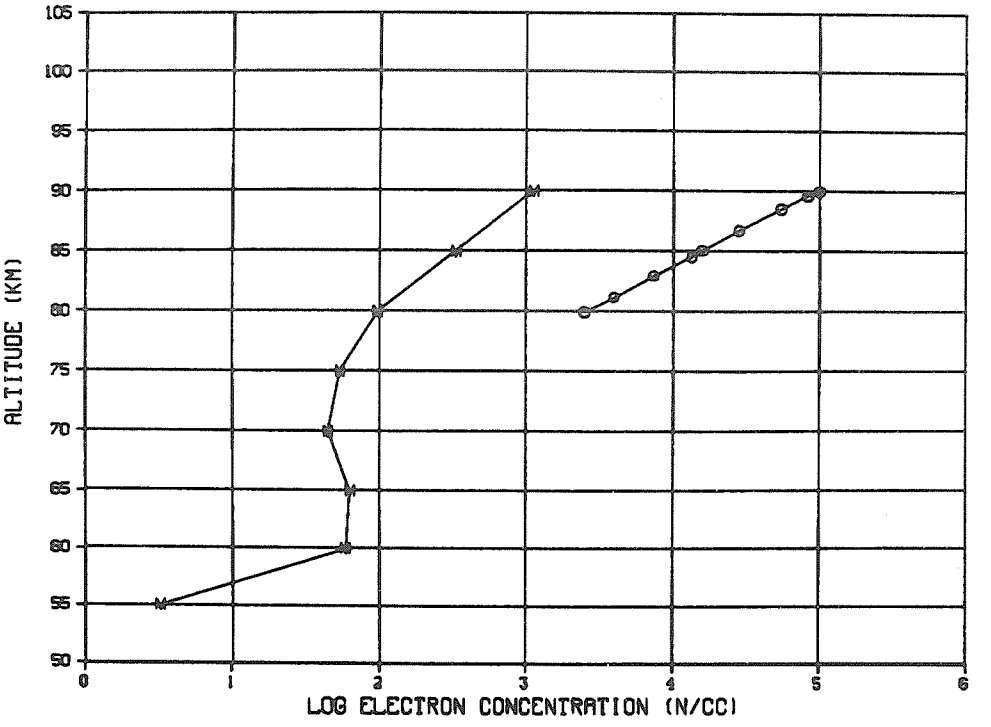


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	223	66	2	24	15	31	69.3	16.0	2	2	75	0	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

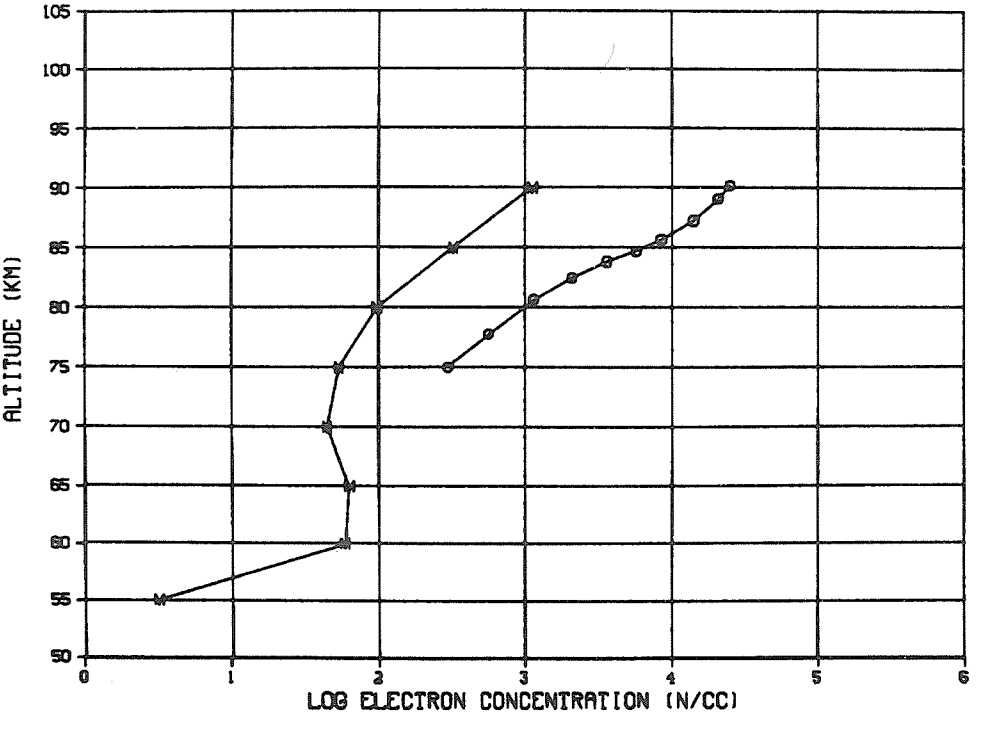


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	225	66	3	10	2326	34	69.3	16.0	2	2	75	0	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

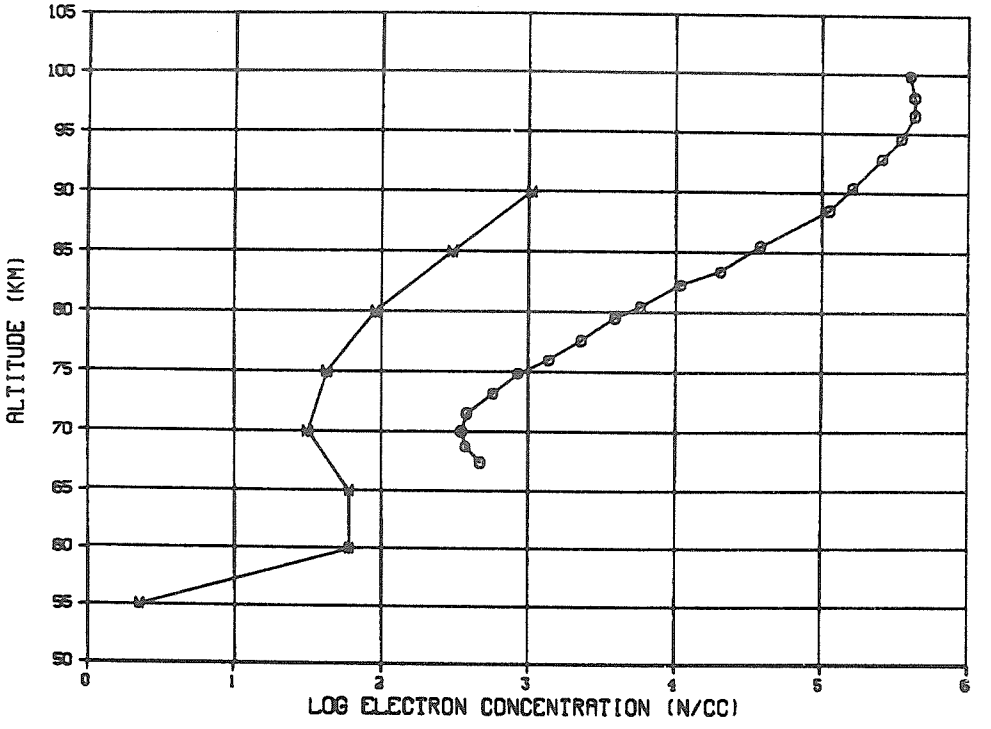


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	224	66	3	9	2320	34	69.3	16.0	2	2	75	0	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

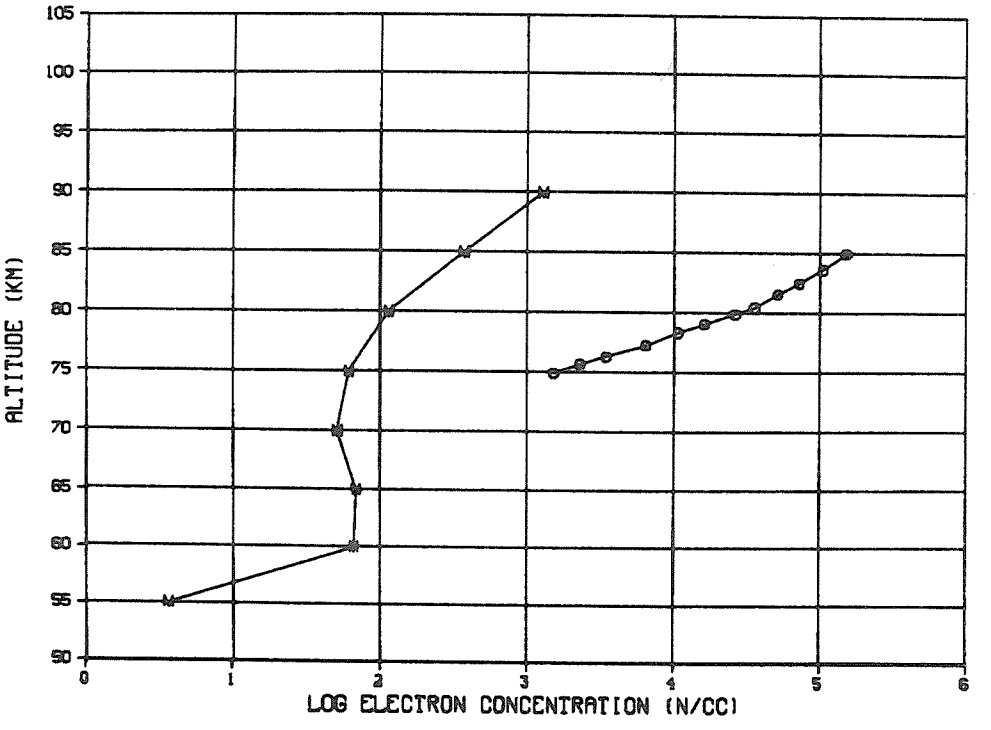


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	265	66	11	20	138	70	69.3	16.0	2	2 75		2	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0 0			0
MODEL (M)													

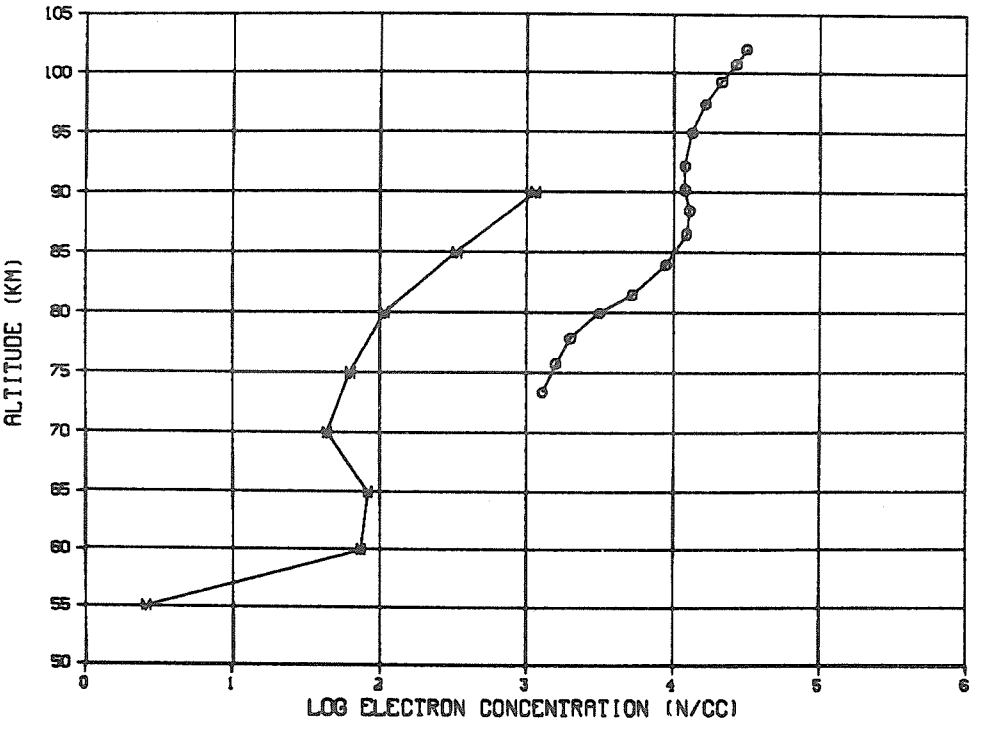


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	226	66	3	22	4	34	69.3	16.0	2	2 75		0	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0 0			0
MODEL (M)													

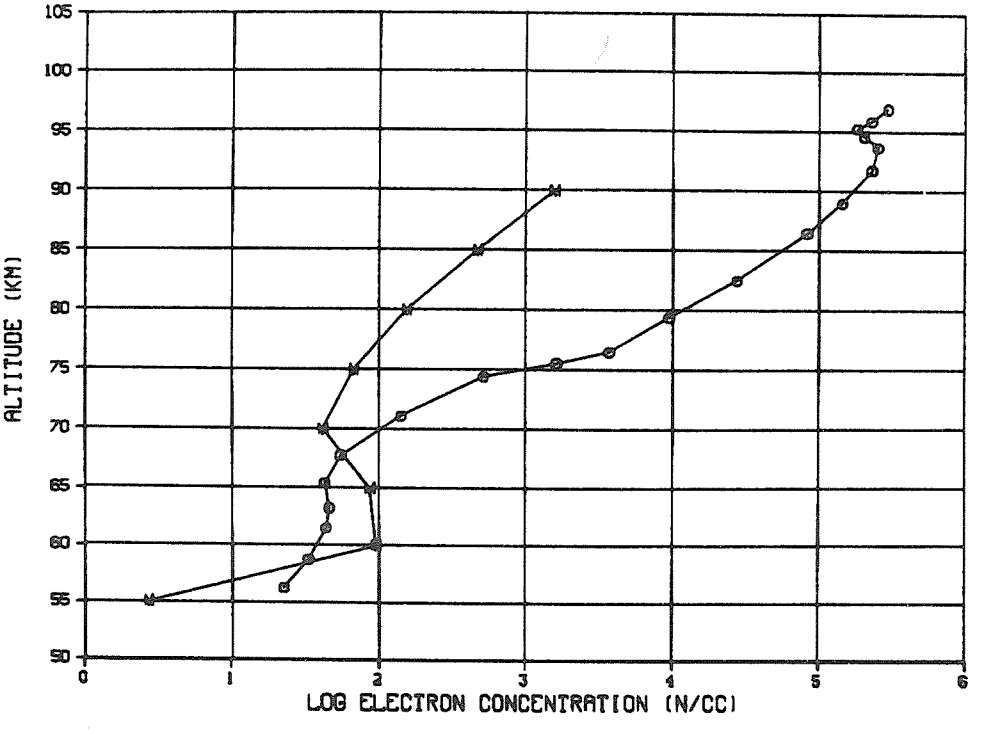


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	353	68	10	24	2150	110	67.8	20.4	2	2	47	1	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

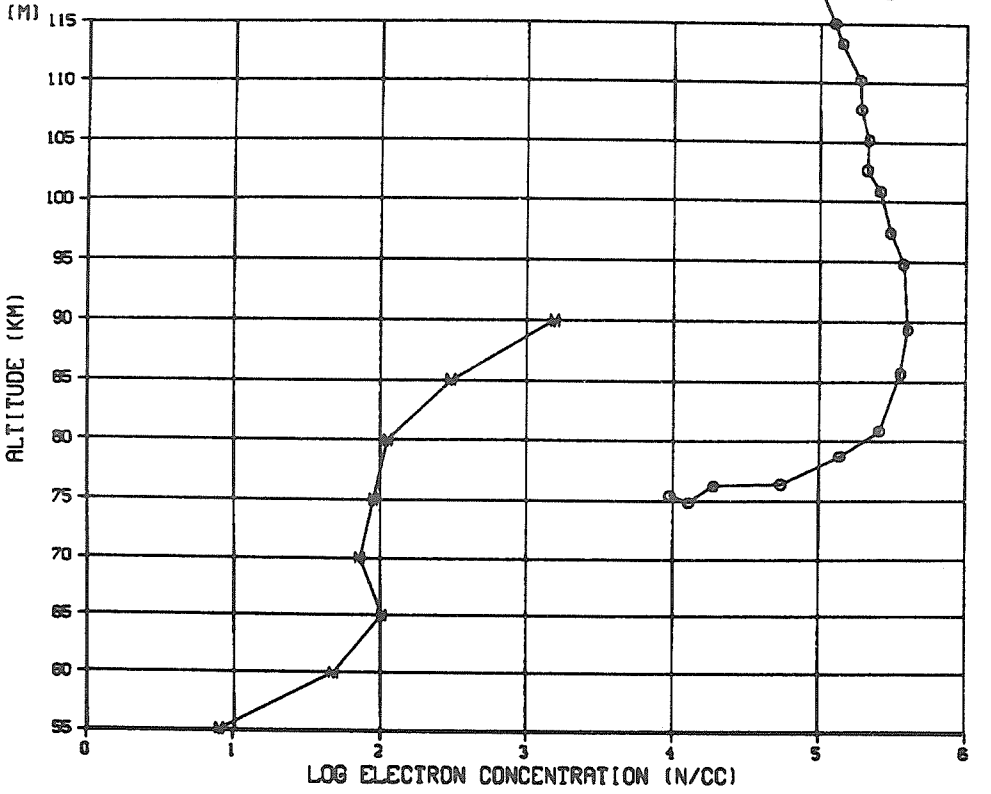


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	362	69	1	18	2024	110	69.3	16.0	2	2	47	1	9
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

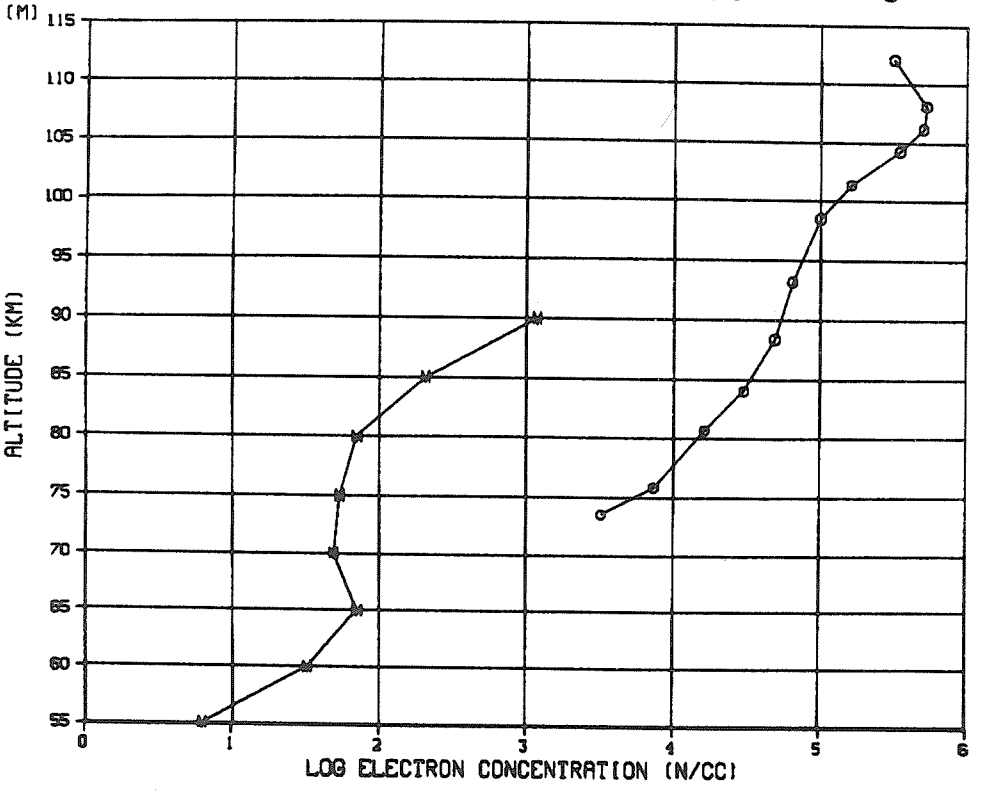


AURORAL ABSORPTION EVENT

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	483	72	8	7	445	66	-69.0	39.0	2	1	100	1	11
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

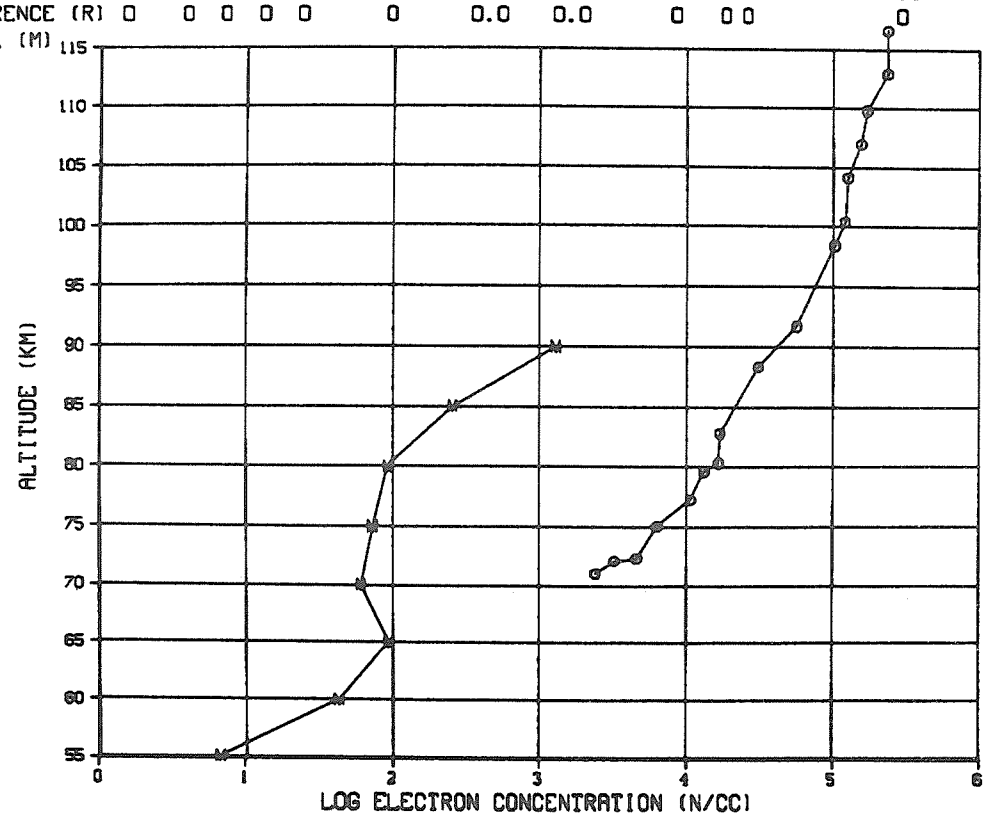


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	488	73	8	23	354	36	-69.0	39.0	2	1	100	7	11
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

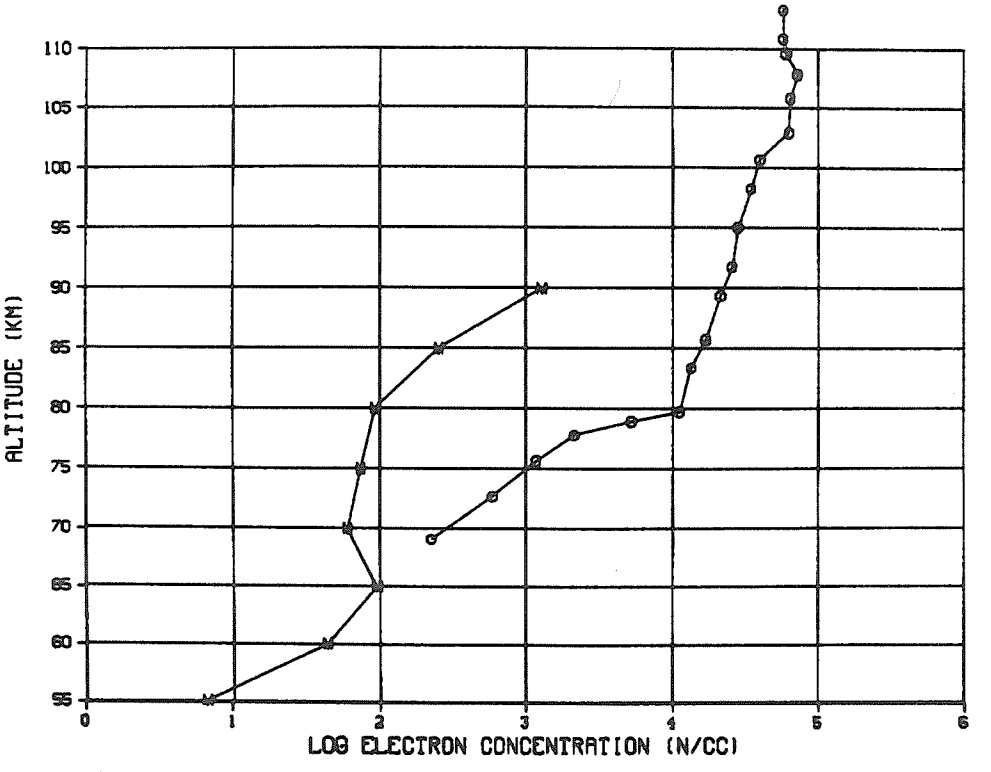


POLAR SUBSTORM

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	482	72	5	14	213	73	-69.0	39.0	2	1	100	1	11
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

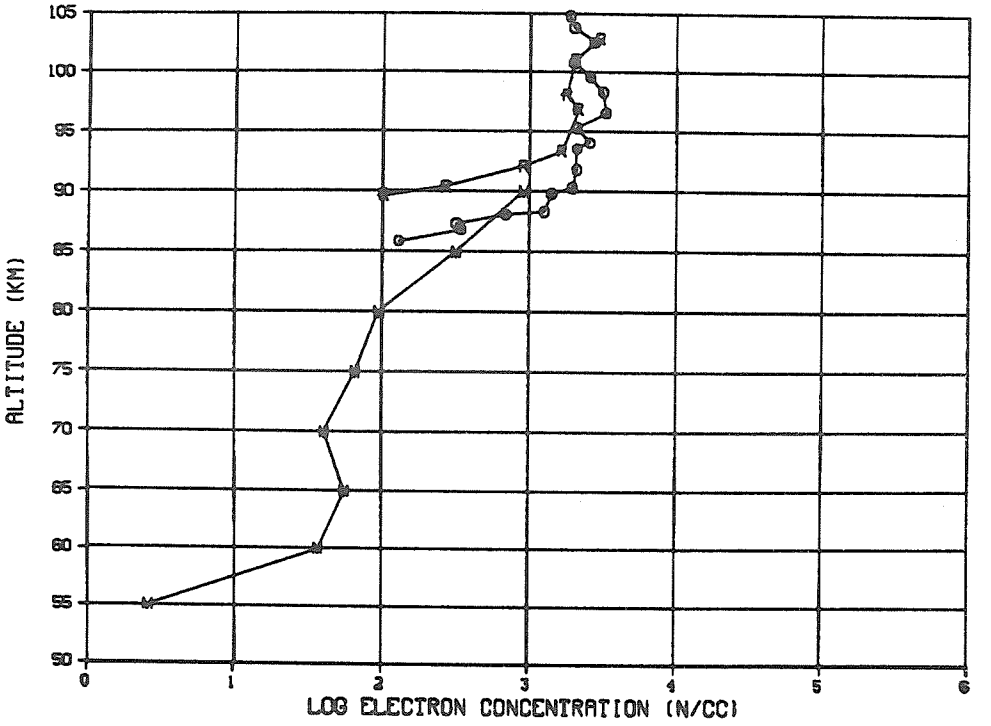


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	480	72	5	16	202	73	-69.0	39.0	2	1	100	1	11
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													

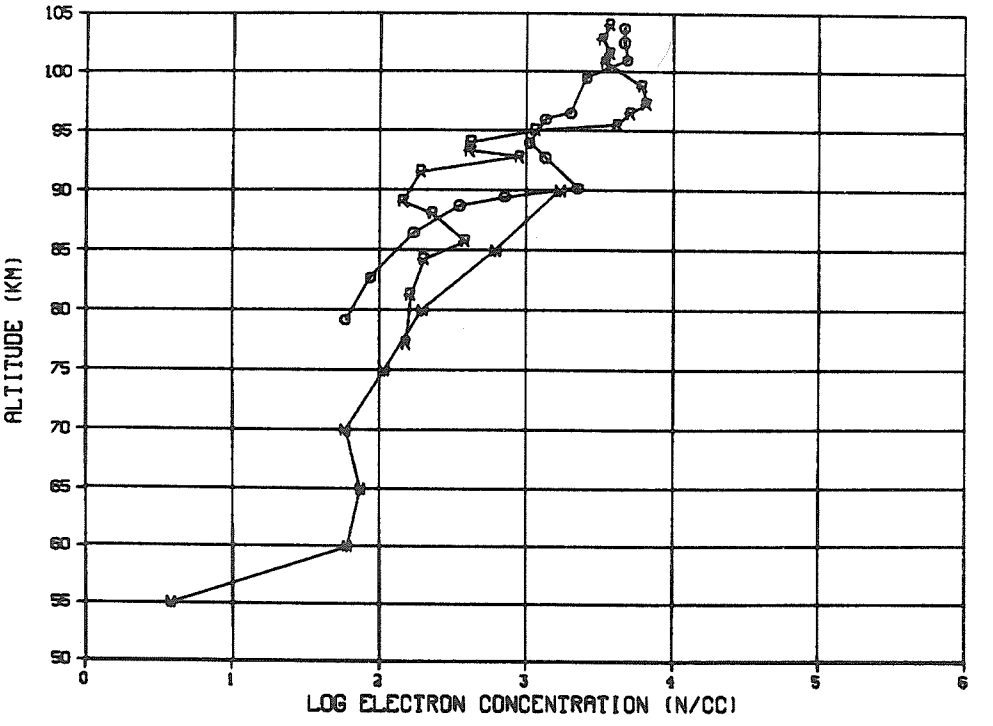


POLAR SUBSTORM

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	995	69	9	30	2241	105	57.2	352.9	2	2	151	3	11
REFERENCE (R)	994	72	8	31	2	65	57.2	352.9	2	1	151	3	0
MODEL (M)													

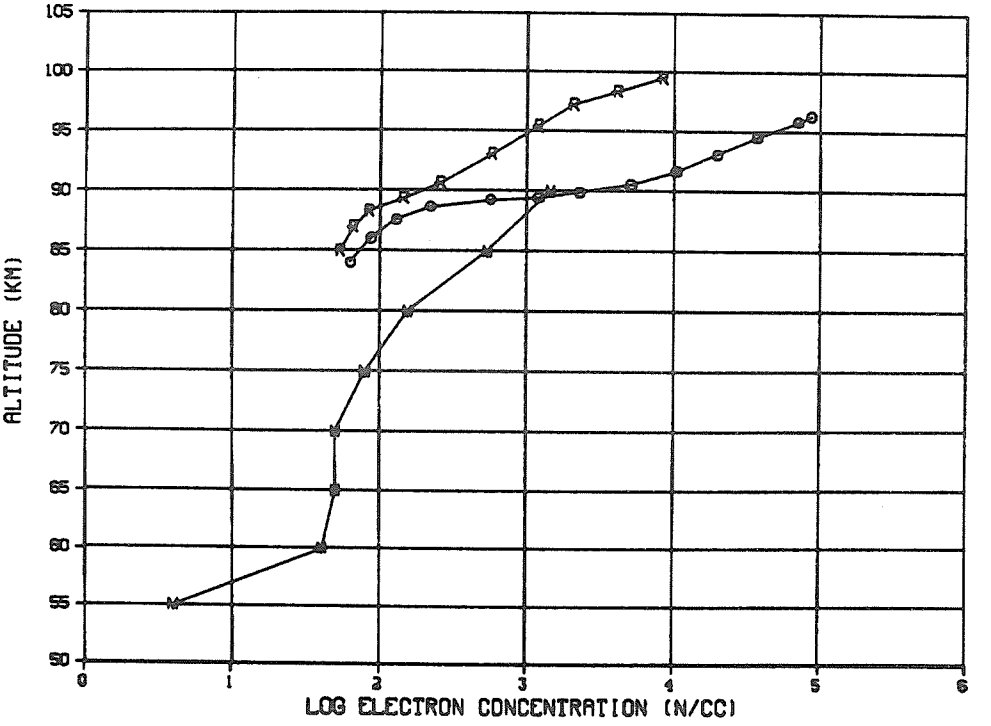


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	996	69	10	1	420	104	57.2	352.9	2	2	151	3	11
REFERENCE (R)	993	72	8	30	2202	65	57.2	352.9	2	1	151	3	0
MODEL (M)													

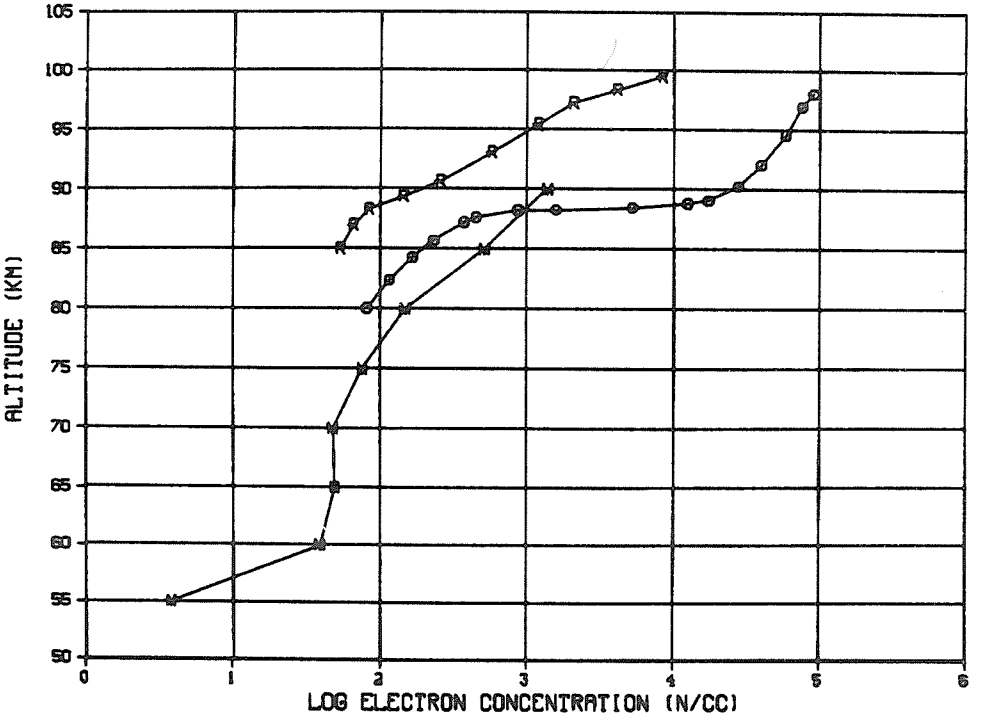


POLAR SUBSTORM

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG REF	FIG	SPC
OBSERVED (O)	967	73	3	24	2115	44	65.3	212.2	1	2 153	4.3	13
REFERENCE (R)	966	73	3	24	2100	44	65.3	212.2	1	2 153	4.3	0
MODEL (M)												

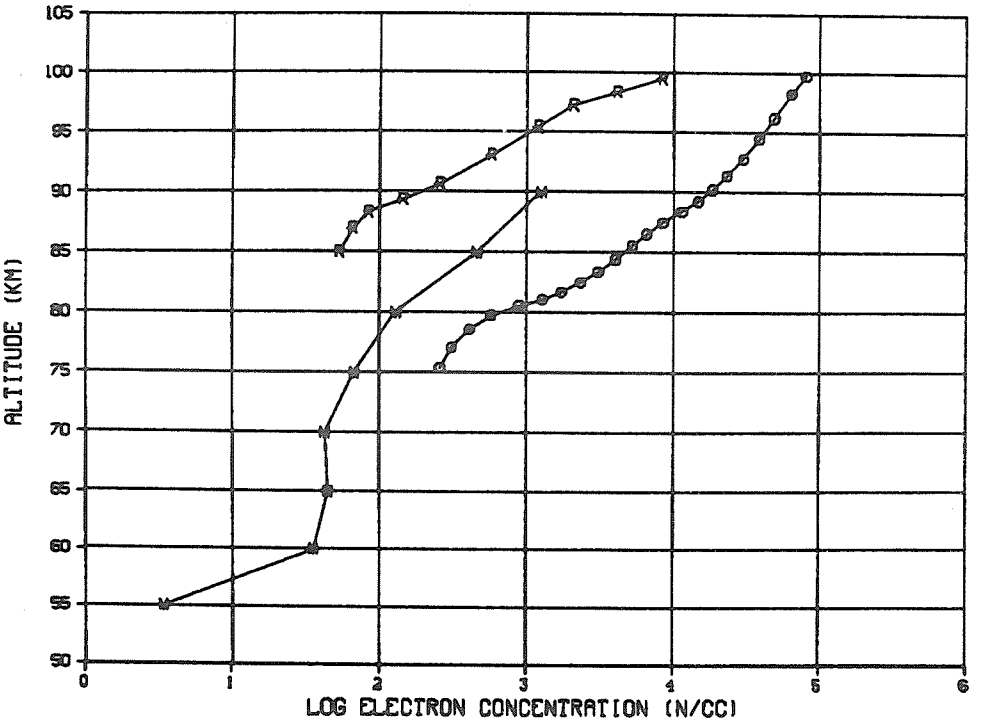


	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG REF	FIG	SPC
OBSERVED (O)	968	73	3	24	2135	44	65.3	212.2	1	2 153	4.3	13
REFERENCE (R)	966	73	3	24	2100	44	65.3	212.2	1	2 153	4.3	0
MODEL (M)												

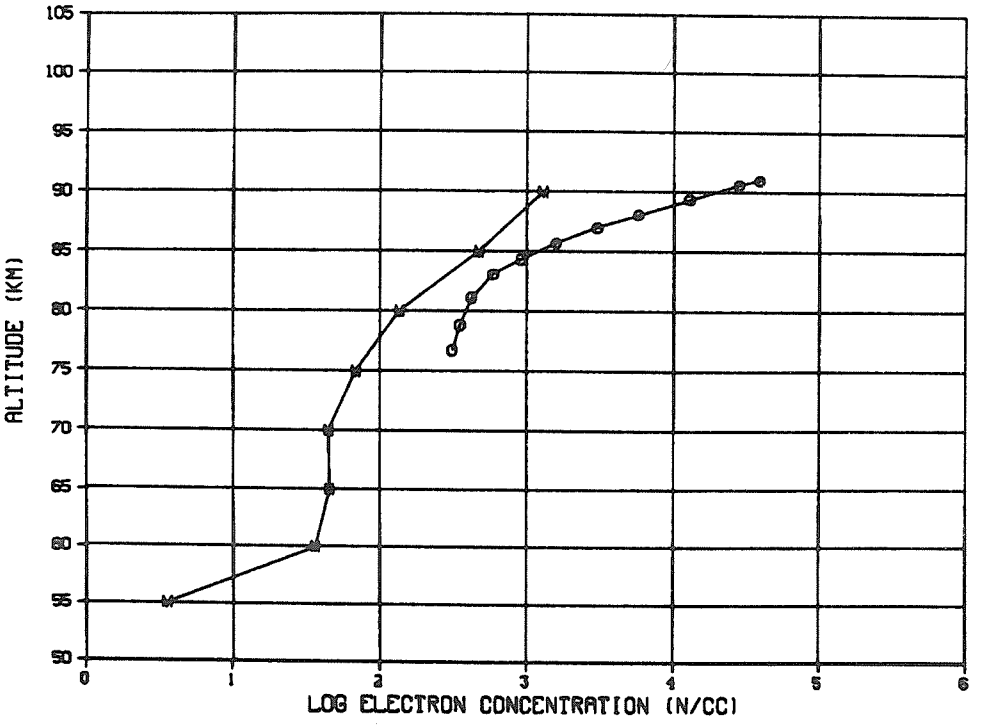


AURORAL ARC CONDITIONS. #966 PRE-ARC; #967 ARC FORMATION; #968 ARC BREAK UP (SEE NEXT PAGE).

	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	969	73	3	24	2250	44	65.3	212.2	1	2	153	4.3	13
REFERENCE (R)	966	73	3	24	2100	44	65.3	212.2	1	2	153	4.3	0
MODEL (M)													



	CURVE	YR	MO	DY	TIME	SSNO	LAT	LONG	METH	MAG	REF	FIG	SPC
OBSERVED (O)	970	73	3	26	2238	44	65.3	212.2	1	2	153	4.7	13
REFERENCE (R)	0	0	0	0	0	0	0.0	0.0	0	0	0		0
MODEL (M)													



AURORAL ARC CONDITIONS. #966 PRE-ARC; #969 SUBSEQUENT AURORAL ACTIVITY (SEE PREVIOUS PAGE).

APPENDIX A

The computer program DISPPLT selects all D-region profiles obtained under specified disturbed conditions, and prepares the data for the plotting program DREGPLT. The input files TAPE5 and TAPE6 are the "header card file," DB1, and the "digitized data file," DB3, described by McNamara [1978]. The input file TAPE7 is the file PRODAT which contains the corresponding values of curve identification number for the disturbed and reference profiles. The program expects the special case parameter to be entered on the keyboard in FORMAT (I2). The output file, TAPE10, should be saved for plotting.

The program listing of DISPPLT below must be changed slightly for magnetically disturbed days to be considered. The statement IF (MAG.NE.1) GO TO 15 must be changed to IF (MAG.NE.2) GO TO 15. The subroutine PROFILE must also be replaced by the version appropriate to magnetically disturbed days, and the first six lines of TAPE7 deleted.

```
      PROGRAM DISPPLT(INPUT,OUTPUT,TAPE5,TAPE6,TAPE7,TAPE8,
     A TAPE9,TAPE10,TAPE11)
C     PROGRAM TO SELECT "UNUSUAL CONDITION" PROFILES AND THE CORRESPONDING
C     REFERENCE PROFILE (IF ANY) AND CALCULATE STATISTICAL MODEL PROFILE
C...   THIS VERSION MAG QUIET DAYS ONLY
C...   TAPE5 = DB1
C...   TAPE6 = DB3
C...   TAPE7 = TABLE OF CORRESPONDING REFERENCE PROFILES
C...   TAPE8 = OUTPUT FILE ..... HEADER CARDS
C...   TAPE11 = OUTPUT FILE ..... HEADER CARDS FOR REFERENCE PROFILES
C...   TAPE9 = OUTPUT FILE ..... DIGITIZED DATA
C...   TAPE10 = OUTPUT ARRANGED IN MORE SUITABLE ORDER
      DIMENSION NUM(100),IYL(100),IML(100),IDL(100),LHL(100),LML(100),
     A ISL(100),FFL(100),FWL(100),DEN(8),HT(8),H(200),
     A FLN(200),OBS(8),IK(100),IR(100),IRFL(100),IKRL(100)
      DIMENSION ADEN(8),AHT(8)
      DIMENSION BLANKS(20)
      DATA BLANKS / 20*4H
C
C     READ IN THE REFERENCE PROFILES CORRESPONDING TO EACH "UNUSUAL PROFILE"
      READ(7,400) (IK(L),IR(L),L=1,64)
400   FORMAT(26I3)
C
C     HEIGHTS AT WHICH DENSITIES ARE TO BE FOUND
      DO 3 I=1,8
3     HT(I)=90.-5.*(I-1)
C
C***  WHAT SPECIAL CASE PARAMETER IS TO BE CONSIDERED??????????
5     READ 10, ISPECL
      IF(ISPECL.EQ.0) STOP
      PRINT 200,ISPECL
200   FORMAT(///1X,*SPECIAL CASE PARAMETER =*,I3)
10    FORMAT(I2)
      REWIND 5
      REWIND 6
      REWIND 7
      REWIND 8
      REWIND 9
      REWIND 11
C
C     READ IN THE HEADER CARD FILE TO FIND ALL REQUIRED PROFILES
      L=0
15    READ(5,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
     A MAG,KOL,IREF,IFIG,ISPEC
100   FORMAT(I5,4I3,I2,I4,2F6.1,2I2,I3,I4,A5,2I3)
      IF(KURVE.EQ.9999) GO TO 25
C---  MAGNETICALLY QUIET DAYS ONLY
      IF(MAG.NE.1) GO TO 15
      IF(ISPEC.EQ.ISPECL) GO TO 20
      GO TO 15
20    L=L+1
      IF(L.LE.100) GO TO 22
      PRINT 23
23    FORMAT(* TOO MANY CASES*)
      STOP
22    NUM(L)=KURVE
```

```
C      FIND CORRESPONDING REFERENCE PROFILE
       DO 21 I=1,64
       II=I
       IF(KURVE.EQ.IK(I)) GO TO 24
21     CONTINUE
       GO TO 19
24     IKR=IR(II)
       IKRL(L)=IKR
19     CONTINUE
       IYL(L)=IY
       IML(L)=IM
       IDL(L)=ID
       LHL(L)=LH
       LML(L)=LM
       ISL(L)=ISSNO
       FFL(L)=FLAT
       FWL(L)=360.-FLON
       IRFL(L)=IREF
C      WRITE OUT THE HEADER CARD INFORMATION
       WRITE(8,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
      A MAG,KOL,IREF,IFIG,ISPEC,IKR
       PRINT 100, KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
      A MAG,KOL,IREF,IFIG,ISPEC,IKR
       GO TO 15
C      ALL DATA READ IN
25      REWIND 5
       LL=L
       KK=9999
       WRITE(8,100) KK
C
C      WRITE OUT HEADER CARDS FOR REFERENCE PROFILES
115    READ (5,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
      A MAG,KOL,IREF,IFIG,ISPEC
       IF(KURVE.EQ.9999) GO TO 125
       DO 124 J=1,LL
       IF(KURVE.NE.IKRL(J)) GO TO 124
       WRITE(11,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
      A MAG,KOL,IREF,IFIG,ISPEC
       PRINT 100, KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
      A MAG,KOL,IREF,IFIG,ISPEC
       GO TO 115
124    CONTINUE
       GO TO 115
125    KK=9999
       WRITE(11,100) KK
       REWIND 5
C      FOR EACH REQUIRED PROFILE, CALCULATE STATISTICAL MODEL AND
C      FIND REFERENCE PROFILE
       PRINT 210, LL
210    FORMAT(/1X,*THERE ARE *,I3,* SUCH PROFILES*)
       IF(LL.EQ.0) GO TO 5
C      READ IN THE DIGITIZED PROFILES ONE BY ONE
40     READ(6,110) KURVE
110    FORMAT(I4)
       IF(KURVE.EQ.9999) GO TO 74
       J1=-5
60     J1=J1+6
       J2=J1+5
       READ(6,120) (FLN(J),H(J),J=J1,J2)
120    FORMAT(12F6.2)
       IF(H(J2).NE.0.) GO TO 60
C      SEE IF THIS CURVE IS A REQUIRED SPECIAL CASE
       DO 71 L=1,LL
        IF(KURVE.NE.NUM(L)) GO TO 71
C       CURVE IS REQUIRED ..  WRITE IT OUT
       WRITE(9,110) KURVE
       WRITE(9,120) (FLN(J),H(J),J=1,J2)
       GO TO 40
71     CONTINUE
```

```
C      SEE IF CURVE IS A REQUIRED REFERENCE CURVE
       DO 73 L=1,LL
       IF(KURVE.NE.IKRL(L)) GO TO 73
C      CURVE IS REQUIRED
       WRITE(9,110) KURVE
       WRITE(9,120) (FLN(J),H(J),J=1,J2)
       GO TO 40
73     CONTINUE
       GO TO 40
C      CALCULATE STATISTICAL MODEL PROFILE
74     CONTINUE
       DO 75 L=1,LL
       ABSLAT=ABS(FFL(L))
       FLON=360.-FWL(L)
       CALL PROFILE(IYL(L),IML(L),IDL(L),LHL(L),LML(L),ISL(L),
      A ABSLAT,FWL(L),DEN)
C::: ARRANGE THE POINTS IN ASCENDING HEIGHT ORDER :::::
       DO 77 I=1,8
       J=8-I+1
       ADEN(I)=DEN(J)
77     AHT(I)=HT(J)
C      WRITE OUT THE STATISTICAL PROFILE
       NUML=1000+NUM(L)
       WRITE(9,110) NUML
       WRITE(9,120) (ADEN(I),AHT(I),I=1,8)
C      PRINT 300,IYL(L),IML(L),IDL(L),LHL(L),LML(L),ISL(L),
C     A FFL(L),FLON
75     CONTINUE
300    FORMAT(//* 19*,I2,3I3,I2,I5,2F6.1)
C
C      PRINT 105,NUM(L),HT
C      PRINT 150,DEN
C      PRINT 151,OBS
105    FORMAT(1X,*PROFILE NUMBER = *,I4,/1X,* HEIGHTS  *,8F6.1)
150    FORMAT(1X,*CALCULATED*,8F6.1)
151    FORMAT(1X,* OBSERVED *,8F6.1)
C
       REWIND 8
       REWIND 9
       REWIND 11
C      WRITE OUT THE DATA IN A MORE SUITABLE FORM
78     READ(8,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
      A MAG,KOL,IREF,IFIG,ISPEC,IKR
       IF(KURVE.EQ.9999) GO TO 99
79     READ(9,110) KKV
       J1=-5
80     J1=J1+6
       J2=J1+5
       READ(9,120) (FLN(J),H(J),J=J1,J2)
       IF(H(J2).NE.0.) GO TO 80
C      SEE IF THIS IS THE REQUIRED DISTURBED PROFILE
       IF(KKV.NE.KURVE) GO TO 79
       WRITE(10,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
      A MAG,KOL,IREF,IFIG,ISPEC,IKR
C      FIND HEADER CARD FOR REFERENCE PROFILE AND WRITE IT OUT
93     READ(11,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
      A MAG,KOL,IREF,IFIG,ISPEC
       IF(KURVE.EQ.9999) GO TO 94
       IF(KURVE.NE.IKR) GO TO 93
       WRITE(10,100) KURVE,IY,IM,ID,LH,LM,ISSNO,FLAT,FLON,METH,
      A MAG,KOL,IREF,IFIG,ISPEC
       REWIND 11
       GO TO 95
94     REWIND 11
       WRITE(10,432) (BLANKS(II),II=1,20)
432    FORMAT(20A4)
95     CONTINUE
       WRITE(10,110) KKV
       WRITE(10,120) (FLN(J),H(J),J=1,J2)
       REWIND 9
```

```
C     LOOK FOR REFERENCE PROFILE
81    READ(9,110) KKW
      IF(EOF(9).EQ.0.) GO TO 87
C      NO REFERENCE PROFILE
      DO 86 I=1,12
      FLN(I)=0.
86    H(I)=0.
      KZ=0
      WRITE(10,110) KZ
      WRITE(10,120) (FLN(I),H(I),I=1,6)
      REWIND 9
      GO TO 88
87    CONTINUE
      J1=-5
82    J1=J1+6
      J2=J1+5
      READ(9,120) (FLN(J),H(J),J=J1,J2)
      IF(H(J2).NE.0.) GO TO 82
      IF(KKW.NE.IKR) GO TO 81
      WRITE(10,110) KKW
      WRITE(10,120) (FLN(J),H(J),J=1,J2)
C     LOOK FOR MODEL PROFILE .... NO NEED TO REWIND
88    CONTINUE
      KKX=1000+KKV
83    READ(9,110) KKK
      J1=-5
84    J1=J1+6
      J2=J1+5
      READ(9,120) (FLN(J),H(J),J=J1,J2)
      IF(H(J2).NE.0.) GO TO 84
      IF(KKK.NE.KKX) GO TO 83
      WRITE(10,110) KKX
      WRITE(10,120) (FLN(J),H(J),J=1,J2)
C
      REWIND 9
      GO TO 78
C
99    CONTINUE
C
C
C     RETURN FOR NEXT SPECIAL CASE PARAMETER
      GO TO 5
      END
      SUBROUTINE PROFILE (IY,IM,ID,LH,LM,ISSNO,FLAT,WLON,DEN)
C     S/R TO CALCULATE A D-REGION PROFILE USING THE STATISTICAL MODEL
C     WITH COEFFICIENTS A,B,C,D,E
C.... MAGNETICALLY QUIET DAYS ONLY.   DENSITY INCREASES BY A FACTOR
C     OF ABOUT TWO ON DISTURBED DAYS
      DIMENSION A(8),B(8),C(8),D(8),E(8),F(8),T(8),DEN(8)
C     A = CONSTANT TERM    90(5)55 KM
      DATA A / 3.21,2.32,1.87,1.64,1.49,1.25,.81,.82 /
C     B = COS KI TERM
      DATA B / .80,.86,1.03,1.00,.86,.57,.66,.77 /
C      C = GEOMAGNETIC LATITUDE TERM
      DATA C / 0.,.23,.16,.09,.17,.58,.78,0. /
C     D = SUNSPOT TERM
      DATA D / 0.,.13,.20,.25,.13,.26,.26,0. /
C     E = SEASONAL TERM
      DATA E / .15,.16,.17,0.,-.05,0.,.12,0. /
C     RESIDUAL STANDARD DEVIATION
      DATA F / .53,.50,.46,.39,.33,.32,.40,.47 /
C
      PI=3.141592654
C     PREPARE TO CHANGE TO GEOMAGNETIC LATITUDE AT WLON DEGREES (WEST)
      DEGRAD=PI/180.
      THETGM=11.5*DEGRAD
      COSGM=COS(THETGM)
      SINGM=SIN(THETGM)
      PHIGM=291.*DEGRAD
C
```

```
C       CONVERT TO GEOMAGNETIC LATITUDE
        COLAT=(90.-FLAT)*DEGRAD
        ALON=WLON*DEGRAD
        COSA=COS(COLAT)*COSGM+SIN(COLAT)*SINGM*COS(ALON-PHIGM)
        GEOML=90.-ACOS(COSA)/DEGRAD
        TLAT=SIN(2.*GEOML*PI/180.)
        ALAT=0.1+0.9*(SIN(GEOML*PI/180.))**4
        FMON=IM
        FMON=(FMON-0.5)/12.*2.*PI
        FMON=COS(FMON)
        IF(FLAT.LT.0.) FMON=-FMON
        SEASON=FMON
        IID=ID
        IF(ID.EQ.0) IID=15
        CALL COSKI(IY,IM,IID,LH,LM,FLAT,WLON,COSX)
        DO 20 I=1,8
        IHT=90-(I-1)*5
        T(1)=A(I)
        T(2)=COSX*B(I)
        XLAT=TLAT
        IF(I.GE.5) XLAT=ALAT
        T(3)=XLAT*C(I)
        T(4)=ISSNO*.01*D(I)
        T(5)=SEASON*E(I)
        T(6)=F(I)
        ED=0.
        DO 15 J=1,5
15      ED=ED+T(J)
        DEN(I)=ED
20      CONTINUE
        RETURN
        END
        SUBROUTINE COSKI(LLY,LMON,LDAY,LH,LM,DLAT,DLON,COSX)
C       MODIFIED VERSION OF NEWBERN SMITH'S COS(SOLAR ZENITH ANGLE) S/R
C.... IT IS ASSUMED THAT THE GIVEN LOCAL TIME WAS MEASURED AT THE
C       NEAREST STANDARD MERIDIAN  I.E. THE NEAREST MULTIPLE OF 15 DEGREES
C.....LY = LOCAL YEAR   LAST TWO DIGITS ONLY
C       LMON = LOCAL MONTH
C       LDAY = LOCAL DAY
C       LH = LOCAL HOUR
C       LM = LOCAL MINUTE
C       DLAT = NORTHERN LATITUDE IN DEGREES
C       DLON = WEST LONGITUDE IN DEGREES
        DIMENSION NDO(12),NDL(12)
        DATA DTR / 0.01745329 /
C       DAY NUMBERS FOR ORDINARY AND LEAP YEARS
        DATA NDO,NDL / 1,32,60,91,121,152,182,213,244,274,305,335,
      A 1,32,61,92,122,153,183,214,245,275,306,336/
C       AMPLITUDES OF FOURIER EXPANSION COEFFICIENTS   1955 EPOCH
        DATA P1,P2,P3,P4,P6 /
      A 0.017203534,0.034407068,0.051610602,0.068814136,0.103221204 /
        IF(MOD(LY,4).EQ.0) LD=NDL(LMON)+LDAY-1
        IF(MOD(LY,4).NE.0) LD=NDO(LMON)+LDAY-1
        LY=LLY-60
        MER=INT((DLON+7.5)/15)*15.
C       FIND TIME OF THE EQUINOX FOR THAT YEAR
        IF(LY) 7,7,9
7       IL=INT((3.1-LY)/4.)
        GO TO 11
9       IL=-INT((LY+.1)/4.)
11      DT=-0.7819+0.24225*LY+IL
        TD=LD+(LH+LM/60.+MER/15.)/24.
        TE=TD-DT
C       DECLINATION
        DCL=23.256*SIN(P1*(TE-82.242))+.381*SIN(P2*(TE-44.855))+.167*SIN
      1(P3*(TE-23.355))-.013*SIN(P4*(TE+11.97))+.011*SIN(P6*(TE-10.41))
      2+.339137
        DC=DCL*DTR
        TF=TE-.5
```

```
C       THE EQUATION OF TIME
        EQT=-7.38*SIN(P1*(TF-4.))-9.87*SIN(P2*(TF+9.))+.27*SIN(P3*(TF-53.
       A))-.2*COS(P4*(TF-17.))
        ET=EQT*DTR/4.
        FA=DLAT*DTR
        FB=DLON*DTR
        FC=MER*DTR
        PHO=FC-FB+ET
        T=LH+LM/60.
        PHI=.26179939*(T-12.)+PHO
        A=SIN(FA)*SIN(DC)
        B=COS(FA)*COS(DC)
        COSX=A+B*COS(PHI)
        RETURN
        END
```

Listing of File PRODAT

```
2460008502344094174104174144179449438098089719729479485415405425405435400 64 63
32432392000094594640640540740551851792254548583579583580583581583221220450451
45545128828726822054554448 49992991527  0158160159160357354358354938250933  0
932  0807  0 42 41282  0248  0269  0272  0484  0485  0486  0487  0559  0560  0
488000480000481000482000483000562000 16000 17000 18000 19000 20000 21000
 DELETE FIRST 6 LINES IF DOING MAG DISTURBED DAYS
523524275000356354368000369000360000381923387923375925376925377000378000379000
383000380000384000386000388000389000365000366000382000390000385000804000805000
806000353000362000265000150151143000144000 86000 99000100000 60000 69000 70000
22200022300022400022500022600056 7 41168000 12 41253000254000995994996993970000
967966968966969966
```

APPENDIX A (Continued)

Listing of Subroutine PROFILE for Magnetically Disturbed Days

```
      SUBROUTINE PROFILE (IY,IM,ID,LH,LM,ISSNO,FLAT,WLON,DEN)
C     S/R TO CALCULATE A D-REGION PROFILE USING THE STATISTICAL MODEL
C     WITH COEFFICIENTS A,B,C,D,E,F
C     MAGNETICALLY DISTURBED DAYS ONLY
      DIMENSION A(8),B(8),C(8),D(8),E(8),F(8),T(8),DEN(8),G(8)
C     A = CONSTANT TERM     90(5)55 KM
      DATA A / 3.12,2.30,1.88,1.66,1.49,1.25,0.81,0.82 /
C     B = COS KI TERM
      DATA B / .82,.86,.98,.95,.84,.58,.68,.77 /
C      C = GEOMAGNETIC LATITUDE TERM
      DATA C / 0.,.24,.15,.09,.18,.57,.78,0. /
C     D = SUNSPOT TERM
      DATA D / .15,.15,.22,.26,.13,.26,.25,0. /
C     E = SEASONAL TERM
      DATA E / .17,.18,.18,0.,-0.06,0.,.12,0. /
C     MAGNETIC TERM
      DATA F / .17,.34,.31,.32,.32,.21,.45,0./
C     RESIDUAL STANDARD DEVIATION
      DATA G / .53,.51,.47,.40,.33,.32,.40,.47 /
C
      PI=3.141592654
C     PREPARE TO CHANGE TO GEOMAGNETIC LATITUDE AT WLON DEGREES (WEST)
      DEGRAD=PI/180.
      THETGM=11.5*DEGRAD
      COSGM=COS(THETGM)
      SINGM=SIN(THETGM)
      PHIGM=291.*DEGRAD
C
C     CONVERT TO GEOMAGNETIC LATITUDE
      COLAT=(90.-FLAT)*DEGRAD
      ALON=WLON*DEGRAD
      COSA=COS(COLAT)*COSGM+SIN(COLAT)*SINGM*COS(ALON-PHIGM)
      GEOML=90.-ACOS(COSA)/DEGRAD
      TLAT=SIN(2.*GEOML*PI/180.)
      ALAT=0.1+0.9*(SIN(GEOML*PI/180.))**4
      FMON=IM
      FMON=(FMON-0.5)/12.*2.*PI
      FMON=COS(FMON)
      IF(FLAT.LT.0.) FMON=-FMON
      SEASON=FMON
      IID=ID
      IF(ID.EQ.0) IID=15
      CALL COSKI(IY,IM,IID,LH,LM,FLAT,WLON,COSX)
      DO 20 I=1,8
      IHT=90-(I-1)*5
      T(1)=A(I)
      T(2)=COSX*B(I)
      XLAT=TLAT
      IF(I.GE.5) XLAT=ALAT
      T(3)=XLAT*C(I)
      T(4)=ISSNO*.01*D(I)
      T(5)=SEASON*E(I)
      T(6)=F(I)
      ED=0.
      DO 15 J=1,6
15    ED=ED+T(J)
      DEN(I)=ED
20    CONTINUE
      RETURN
      END
```

APPENDIX B

The program DREGPLT plots the D-region profiles as indicated in the diagrams. The version listed below is suitable for a height range of 50 to 105 km. Slight changes are necessary for profiles containing points outside this range.

Listing of DREGPLT

```
C---------THIS PROGRAM PLOTS ELECTRON DENSITY VERSUS HEIGHT
C---------FOR D REGION PROFILES.
C---------MARCUS ERTLE PROGRAMMER, JUN. 1978.
      PROGRAM DREGPLT(INPUT,OUTPUT,TAPE1=INPUT,TAPE2=OUTPUT,
     XTAPE3)
      COMMON A(2,6),X(100),Y(100),INPT(1)
C     IEND=1
      IEND=0
      CALL TEKTRN(460)
2     CALLBGNPL(IEND)
      KPT=0
      NH=0
      IC=0
      I0=0
      M=0
      N=0
      CALL TITLE(" $",-100,"LOG ELECTRON CONCENTRATION (N/CC)$",
     X100,"ALTITUDE (KM)$",100,8.,6.)
      CALL YINTAX
      CALL XINTAX
      CALL YAXANG(0.0)
      CALL GRAF(0,1,6,50,5,105)
C     CALL GRAF(0,1,6,35,5,90)
C     CALL GRAF(0,1,6,55,5,115)
      CALL GRID(1,1)
4     CALL CURVENO(IDIST,IYR,IMO,IDY,ITIME,ISUN,STLAT,
     XSTLONG,IMETH,IMAG,ICOL,IREF,UFIG,ISC,JREF,
     XJDIST,JYR,JMO,JDY,JTIME,JSUN,SJTLAT,
     XSJTLONG,JMETH,JMAG,JCOL,JJREF,UJFIG,JSC,JJJREF,N,NH,MODE,I0,IC)
      IF(N.EQ.2) 40,5
5     IF(NH.EQ.0) 20,6
6     CALL MARKER(MODE)
      CALL EPOINTS(N)
      CALL FILLUP(M,KPT,N)
      IF(X(M).EQ.0.00) 15,4
15    CALL CURVE(X,Y,KPT,1)
      KPT=0
      M=0
      I0=0
      IF(IC.NE.3) GOTO 4
      CALL MESSAG("CURVE YR MO DY TIME  SSNO    LAT   LONG",39,0.,7.25)
      CALL MESSAG(" METH MAG REF   FIG SPC",23,"ABUT","ABUT")
      CALL MESSAG("OBSERVED (O)  ",14,-1.5,7.)
      CALL INTNO(IDIST,"ABUT","ABUT")
      CALL INTNO(IYR,.75,"ABUT")
      CALL INTNO(IMO,1.1,"ABUT")
      CALL INTNO(IDY,1.45,"ABUT")
      CALL INTNO(ITIME,1.8,"ABUT")
      CALL INTNO(ISUN,2.6,"ABUT")
      CALL REALNO(STLAT,1,3.25,"ABUT")
      CALL REALNO(STLONG,1,4.,"ABUT")
      CALL INTNO(IMETH,5.2,"ABUT")
      CALL INTNO(IMAG,5.65,"ABUT")
      CALL INTNO(IREF,5.85,"ABUT")
      CALL MESSAG(UFIG,5,6.5,"ABUT")
      CALL INTNO(ISC,7.25,"ABUT")
      CALL MESSAG("REFERENCE (R) ",14,-1.5,6.75)
      CALL INTNO(JDIST,.2,"ABUT")
      CALL INTNO(JYR,.75,"ABUT")
      CALL INTNO(JMO,1.1,"ABUT")
      CALL INTNO(JDY,1.45,"ABUT")
      CALL INTNO(JTIME,1.8,"ABUT")
```

```
      CALL INTNO(JSUN,2.6,"ABUT")
      CALL REALNO(SJTLAT,1,3.25,"ABUT")
      CALL REALNO(SJTLONG,1,4.,"ABUT")
      CALL INTNO(JMETH,5.2,"ABUT")
      CALL INTNO(JMAG,5.65,"ABUT")
      CALL INTNO(JJREF,5.85,"ABUT")
      CALL MESSAG(UJFIG,5,6.5,"ABUT")
      CALL INTNO(JSC,7.25,"ABUT")
      CALL MESSAG("MODEL (M)      ",14,-1.5,6.5)
20    CALL ENDPL(IEND)
C     IEND=IEND+1
      GOTO 2
40    CALL ENDPL(IEND)
      CALL DONEPL
      END
      SUBROUTINE CURVENO(IDIST,IYR,IMO,IDY,ITIME,ISUN,STLAT,
     XSTLONG,IMETH,IMAG,ICOL,IREF,UFIG,ISC,JREF,
     XJDIST,JYR,JMO,JDY,JTIME,JSUN,SJTLAT,
     XSJTLONG,JMETH,JMAG,JCOL,JJREF,UJFIG,JSC,JJJREF,N,NH,MODE,I0,IC)
      COMMON A(2,6),X(100),Y(100),INPT(1)
C     PRINT 103,NH
 103  FORMAT(I3)
      IF(NH.GE.1) GOTO 3
1     READ(3,100) IDIST,IYR,IMO,IDY,ITIME,ISUN,STLAT,STLONG,
     XIMETH,IMAG,ICOL,IREF,UFIG,ISC,JREF
      IF(EOF(3)) 2,300
300   READ(3,100) JDIST,JYR,JMO,JDY,JTIME,JSUN,SJTLAT,SJTLONG,
     XJMETH,JMAG,JCOL,JJREF,UJFIG,JSC,JJJREF
      IF(EOF(3)) 2,3
102   FORMAT(I3,I3)
2     N=2
      RETURN
3     NH=NH+1
      IF(I0.EQ.1) 17,4
4     READ(3,101) IMODEL,ICURV
C     PRINT 101,IMODEL,ICURV
      IF(EOF(3)) 2,5
5     I0=1
      IC=IC+1
      IF(ICURV.EQ.IDIST) 6,7
6     IF(IMODEL.EQ.1) 8,9
7     IF(ICURV.EQ.JREF) 12,17
8     MODE=-1
      GOTO 17
9     MODE=1
      GOTO 17
12    MODE=-2
17    RETURN
100   FORMAT(2X,I3,3I3,I5,I4,2F6.1,2I2,I3,I4,A5,I3,I3)
101   FORMAT(I1,I3)
      END
      SUBROUTINE EPOINTS(N)
      COMMON A(2,6),X(100),Y(100),INPT(1)
      READ(3,100)((A(I,J),I=1,2),J=1,6)
      IF(EOF(3)) 5,10
5     N=2
10    RETURN
100   FORMAT(2X,6(F4.2,F6.2,2X))
      END
      SUBROUTINE FILLUP(M,KPT,N)
      COMMON A(2,6),X(100),Y(100),INPT(1)
10    DO 15 K=1,6
      M=M+1
      X(M)=A(1,K)
      Y(M)=A(2,K)
      IF(X(M).EQ.0.00) 12,14
12    RETURN
14    KPT=KPT+1
```

```
15     CONTINUE
       RETURN
       END
       SUBROUTINE PICTUR(I)
       DIMENSION X1(5),Y1(5),X2(9),Y2(9)
C
       DATA X1/-.Ø35,-.Ø35,Ø.,.Ø35,.Ø35/
       DATA Y1/-.Ø5,.Ø5,-.Ø5,.Ø5,-.Ø5/
C
       DATA X2/-.Ø35,-.Ø35,.Ø2Ø,.Ø35,.Ø35,
      X.Ø2Ø,-.Ø5,Ø.,.Ø35/
       DATA Y2/-.Ø5,.Ø5,.Ø5,.Ø4,.Ø4,Ø.,
      XØ.,Ø.,-.Ø5/
C
       GOTO (1,2), I
1      CALL PICTRC(X1,Y1,5)
       RETURN
2      CALL PICTRC(X2,Y2,9)
       RETURN
       END
```

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