REPORT UAG-78

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for
Solar-Terrestrial Physics

THE EQUATORIAL LATITUDE OF AURORAL ACTIVITY DURING 1972-1977

October 1980

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Solar-Terrestrial Physics

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OPTICAL AND ELECTRON MEASUREMENTS OF THE EQUATORIAL AURORAL BOUNDARIES DURING 1972-1977

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ABSTRACT

The equatorial latitude of auroral activity has been derived from both electron and optical observations with the DMSP satellites. Essentially all of these observations have been used to produce a nearly continuous plot of invariant geomagnetic latitude versus time during the 5-year interval June 1972 - September 1977. This plot has two main characteristics: (1) a diurnal variation of approximately ±5° which is somehow associated with the precession of the Earth's magnetic dipole axis about the Earth's rotation axis and (2) an irregular variation of roughly 5-10° for intervals of one to several days associated with the occurrence of solar flares and coronal holes. With the help of a condensed, Bartels-type display of these measurements, we conclude that (1) modest auroral expansions (to $\Lambda \sim 60°$) occur during the main body of high-speed streams from coronal holes and (2) great expansions (to $\Lambda < 55°$) occur only during intervals of intense interplanetary magnetic fields, such as may occur at the leading edge of a high-speed stream or at a flare-produced interplanetary shock.

Introduction

Using solar, interplanetary, and geomagnetic observations during the declining phase (1972-1976) of sunspot cycle 20, several workers found a high degree of correlation between the occurrence of coronal holes, solar wind high-speed streams, and recurrent geomagnetic disturbances [cf. Bell and Noci, 1976; Neupert and Pizzo, 1974; Nolte et al., 1976; Sheeley et al, 1976]. Later, Sheeley [1978] used auroral observations obtained in the U.S. Air Force Defense Meteorological Satellite Program (DMSP) during 1973-1974 to compare the variations of auroral latitude with the occurrences of coronal holes and solar flares during the Skylab era. The transits of low-latitude coronal holes across the solar disk were accompanied by expansions of the Earth's auroral ovals to invariant latitudes that were often less than 60°. Comparable, flare-induced expansions were rare during the Skylab era, but a few major events with expansions to 53° latitude did occur in 1972.

Subsequently, in 1978 we decided to analyze all of the DMSP auroral observations that were then available. These data consisted of both electron and optical observations for both Northern and Southern Hemispheres of the Earth during the interval June 1972-September 1977. The measurements of equatorwardmost auroral positions were transformed from geographic coordinates to invariant geomagnetic latitude and plotted versus time in 27-day segments for comparison with solar phenomena.

The optical and electron observations are plotted both separately and together. Sheeley and Howard [1980] were interested primarily in the correlation of oval size with the occurrence of solar phenomena so they used the combined data set to increase their statistical sample. Dandekar [1979] has analyzed these DMSP optical observations for the dependence of the equatorial edge of the auroral oval on the magnetic activity indices Kp and Q. However, to benefit researchers with other interests, we have included large-scale plots of both the separated and the combined data in this report.

Data Reduction Techniques

As described elsewhere [Sheeley, 1978; Sheeley and Howard, 1980], the measurements of equatorwardmost auroral latitude were derived from the Air Force DMSP auroral analysis records. These records contained the geographic coordinates of the equatorial boundary of the auroral activity as a function of time on an orbit-by-orbit time scale. We simply transformed from geographic coordinates to invariant geomagnetic coordinates using the published maps of Evans et al. [1969] for the 100-km level. In practice, we approximated these maps by a closed-form algebraic expression which gave invariant geomagnetic latitude with an accuracy of ±1°. Dandekar [1979] has discussed the nature and limitations of these DMSP optical data.

We obtained the auroral analysis records in several sections. The largest section was transformed to magnetic tape at the Air Force Geophysical Laboratory (AFGL). However, this section did not include a 6-month interval during the first half of 1973 as well as several other smaller intervals during the subsequent four years. We obtained the 6-month section in tabular form on microfilms made available by the USAF Air Weather

Service through the NOAA National Geophysical and Solar-Terrestrial Data Center (NGSDC). Most of the smaller sections were also supplied in tabular form by the NOAA NGSDC courtesy of H. W. Kroehl. These tabular data were punched onto cards and transferred to magnetic tape for processing with the large section of data from AFGL.

Despite our attempts to be complete, several sections of data are still missing. Some sections seem to have been lost or loaned to individual users and long forgotten. (The January 1973 optical data fall in this category because published images during this interval can be found in the literature [cf. Akasofu, 1974]). Other sections include times when electron observations or optical observations (or both) were not obtained. Of course, during each solstice optical data were not obtained in the Earth's summer hemisphere.

Temporal Plots of Equatorwardmost Invariant Latitude

This part of the report contains plots of the equatorwardmost latitude of auroral activity on an orbit-by-orbit time scale. The optical measurements begin in June 1972 and extend (with some interruptions) through September 1977. The electron measurements begin in August 1973 and also extend through September 1977. Invariant geomagnetic latitude, Λ, is plotted versus time in 27-day segments for comparison with solar phenomena. Optical data in the Northern and Southern Hemisphere are indicated by the letters N and S, respectively, in Appendix B. Electron data are indicated by the letters A (north) and B (south) in Appendix A. In the combined data, the points often overlap so much that the letters cannot be distinguished (Appendix C). Sheeley and Howard [1980] regarded this overlap as evidence that either kind of auroral data can be used for comparison with solar phenomena.

Our plotting technique suffers from two drawbacks. The first drawback is a systematic error that was not discovered until all the data had been plotted. Namely, each point was plotted approximately 1.4° higher in latitude than it should have been. Consequently, this relatively small correction of 1.4° must be subtracted from each plotted Λ-value in order to obtain the correct invariant geomagnetic latitude (which itself has been derived with an accuracy of ±1°.)

The second drawback is that the plot "saturates" for values of Λ less than 55°. Coupled with the first drawback, this means that whenever we obtained a value of Λ that was less than 55°, we arbitrarily plotted that point at the latitude of 56.4°. Thus, in the September 14, 1974 Bartels rotation (electron data) some of the points at 56.4° probably had values less than 55°. For example, the "saturated" points on September 15-16 may correspond to relatively great expansions of the auroral ovals. However, the other "saturated" points in this Bartels rotation probably indicate measurement errors because each one is widely separated from the remaining points on the same day. (We estimate that roughly 1-2% of all the measurements are incorrect due to a combination of human errors in the various stages of observation and reduction of the data. Based on 30,000 total data points, this amounts to 300-600 total errors or roughly 5-10 errors per Bartels rotation.)

When such "saturated" points are real, they are of particular interest because they are often associated with exceptional interplanetary conditions. Consequently, for completeness we have tabulated all of these "saturated" points despite the high probability that many of them are measurement errors. They are summarized in Tables 1, 2, and 3 according to whether the calculated value of Λ was in the range 0-45°, 45-50°, or 50-55°, respectively. In these tables, the symbol E refers to electron observations.

In their highly compressed 27-day format, the Λ-plots seem rather noisy. Short-term variations of approximately ±5° are always superimposed on the long-term variations of latitude regardless of the season of the year or the interplanetary conditions. In fact, during each 27-day interval the plot appears as a 10° -wide band that weaves back and forth between the 55° and 75° latitude extremes.

Whereas the longer-term meandering undoubtedly indicates real expansions and contractions of the sizes of the auroral ovals in response to changing interplanetary conditions, the amplitude of the diurnal variation is much too large to be real. Indeed, a 10° increase in the radius of an oval would be comparable to the expansion that is typically associated with a large magnetic storm [cf. Feldstein, and Starkov, 1967]. Thus, Sheeley and Howard [1980] assumed that the diurnal variation is mainly an "eccentricity" effect caused by the misalignment of the Earth's magnetic dipole and rotation axes, and by the consequent sampling of different parts of the ovals at different local times.

It is instructive to consider the diurnal variation briefly despite its probable sampling origin. The variation is particularly clear in the separate plots of electron and optical data. In the electron observations (both hemispheres included, but not distinguished), the phase of this variation seems to remain essentially unchanged throughout the interval August 1973-September 1977 independent of the season. On each day, Λ tends to reach its maximum value at 0700 ± 0200 UT and its minimum value at 1900 ± 0200 UT. The optical observations show essentially this same phase during November-February when Northern Hemisphere data are available. Figure 6 of the paper by Sheeley [1978] illustrates this variation on an expanded time scale.

The optical observations show a different behavior during May-August when Southern Hemisphere data are available. In these measurements, there is a tendency for Λ to reach its maximum value a few hours after noon and its minimum value a few hours after midnight universal time. However, this tendency is present only about half of the time. On the remaining days, the points are either widely scattered or distributed nearly vertically in the Λ-plots.

Table 1. Observations with $\Lambda<45°$

Date			Time	Lat	Long	Λ	
72	8	16	1644	-53.1	295	37.3	
72	11	1	1802	44.7	14	40.9	
72	11	4	1649	41.6	67	37.1	
73	2	9	1612	45.3	76	40.8	
73	3	12	1537	-50.7	240	42.1	
73	4	13	0428	-58.0	297	42.1	
73	4	30	1536	-52.5	238	44.2	
73	4	30	1718	-51.5	263	38.7	
73	5	1	1522	-56.6	304	40.6	
73	5	6	1915	-58.3	303	42.3	
73	5	18	0034	-50.8	284	35.7	
73	5	18	2224	23.0	79	20.4	
73	5	23	0805	-55.0	250	44.2	
73	5	27	2202	-59.9	326	44.6	
73	6	12	1009	-52.8	242	43.7	
73	6	20	0323	-58.1	294	42.3	
73	8	1	1648	-52.5	250	41.8	
73	8	25	1505	45.7	63	40.8	E
74	9	20	2002	-14.6	342	16.4	E
74	10	26	0624	49.3	86	44.7	
75	6	16	0925	-49.7	226	44.4	
75	7	8	1006	-52.3	238	44.2	
75	8	12	1001	-59.0	296	43.1	
76	5	7	0346	-1.4	245	6.3	
76	5	15	0140	-58.2	278	43.5	E
76	7	7	1517	2.0	88	2.0	E
76	10	17	0832	46.5	191	43.5	
76	11	1	0110	46.4	82	42.0	E
77	9	12	0552	-51.0	274	36.8	
77	9	23	1700	43.2	35	38.0	E
77	9	23	2356	42.5	203	41.5	E

Table 2. Observations with 45°< Λ <50°

Date	Time	Lat	Long	Λ	Date	Time	Lat	Long	Λ
72 9 16	0919	-65.3	306	49.3	75 2 14	0731	53.5	98	48.6
72 10 14	1056	-43.2	193	47.2	75 2 15	0529	50.0	71	45.1
72 10 14	1242	51.9	164	46.8	75 2 15	0712	52.2	95	47.4
72 10 18	1144	-37.4	171	47.4	75 2 16	0512	53.1	64	47.8
72 10 28	0846	54.3	145	48.9	75 2 16	0654	51.5	90	46.8
72 11 19	1408	51.3	146	46.0	75 3 1	0615	52.2	80	47.3
72 11 29	0151	53.9	122	48.8	75 3 2	0556	51.3	75	46.6
72 11 30	1453	54.5	162	49.4	75 3 3	0537	54.1	69	48.8
72 11 30	1634	54.0	137	48.7	75 3 3	0718	54.3	93	49.3
72 12 5	1401	49.9	86	45.3	75 3 16	0458	53.3	60	48.0
73 3 8	1635	53.0	105	48.1	75 3 17	0440	53.0	55	47.7
73 3 21	1648	49.8	104	45.3	75 3 17	0622	50.8	82	46.0
73 4 29	1738	50.0	91	45.4	75 4 30	0936	-59.0	243	49.4
73 6 17	0854	-53.2	223	48.3	75 7 30	0358	-51.5	214	49.1
73 6 18	1033	-63.2	296	47.3	75 8 28	1126	-53.6	236	45.7
73 6 29	0737	50.6	156	45.3	75 8 30	1049	51.5	134	46.3 E
73 6 29	1618	53.5	110	48.6	75 9 9	1100	-49.0	11	49.1 E
73 7 1	1713	53.0	91	48.1	75 10 14	1757	51.1	29	46.3 E
73 7 3	0835	-64.7	-54	48.7	75 12 10	1728	52.4	36	47.3 E
73 8 23	0645	-61.4	343	48.7 E	76 1 9	1914	53.0	11	49.8 E
73 9 21	1433	-51.1	226	45.8	76 1 9	1948	-64.3	332	49.5 E
74 10 12	0725	52.7	99	47.9	76 1 9	2130	-65.8	305	49.8 E
74 11 10	0131	52.8	85	47.9	76 1 17	1054	53.9	112	48.9 E
74 11 10	0507	52.3	65	47.1	76 3 26	1618	55.4	57	50.0 E
74 11 10	0648	51.7	91	47.0	76 4 5	1922	-59.9	343	47.5 E
74 11 11	0448	54.4	59	49.0	76 4 5	2105	-65.8	312	49.9 E
74 11 11	0630	52.4	86	47.5	76 4 6	1906	-59.7	347	48.5 E
74 11 20	0039	51.9	72	46.8	76 4 7	1906	-58.6	347	47.9 E
74 11 22	0147	53.8	89	48.8	76 4 8	2019	-65.2	324	49.7 E
74 12 10	0416	54.7	51	49.3	76 4 9	1818	-54.7	1	49.6 E
74 12 10	0559	50.7	78	45.9	76 4 18	1925	-63.2	340	49.4 E
74 12 11	0549	50.4	74	45.5	76 4 19	1908	-60.6	346	48.9 E
74 12 12	0522	51.2	69	46.1	76 4 20	1852	-59.3	350	49.4 E
75 1 9	0508	52.0	64	46.8	76 4 22	1820	-54.4	1	49.4 E
75 1 9	0650	52.8	85	47.9	76 7 9	0424	-58.4	237	49.9 E
75 1 10	0631	53.8	84	48.8	77 2 13	0340	-57.1	248	46.6 E
75 2 2	0017	51.1	78	46.2 E	77 2 25	0934	54.1	134	48.8 E

Table 3. Observations with 50°< Λ <55°

Date	Time	Lat	Long	Λ	
72 7 3	1207	-58.2	10	54.0	
72 8 5	0231	-69.1	303	53.1	
72 8 11	0427	-69.6	274	55.0	
72 8 20	0033	58.0	112	52.6	
72 8 26	0415	-69.6	278	54.7	
72 8 26	0551	-64.8	258	52.3	
72 9 1	0932	-66.3	257	53.8	
72 9 17	0543	-66.7	259	53.8	
72 9 18	0956	50.2	226	54.3	
72 9 21	0733	55.3	94	50.2	
72 10 13	0536	52.7	193	50.1	
72 11 1	0917	49.1	233	54.9	
72 11 9	0915	58.1	49	52.7	
72 12 4	0818	56.4	79	51.1	
72 12 22	1437	-50.5	35	54.8	
73 1 3	1613	60.0	137	54.4	
73 1 7	1034	57.4	192	54.9	
73 3 8	1452	56.5	133	51.1	
73 3 18	1843	60.0	99	54.4	
73 3 31	1716	54.0	193	51.6	
73 4 1	1913	-45.5	69	53.2	
73 4 29	1408	-50.0	192	54.0	
73 5 14	0114	60.7	68	55.0	
73 5 14	0206	-62.5	233	54.5	
73 5 14	1032	57.5	129	52.0	
73 5 16	0153	55.4	86	50.2	
73 5 16	2355	58.8	118	53.3	
73 5 21	0130	51.9	207	51.8	
73 5 21	0903	-70.8	302	54.8	
73 6 6	0815	-36.7	144	51.6	
73 6 8	1200	57.0	26	52.5	
73 7 6	0649	-68.6	336	54.0	
73 7 29	0400	-69.0	283	53.7	
73 8 6	0322	-68.3	308	52.3	
73 8 26	0601	-64.3	351	53.4	E
73 11 16	1214	59.8	158	54.5	
74 4 18	0508	-69.0	291	53.3	
74 4 19	1529	-46.9	67	54.5	
74 4 25	0802	-57.3	220	52.9	
74 5 16	0636	-62.4	239	53.2	
74 5 17	0937	-51.0	200	52.6	
74 6 11	1205	-52.0	196	54.6	
74 7 10	0951	-53.0	200	54.4	
74 8 20	0723	-65.0	245	54.5	
74 9 16	0057	-65.6	250	54.1	E
74 9 18	1721	-55.9	11	53.2	E
74 9 18	2048	-69.1	309	53.1	E
74 9 20	1650	-54.3	20	54.3	E
74 9 21	1633	-51.7	25	53.9	E
74 9 22	1618	-51.7	29	54.6	E
74 9 24	1730	-55.8	9	52.5	E
74 9 26	1659	-53.3	18	53.3	E
74 9 27	1643	-52.8	22	54.0	E
74 10 13	2030	57.9	65	52.4	
74 10 14	1728	-58.2	8	53.8	E
74 10 15	0018	-67.0	259	54.2	E
74 10 16	1108	58.0	153	52.6	
74 10 16	1613	58.8	139	53.2	
74 10 16	2259	57.3	28	52.7	
74 10 20	1921	-64.8	335	50.2	E
74 10 20	2209	58.7	32	53.9	
74 10 20	2246	-69.5	279	54.5	E
74 10 20	2351	55.9	59	50.5	E
76 10 21	1721	-56.3	11	53.4	E
74 10 21	2049	-70.2	307	54.2	E
74 10 21	2335	59.6	52	54.1	E
74 10 24	0302	-59.4	224	53.7	E
74 10 26	0151	56.5	56	51.0	
74 10 26	1258	57.8	30	53.1	
74 11 5	0104	59.3	75	53.7	
74 11 10	0324	57.9	37	52.8	
74 11 11	1954	55.3	1	53.7	E
74 11 19	2256	58.2	43	52.9	
74 11 21	0203	59.2	89	53.7	
74 11 21	1937	-67.1	329	51.9	E
74 11 21	2223	58.3	35	53.3	
74 11 22	0005	56.0	62	50.6	
74 12 5	1740	-56.4	7	52.3	E
74 12 11	0357	55.7	46	50.3	E
75 1 10	0447	58.8	55	53.3	
75 2 14	0406	56.7	46	51.3	
75 2 14	0547	59.3	70	53.7	
75 2 15	0347	58.7	41	53.5	
75 2 16	0329	56.7	36	51.6	
75 3 2	0412	58.6	46	53.2	
75 3 2	0736	55.6	99	50.5	
75 3 7	1502	56.0	102	50.9	
75 3 10	2133	50.2	334	54.2	E
75 3 12	0249	55.8	26	51.3	
75 3 18	0420	56.5	49	51.1	
75 3 18	2005	-70.1	320	54.3	E
75 7 29	0410	-52.0	212	50.3	
75 9 9	1244	58.7	79	53.2	E
75 11 2	1949	55.0	3	53.0	E
75 11 4	1231	55.2	113	50.1	E
75 11 9	1653	60.0	48	54.5	
75 11 22	1636	59.6	54	54.0	E
75 11 22	1740	58.8	36	53.8	E
75 11 22	1818	56.6	27	52.0	E
75 11 22	2000	55.0	1	53.4	E
75 11 24	1807	-63.7	358	54.6	E
75 12 2	0155	51.9	207	51.8	E
76 1 9	1731	57.2	36	52.1	E
76 1 9	2058	48.7	344	50.3	E
76 1 9	2240	46.9	318	54.9	E
76 1 9	2316	-68.5	277	53.7	E
76 1 10	0054	-66.1	254	54.0	E
76 1 10	1942	55.4	4	53.3	
76 3 26	1436	55.8	83	50.6	E
76 3 26	1942	54.7	6	52.3	E
76 4 2	0311	-59.8	225	53.8	E
76 4 2	1642	-50.1	27	53.4	E
76 4 2	1752	59.9	36	54.8	E
76 4 2	2010	-67.0	324	51.5	E
76 4 3	0908	58.8	166	53.9	E
76 4 3	2137	-68.9	301	52.9	E
76 4 3	2319	-68.4	276	53.7	E
76 4 4	0100	-66.1	253	54.2	E
76 4 4	0240	-62.4	231	54.8	E
76 4 4	1754	-54.0	8	51.1	E
76 4 4	2121	-67.8	306	51.8	E
76 4 5	1737	-51.6	13	51.1	E
76 4 6	1539	-47.2	44	53.5	E
76 4 7	1539	-46.5	44	53.0	E
76 4 7	1721	-50.1	18	51.4	E
76 4 9	2327	-66.3	276	51.6	E
76 4 17	1612	-48.5	35	53.6	E
76 4 17	1756	-54.3	7	51.1	E
76 4 18	1740	-52.8	12	51.5	E
76 4 19	1541	-48.2	43	54.2	E
76 4 19	2052	-67.3	341	53.3	E
76 4 20	1708	-50.1	21	52.2	E
76 4 22	1636	-48.1	30	52.5	E
76 5 1	0552	-43.4	183	50.3	E
76 5 3	0040	-65.0	258	52.5	E
76 5 3	0221	-62.2	235	53.7	
76 5 3	0338	-58.9	219	54.5	E
76 5 3	0609	-53.0	206	52.5	
76 11 10	0647	56.2	174	51.8	
76 12 10	0044	-62.9	261	50.0	E
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76 12 23	0203	56.8	87	51.5	
76 12 29	1423	-46.7	64	54.1	E
77 4 6	1719	58.4	44	53.1	E
77 8 1	2347	41.0	292	54.1	E
77 8 28	2019	-69.7	312	53.7	E
77 8 28	2200	-69.8	286	54.3	E
77 9 23	2237	-69.6	276	54.8	F
77 9 26	1704	-57.8	13	54.6	E
77 9 26	1848	-66.8	339	52.5	E
77 9 26	2031	-70.8	308	54.8	E

A Daily Index of Equatorwardmost Auroral Latitude

Sheeley and Howard [1980] summarized all of the Λ-measurements on a daily basis to facilitate their comparison with solar phenomena such as coronal holes and solar flares. For completeness, we have reproduced their summary here. A "J-index" of daily minimum Λ was constructed as follows: First, for each day, the minimum latitude for the electron data and the minimum latitude for the optical data were identified. Then, to reduce the possible influence of sporadic data points, these two values were averaged. When only one kind of data was available the minimum latitude for that kind was used. Finally, an index on a scale of 0 to 7 was assigned depending on the location of this latitude, $\langle \Lambda \text{ min} \rangle$, within one of the following 2.5°-latitude ranges:

$\langle \Lambda \text{ min} \rangle$	J
72.5-75.0	0
70.0-72.5	1
67.5-70.0	2
65.0-67.5	3
62.5-65.0	4
60.0-62.5	5
57.5-60.0	6
55.0-57.5	7

Also, J=7 was used whenever $\langle \Lambda \text{ min} \rangle$ was less than 55°. (This "saturation" of the J-index was determined after $\langle \Lambda \text{ min} \rangle$ had been calculated from individual latitudes, one or both of which may have been less than 55°.)

The J-index is compared with the C9 index of geomagnetic activity in a 27-day Bartels-type format during the interval June 1972-September 1977. In the J-index format, blank spaces without entries correspond to days for which auroral latitude measurements were not available. The agreement is only fair considering the fact that the electric currents in the auroral ovals are supposed to be the source of the fluctuations of the geomagnetic field and vice versa [cf. Banks and Doupnik, 1975]. Some sporadic discrepancies were caused by errors in the measurement of auroral latitudes and their transposition from the Δ-plots to the J-index. See Fig. 1. Other discrepancies may have resulted from the paucity of observations during specific time intervals.

On the other hand, each display shows the same long-lived recurrence patterns that are associated with coronal holes and high-speed solar wind streams [cf. Sheeley and Harvey, 1980]. Typically, C9 indices in the range 5-7 correspond to J indices that are also in the range 5-7 (Λ in the range 55.0° - 62.5°). This relation seems to have been characteristic of the auroral expansions that were associated with high-speed streams from coronal holes during 1973-1977. As Sheeley and Howard [1980] have discussed in detail, auroral expansions below 55° occurred only during intervals of intense interplanetary magnetic field strength such as were present occasionally at the leading edge of a high-speed stream or at a flare-produced interplanetary shock. The reader is referred to the papers by Sheeley [1978] and Sheeley and Howard [1980] for a more detailed discussion of these observations and their relation to solar phenomena.

Acknowledgments

The DMSP auroral imagery and analysis records were made available by the USAF Air Weather Service through the National Geophysical and Solar-Terrestrial Data Center, NOAA, Boulder, Colorado. Also we thank the Space Environment Support Branch of the Air Force Global Weather Central, Offutt AFB, Nebraska for providing the DMSP satellite data. We are also grateful to H. W. Kroehl (NOAA) and C. -I. Meng (JHU/APL) for useful discussions and to D. J. Michels (NRL) for loaning us copies of the 1973-1974 auroral observations that he had purchased from NOAA. Financial support at NRL was obtained from NASA DPR W-14, 429. Finally, we are grateful to the staff of the World Data Center A for Solar-Terrestrial Physics for both encouraging this work and for publishing this final report.

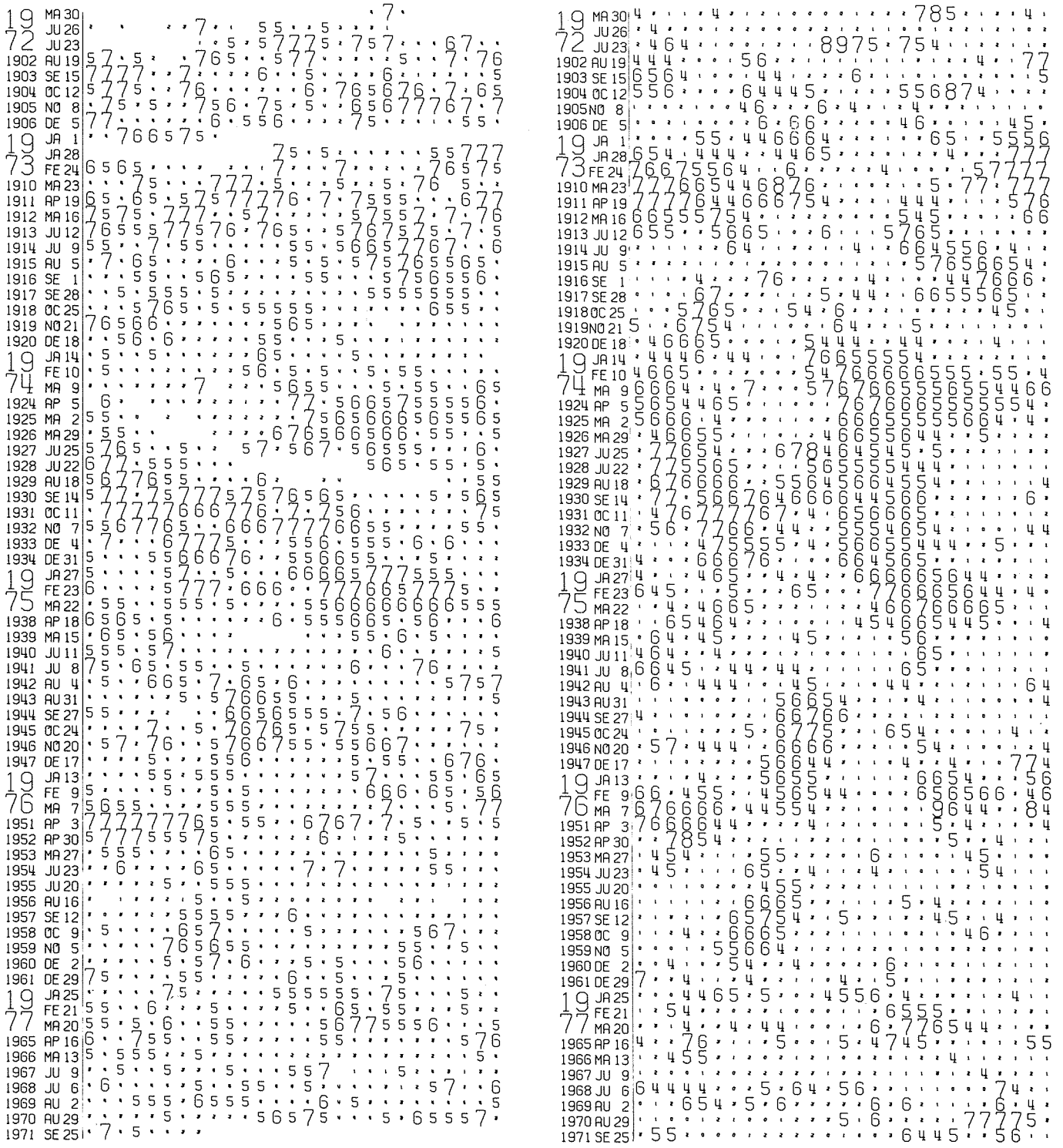

Figure 1. Comparison of 27-day Bartels displays of an index of lowest daily auroral latitude (left) and the daily geomagnetic index C9 (right). Patterns of enhanced geomagnetic activity (C9=5-7) correspond to patterns of low-latitude auroras (J=5-7 or Λ=55.0-62.5°).

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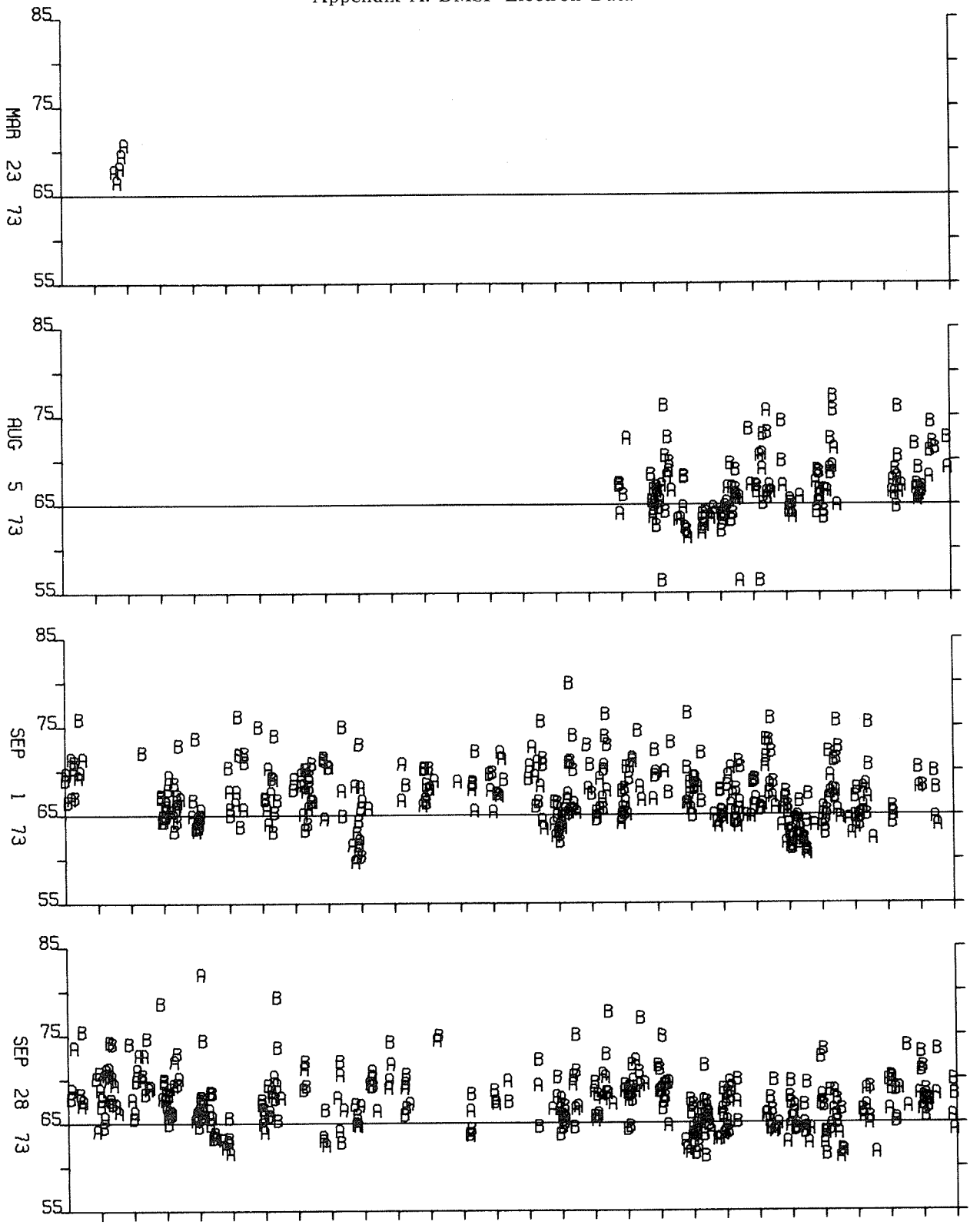
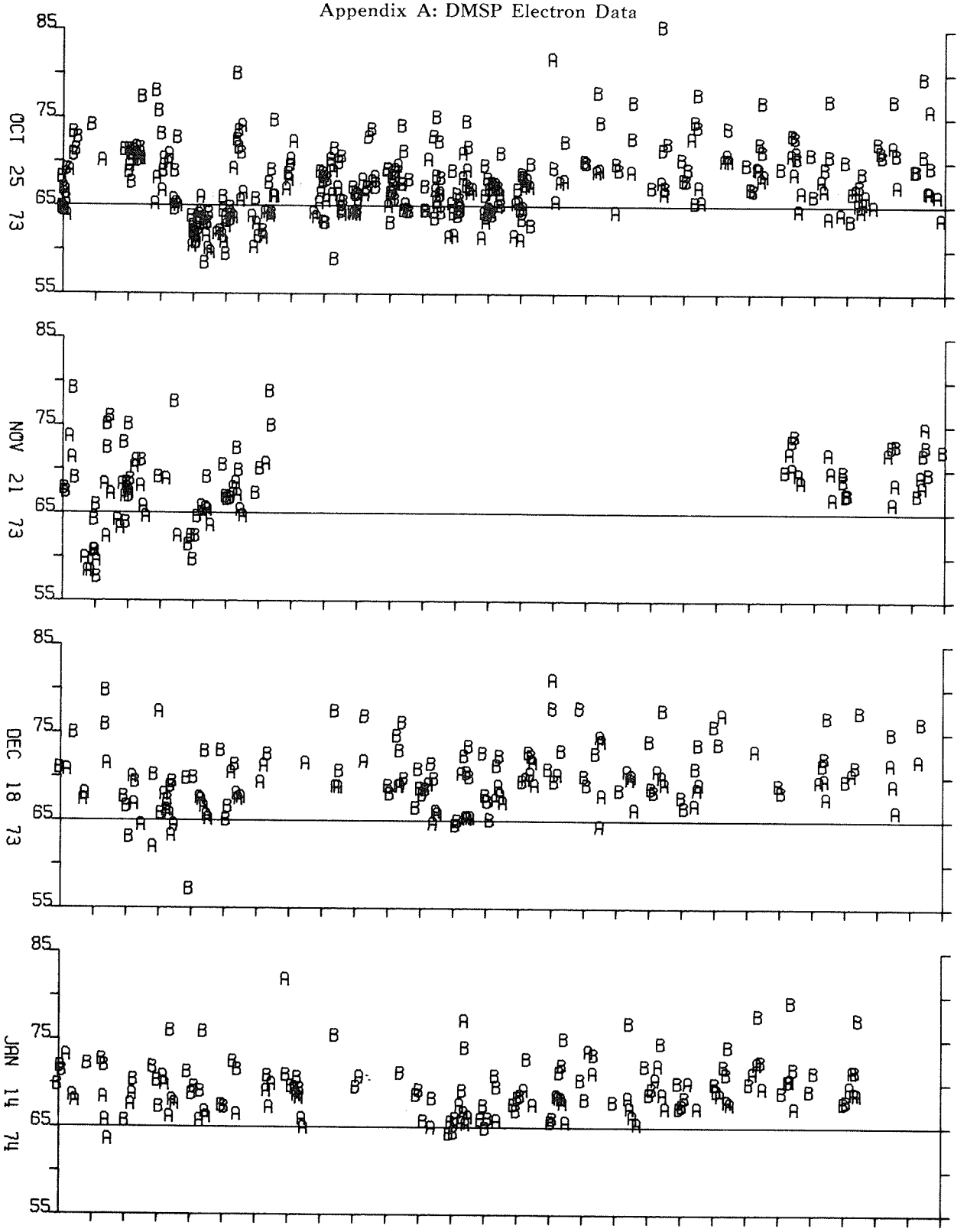
APPENDIX

Equatorial Latitude of Auroral Activity, 1972-77

The temporal variation of the equatorial latitude of the auroral ovals during the interval June 1972 - September 1977. The measurements are presented in 27-day Bartels segments the first day of which is indicated on the left. The vertical scale indicates invariant geomagnetic latitude. Optical measurements are indicated by the letters N (north) and S (south), and electron measurements are indicated by the letters A (north) and B (south). Each point has been plotted approximately 1.4° higher in latitude than it should have been, and the plotter saturated at latitudes less than 55° (see page 2 of text).

Appendix A: DMSP Electron Data

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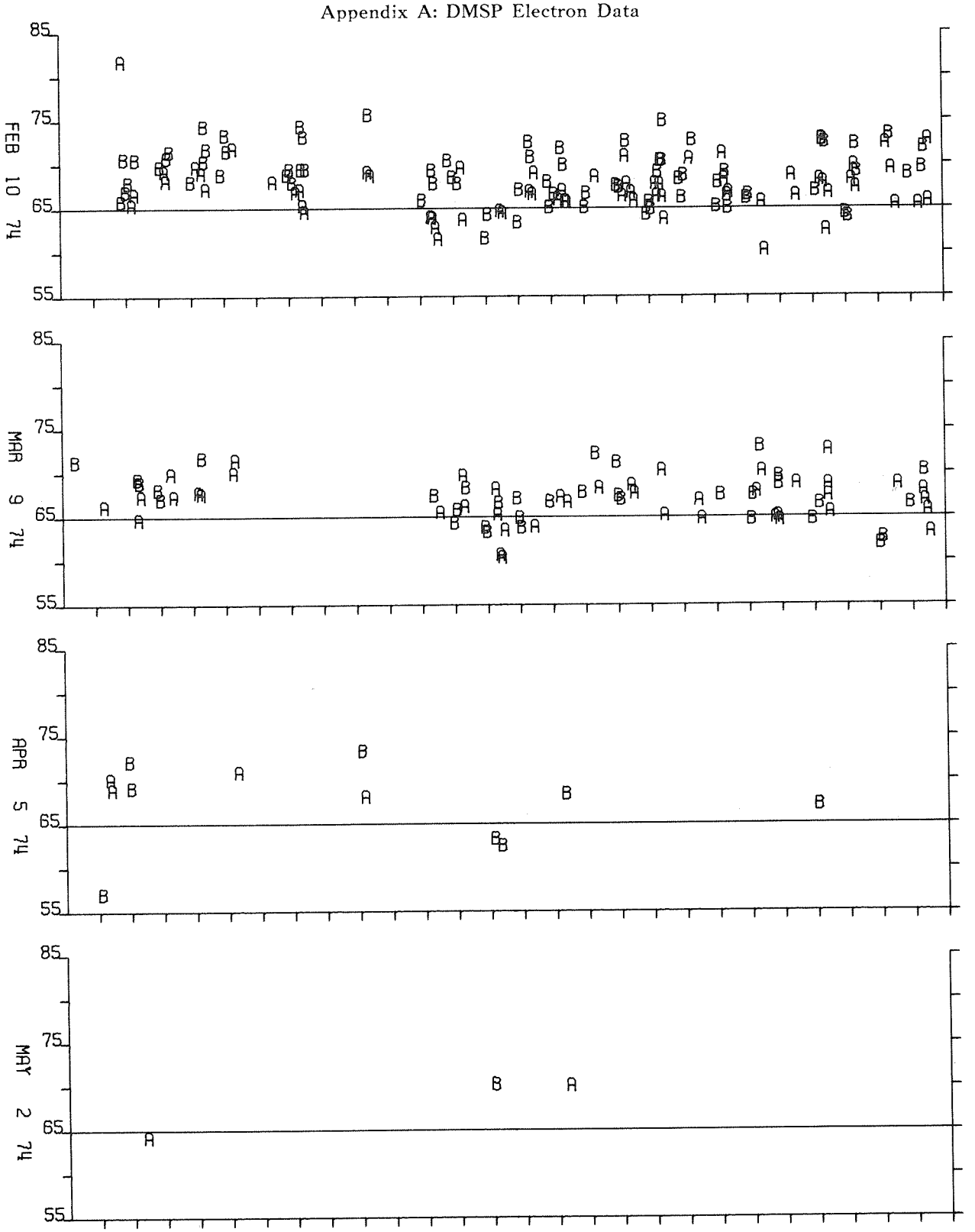

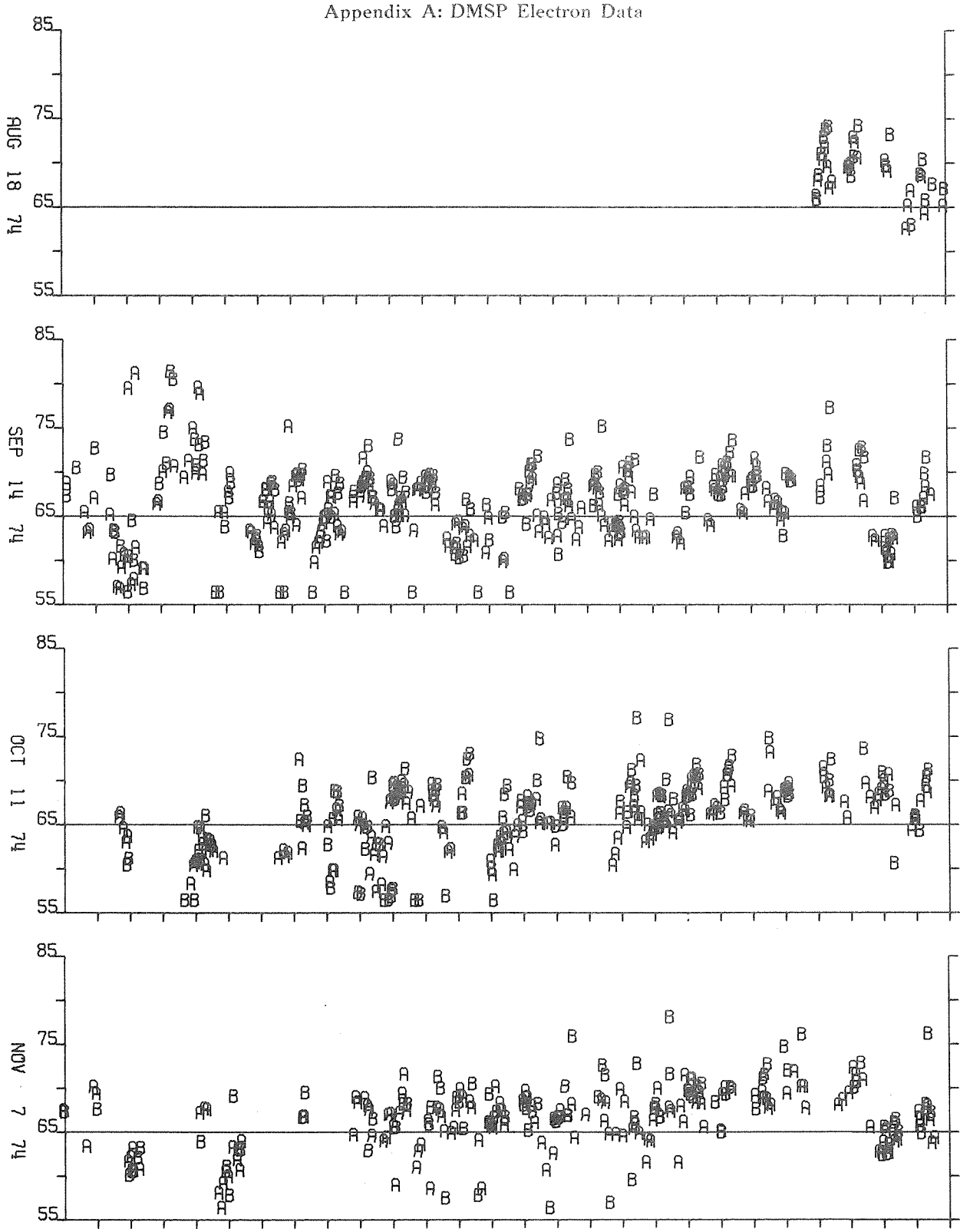
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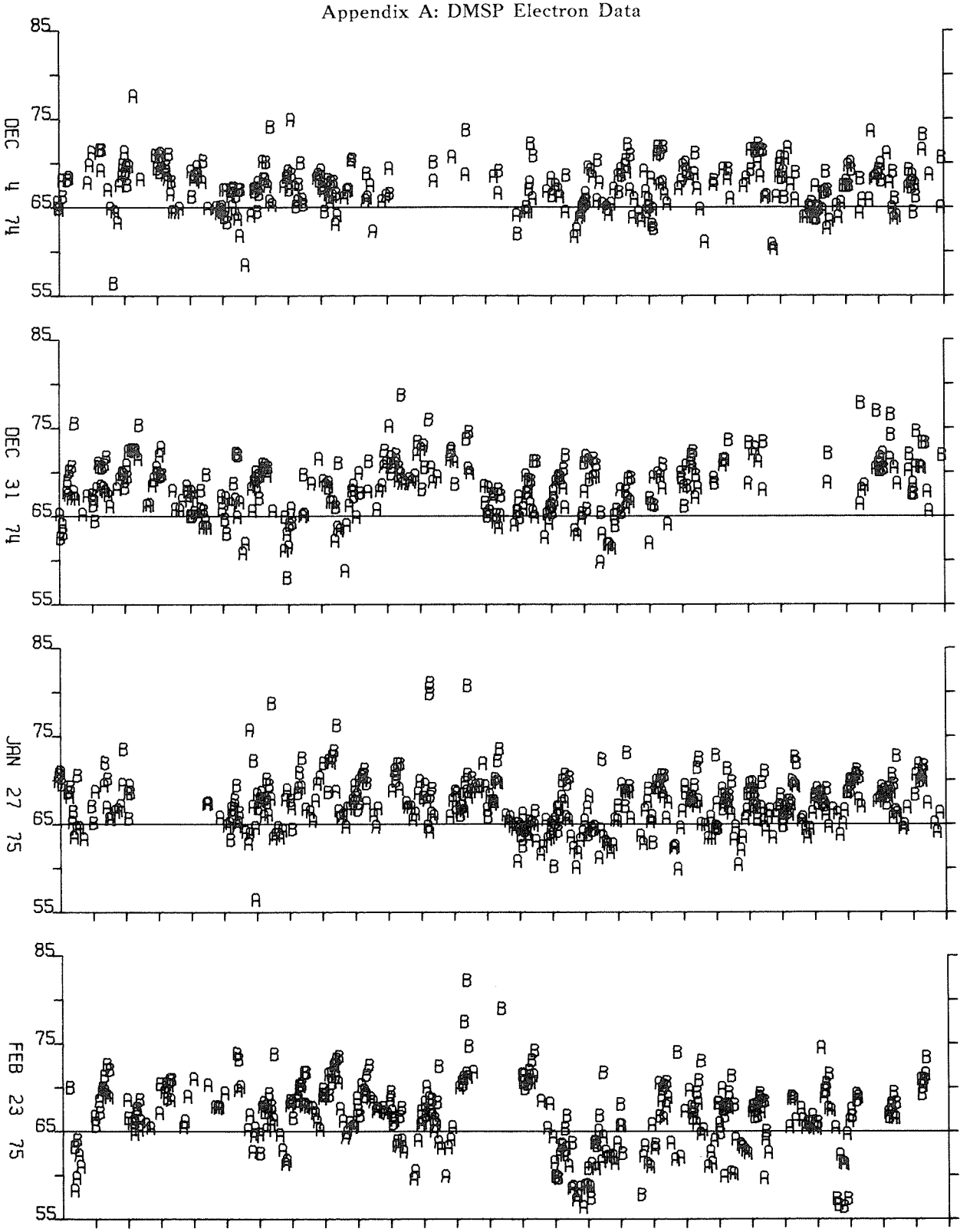

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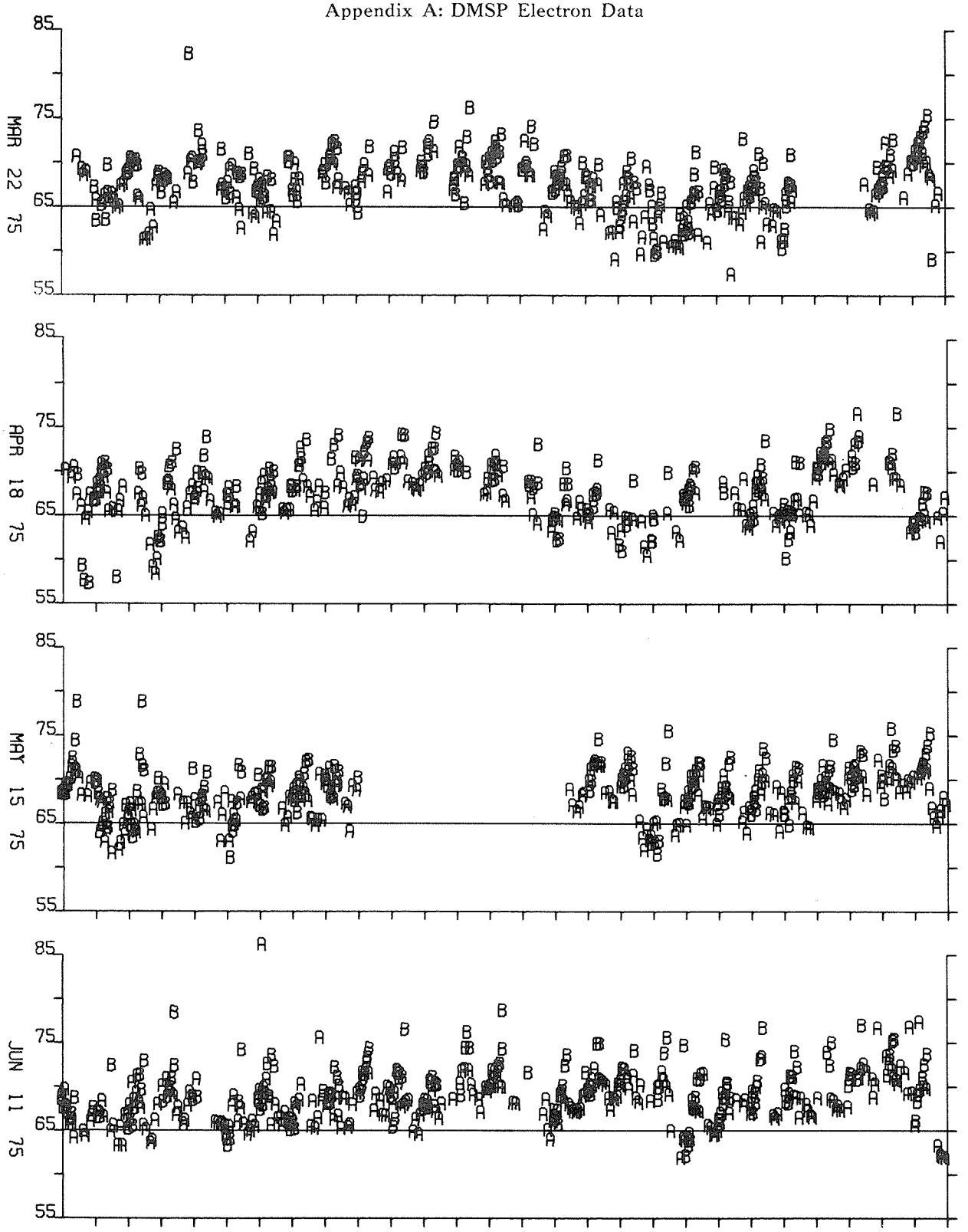

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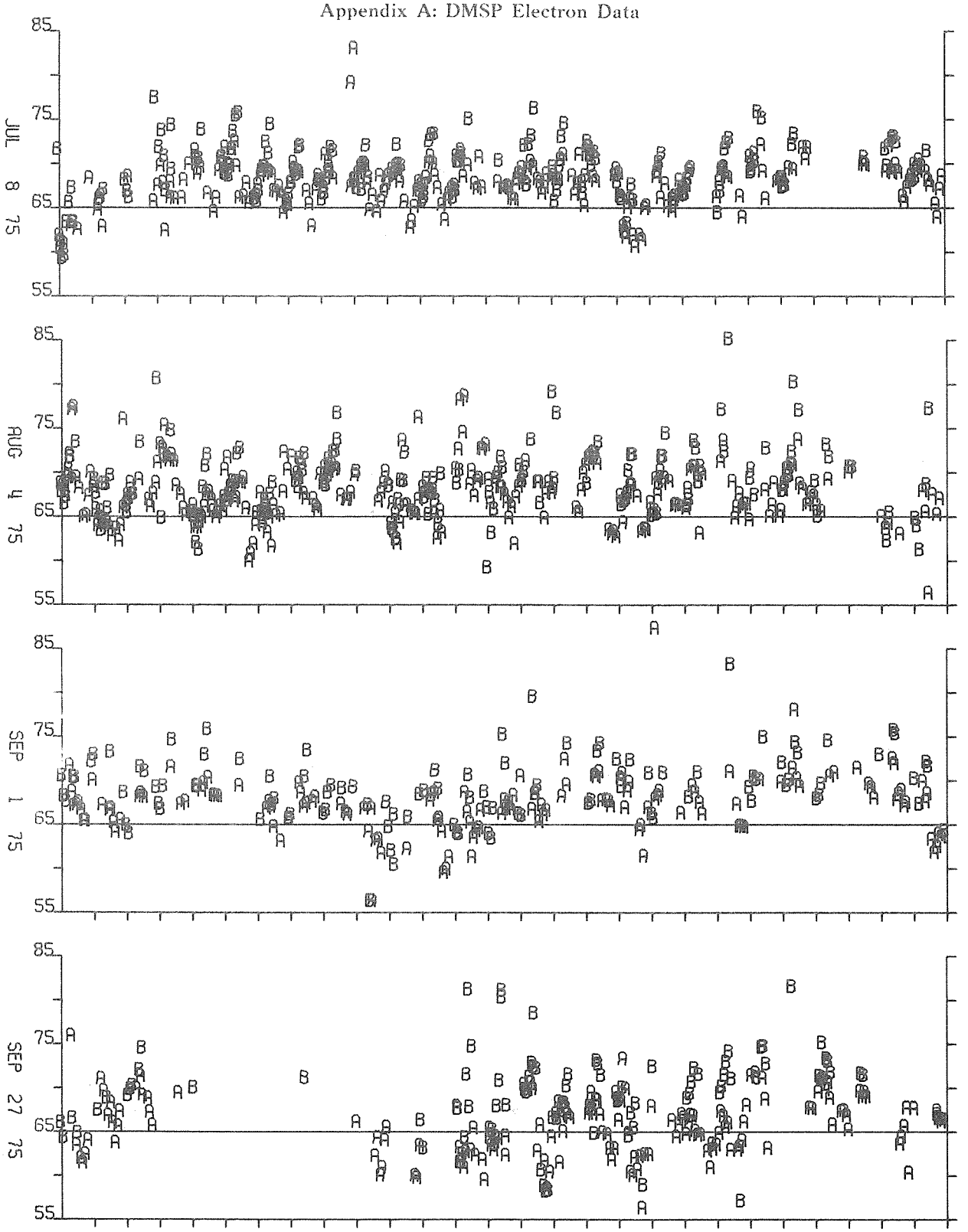

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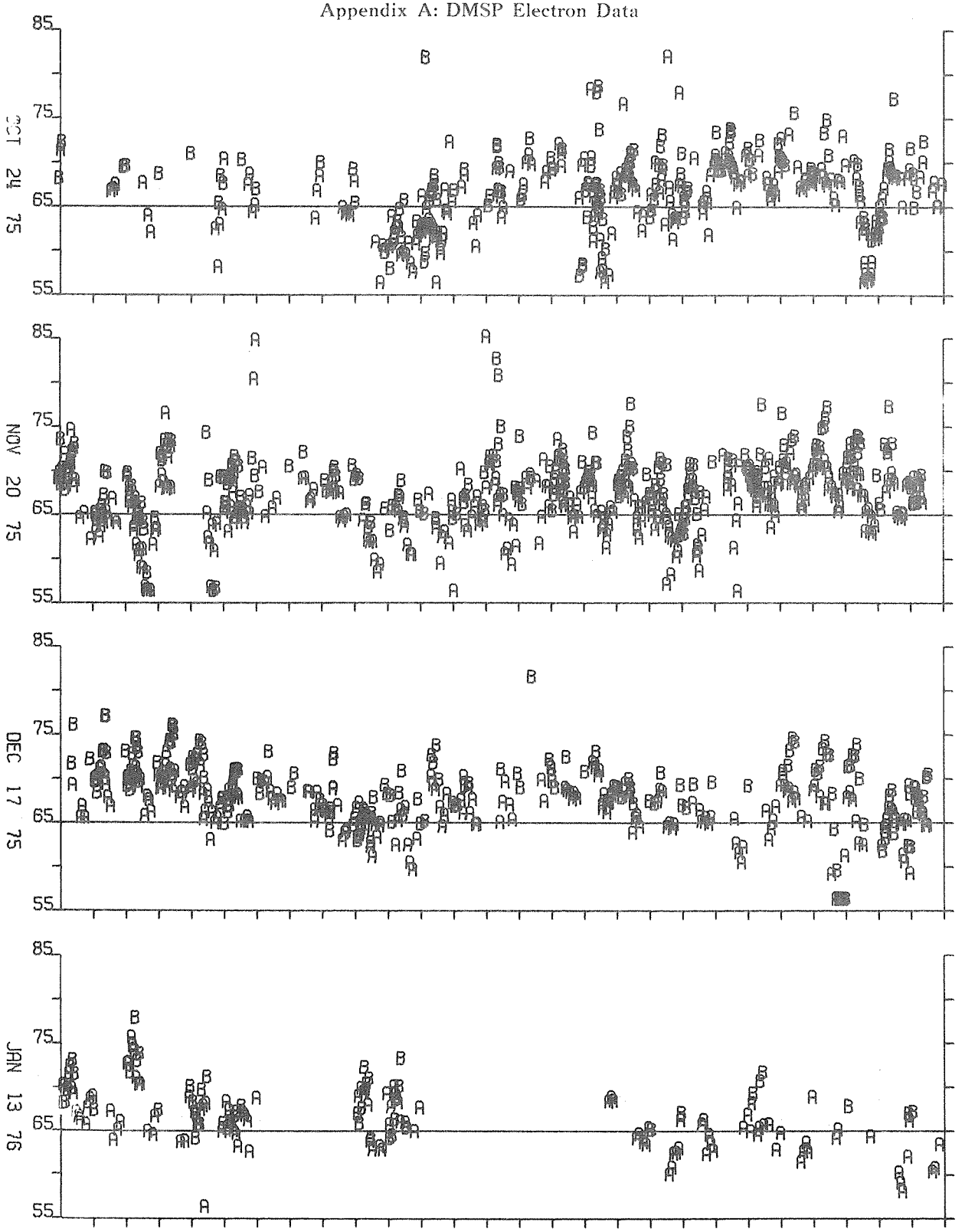

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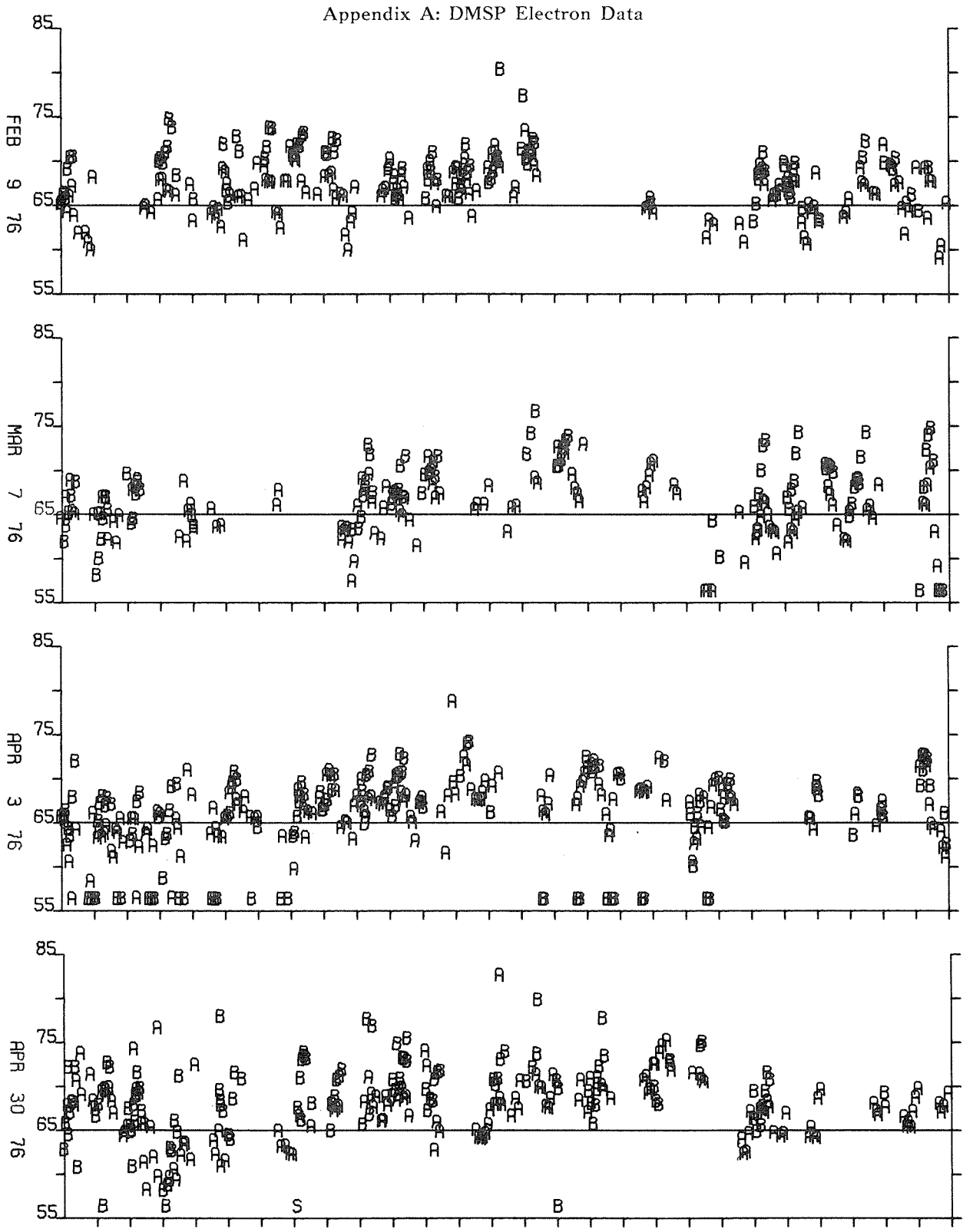

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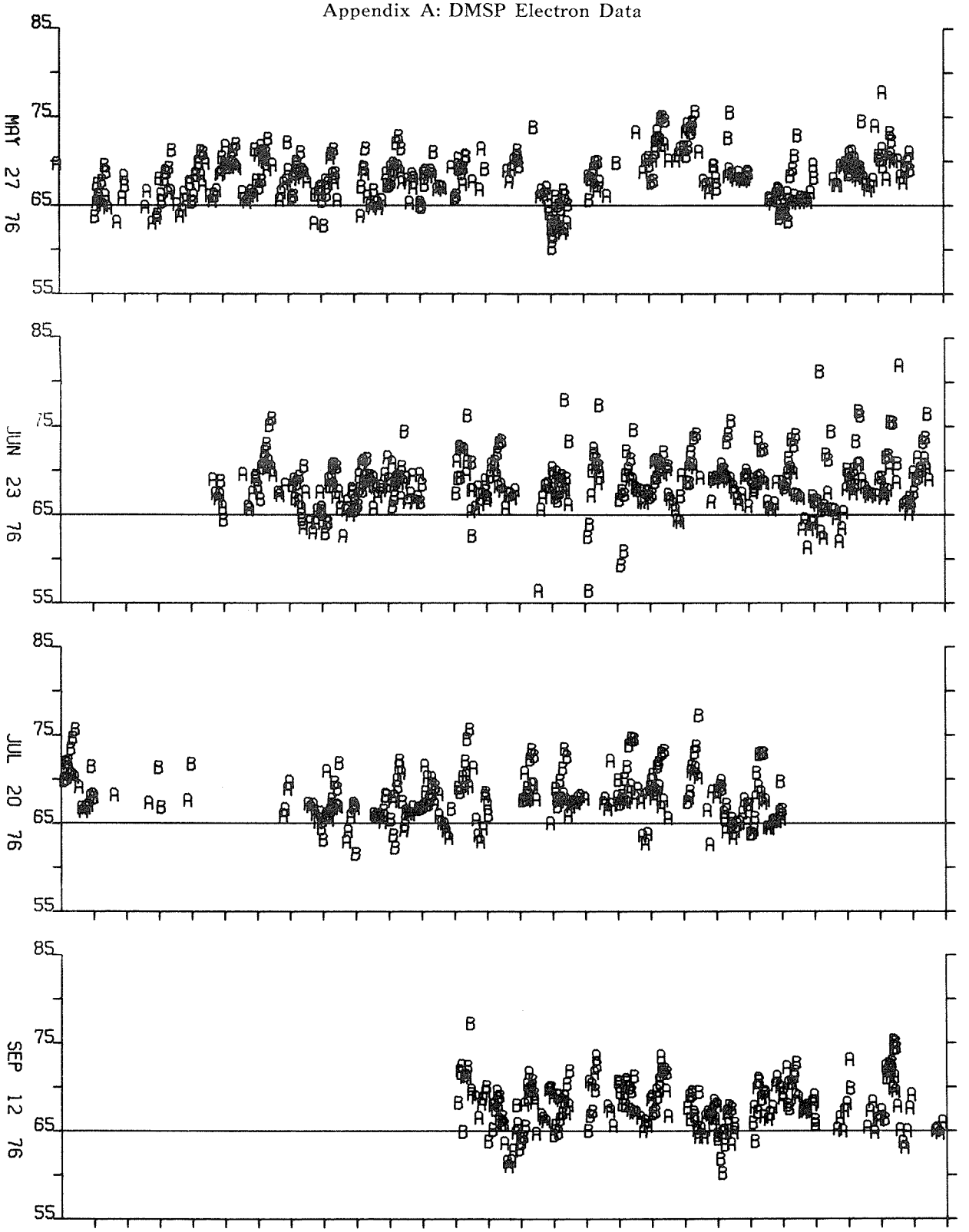

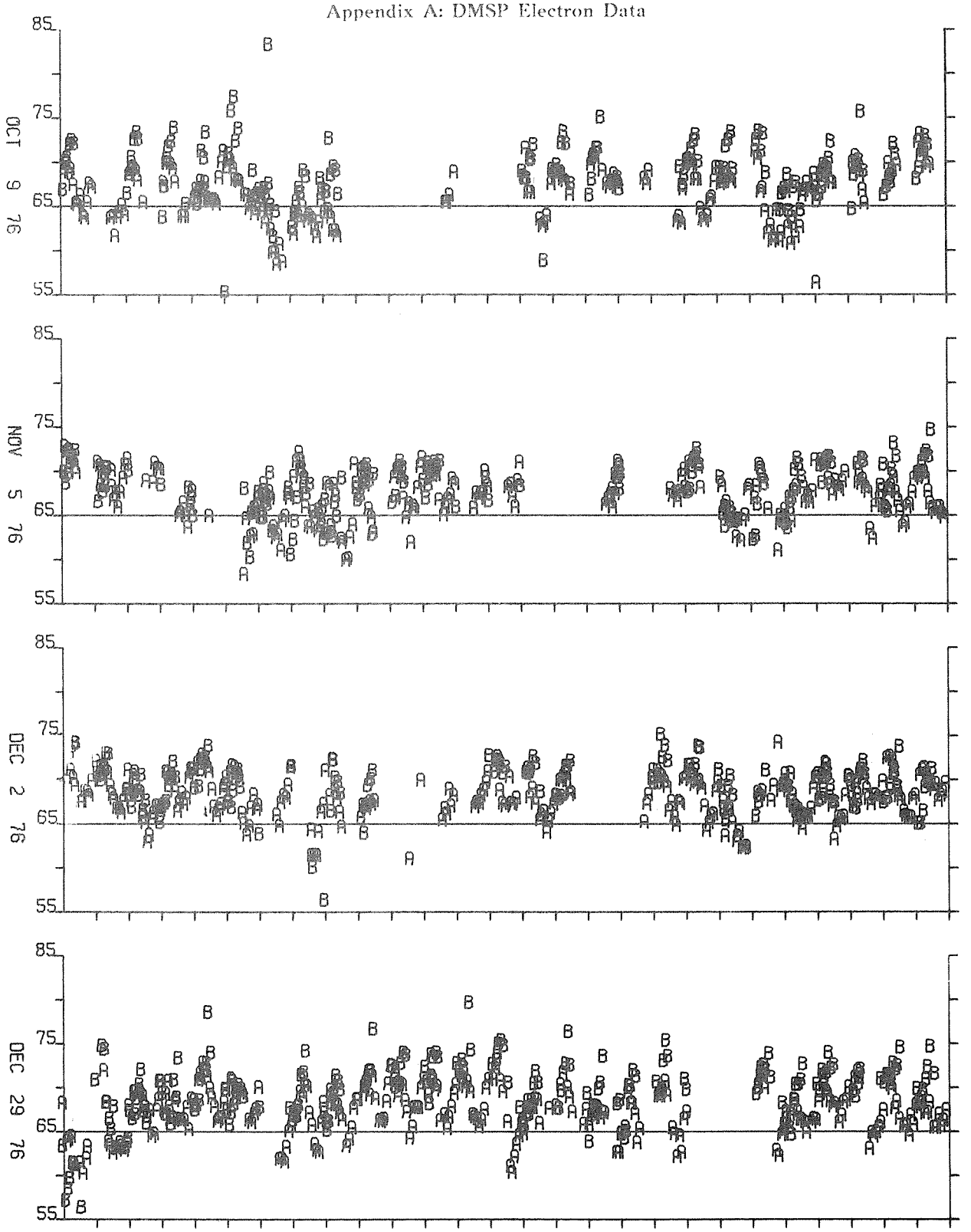
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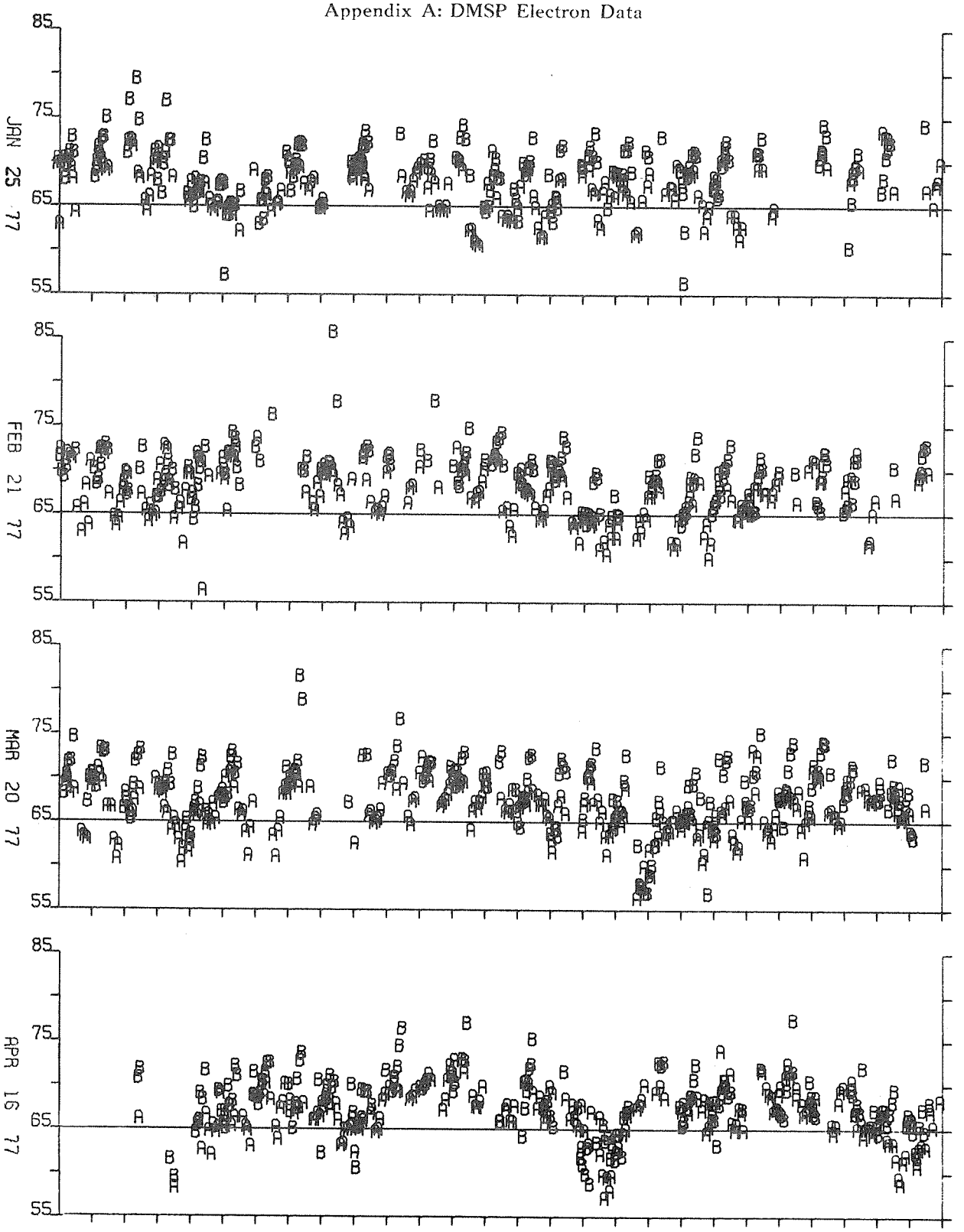

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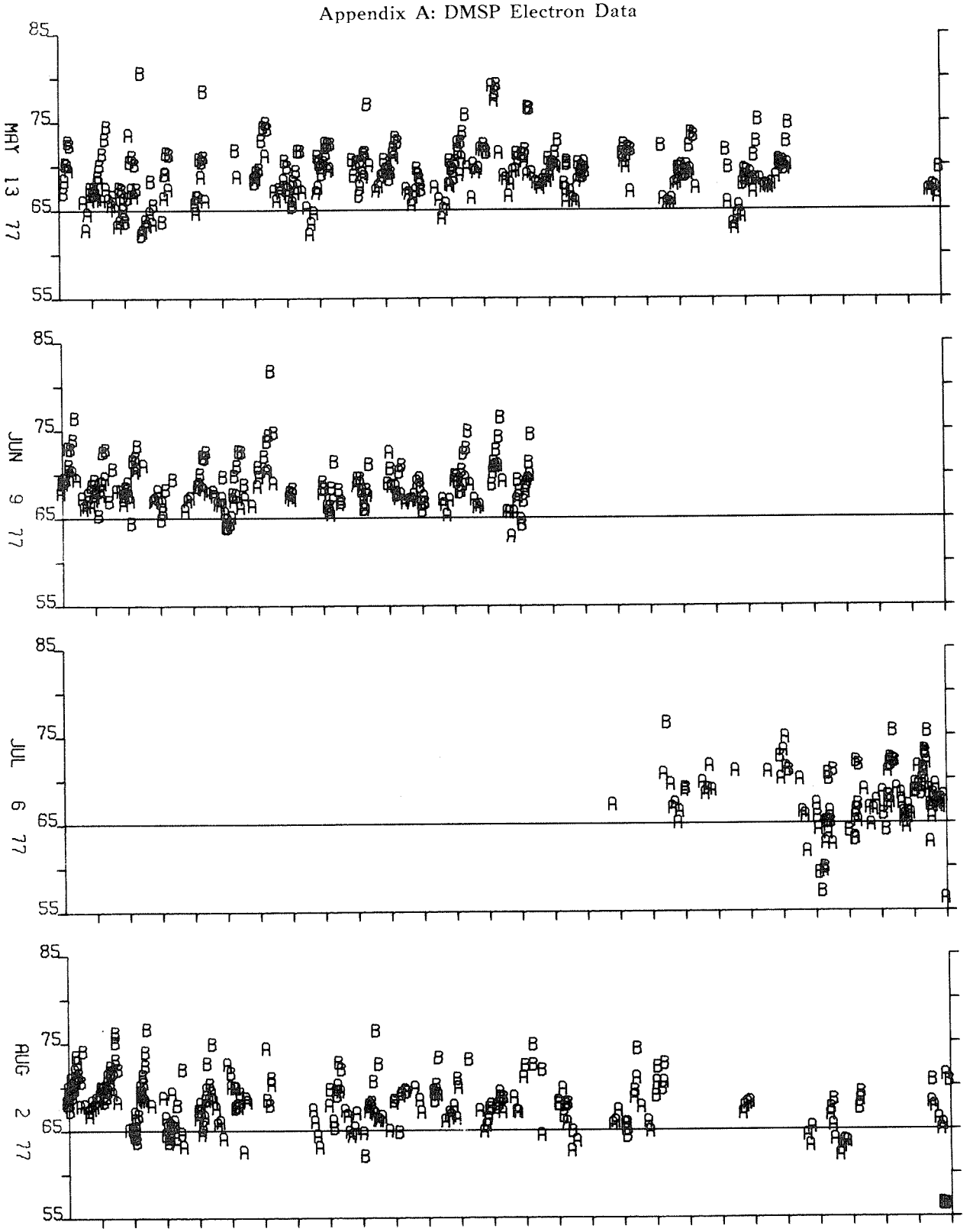

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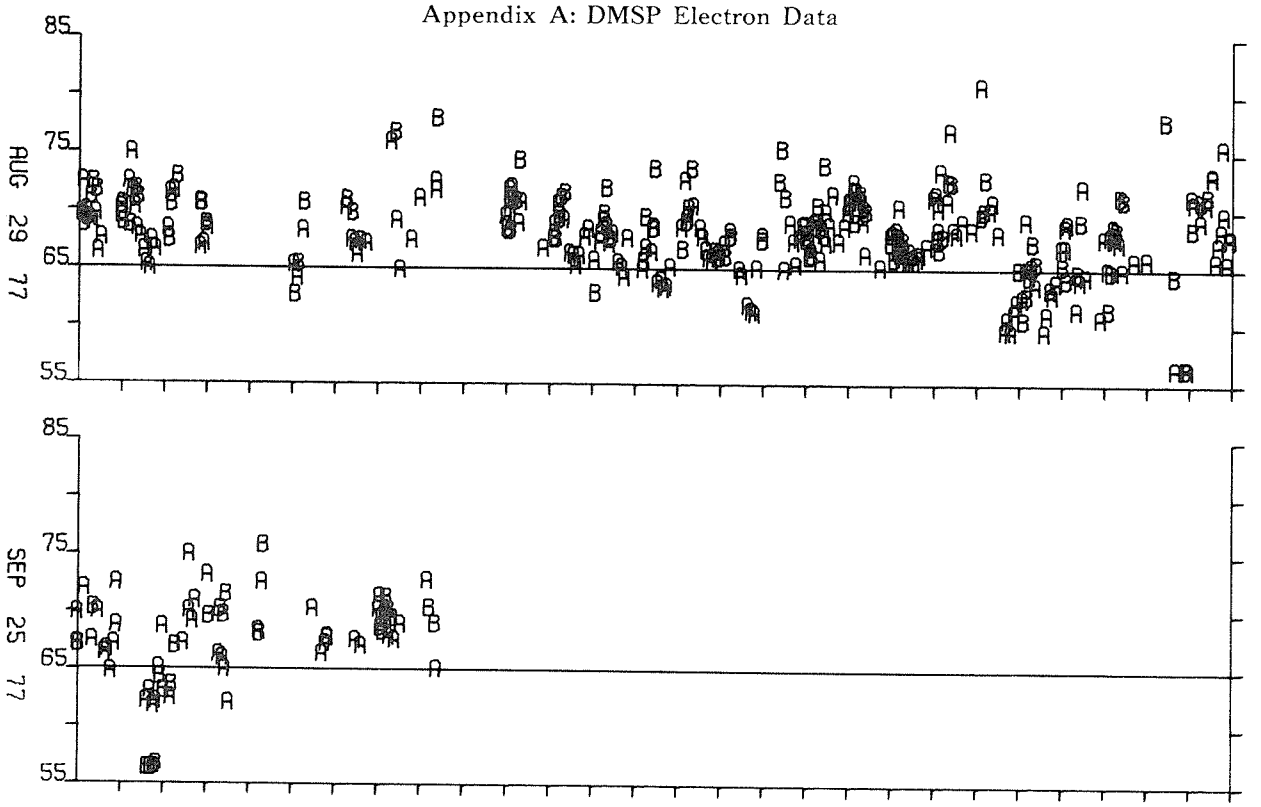

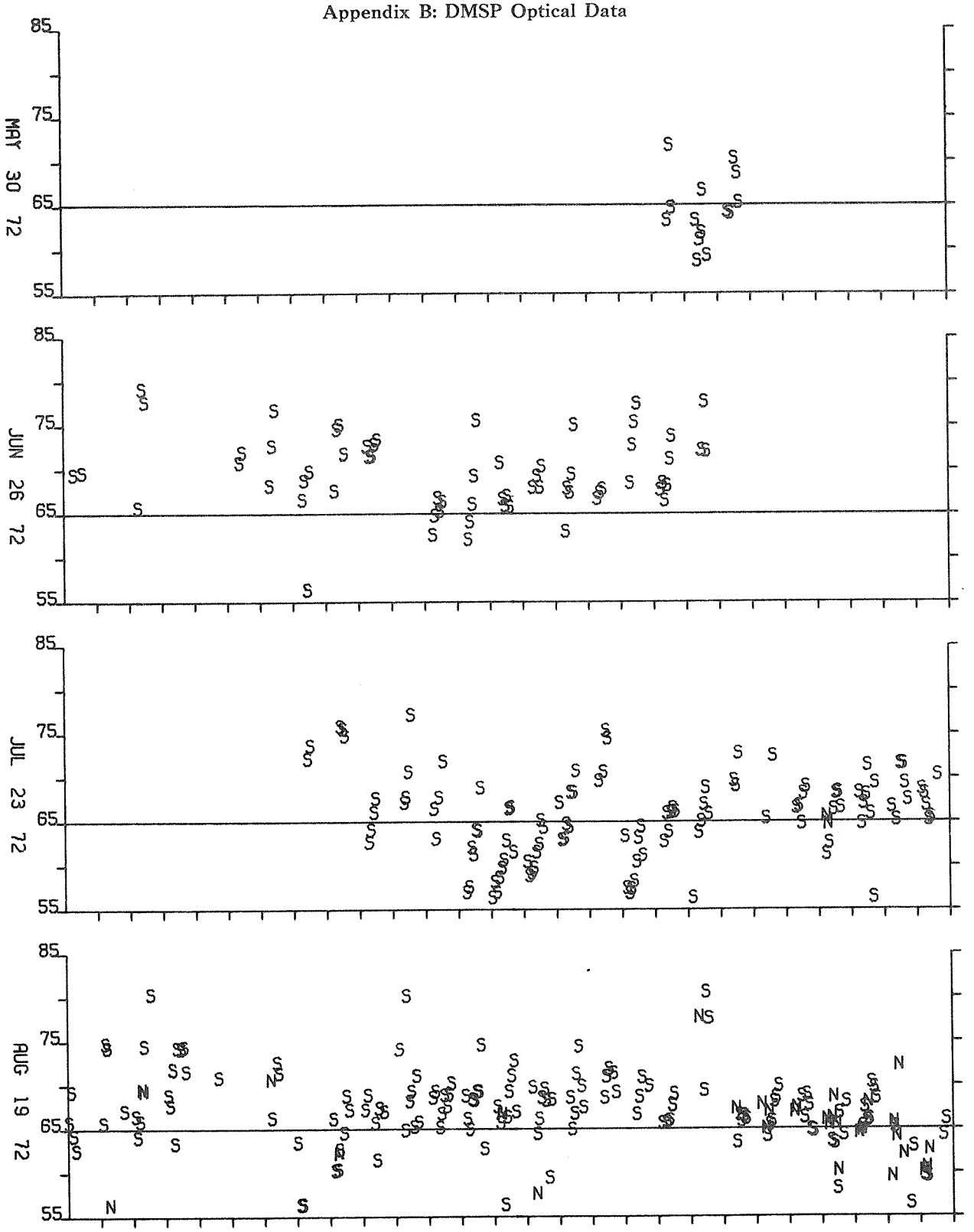
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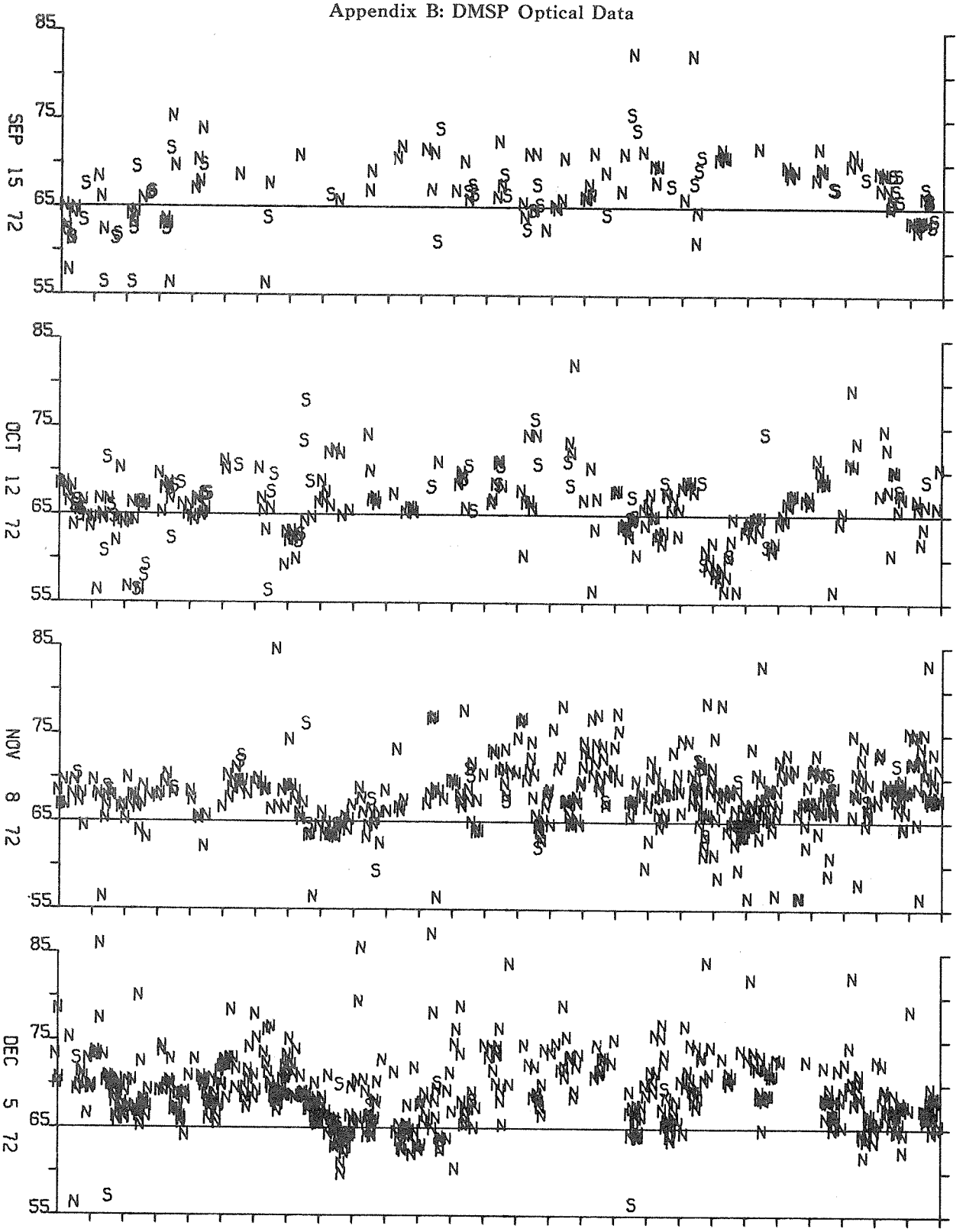
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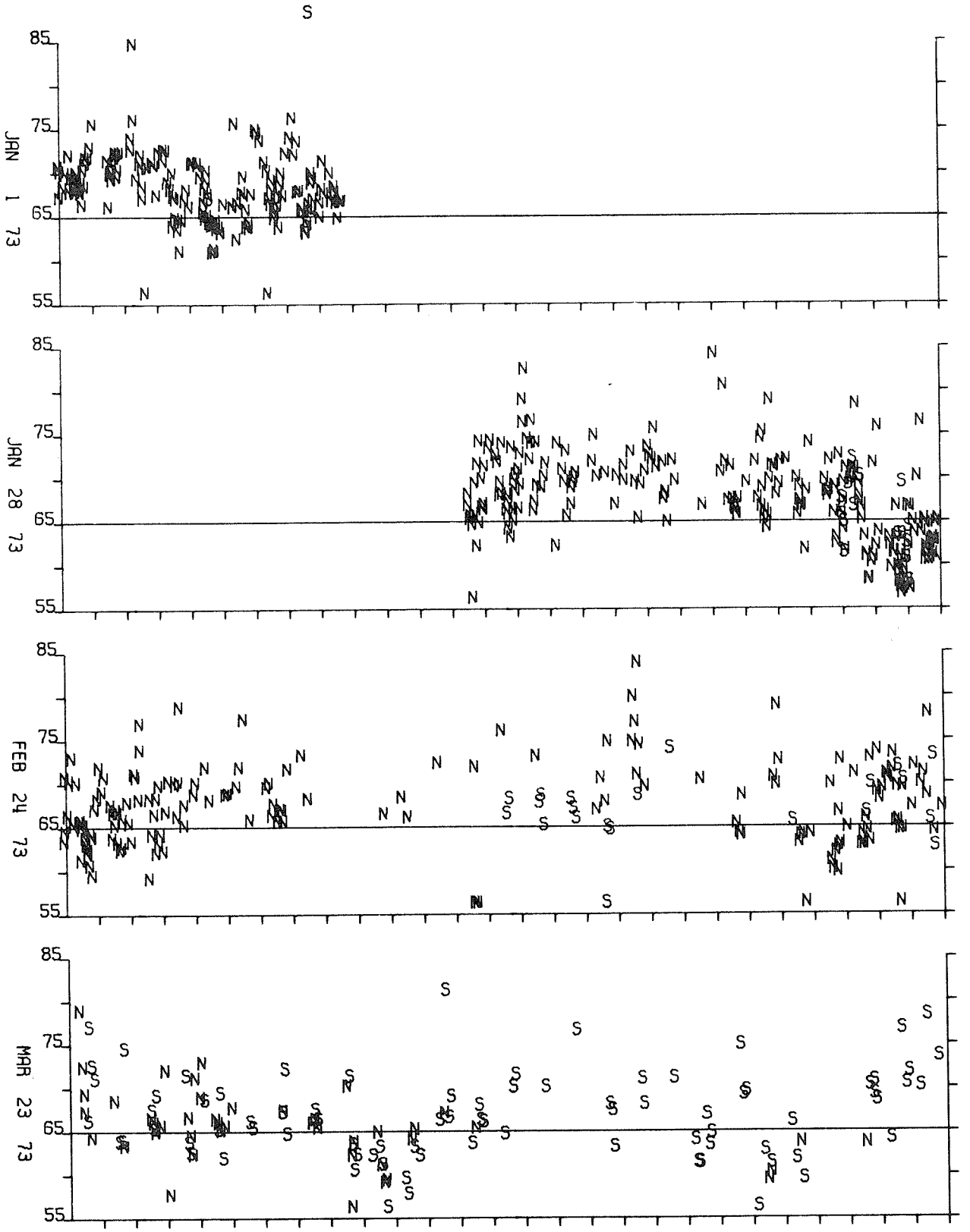
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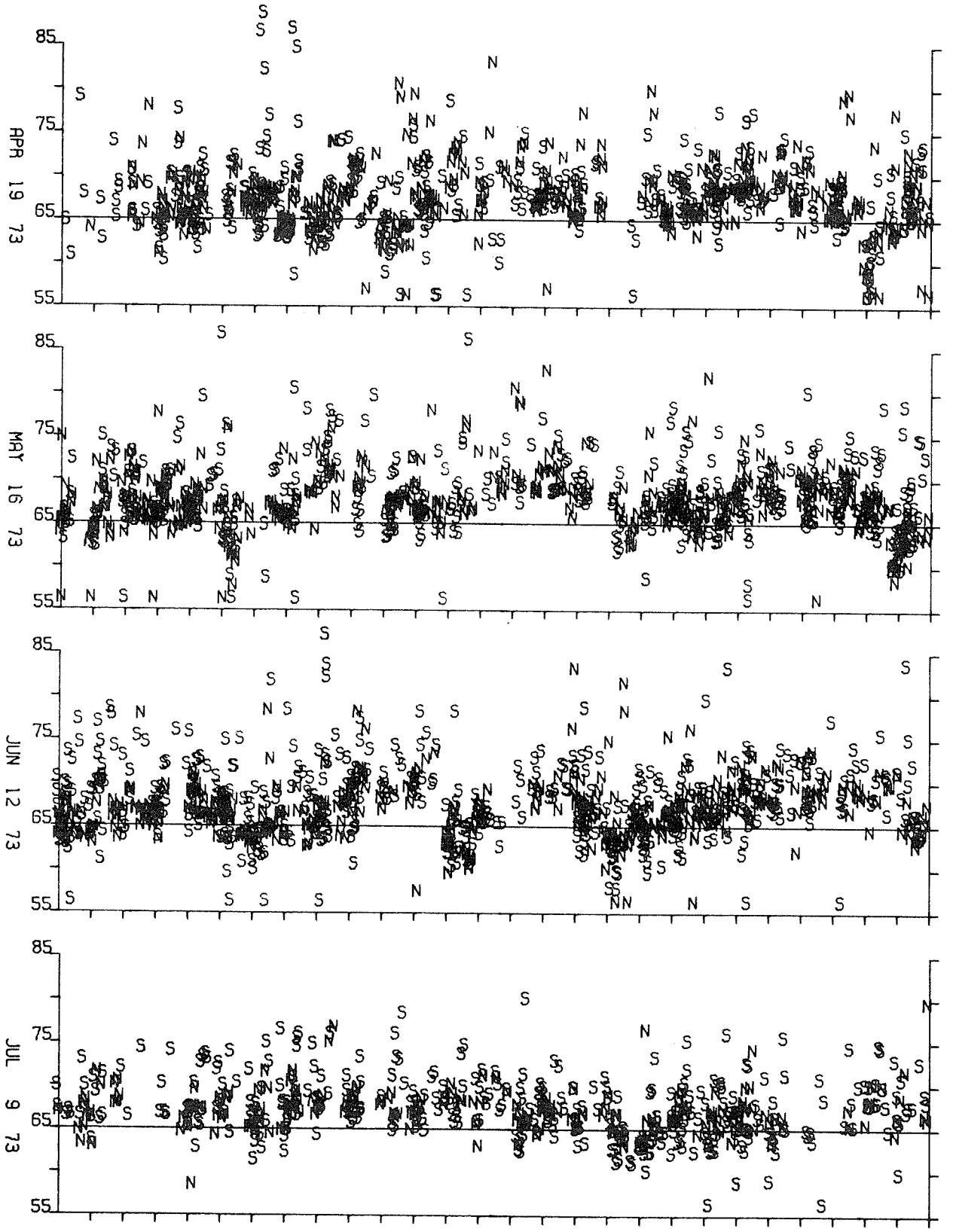

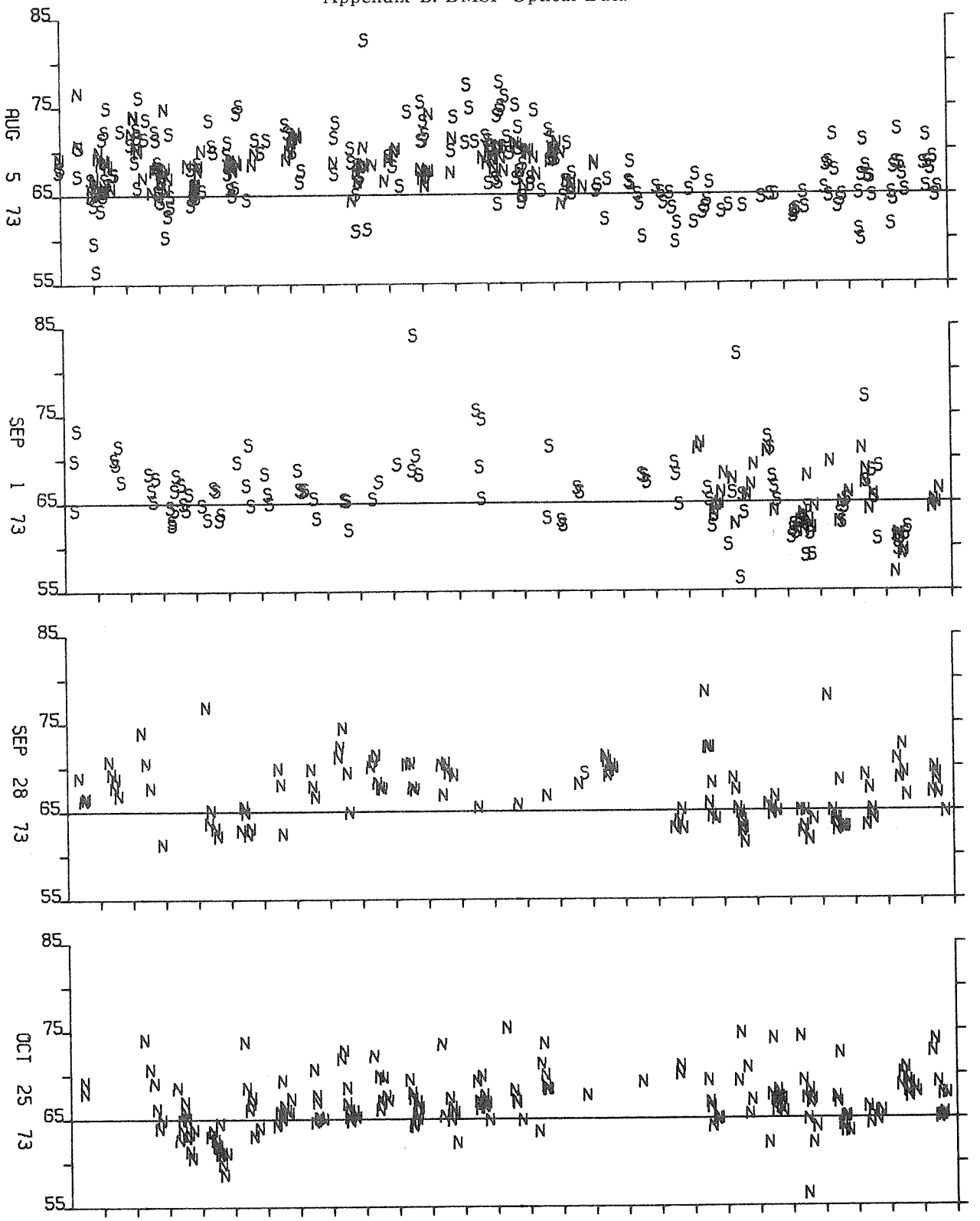
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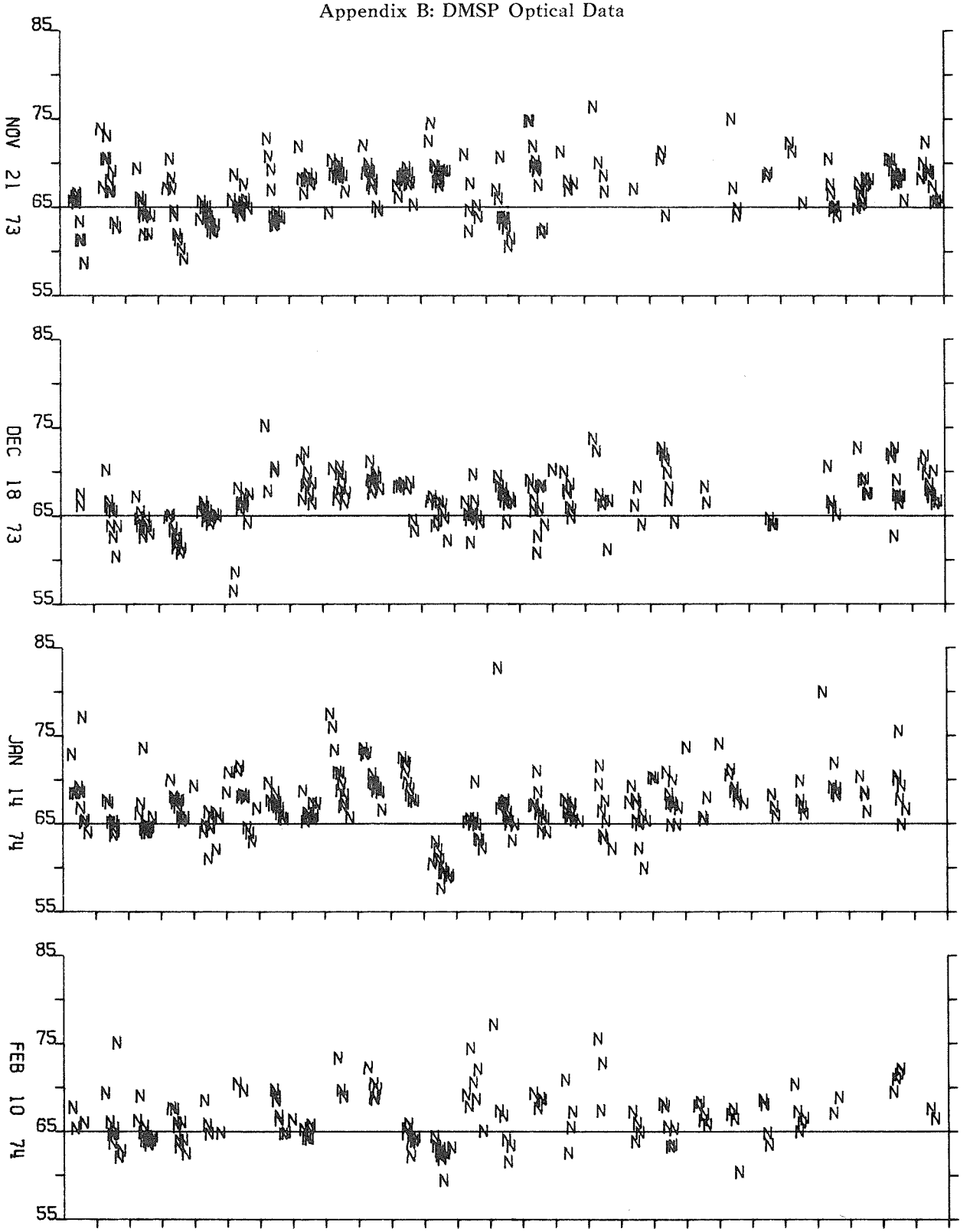
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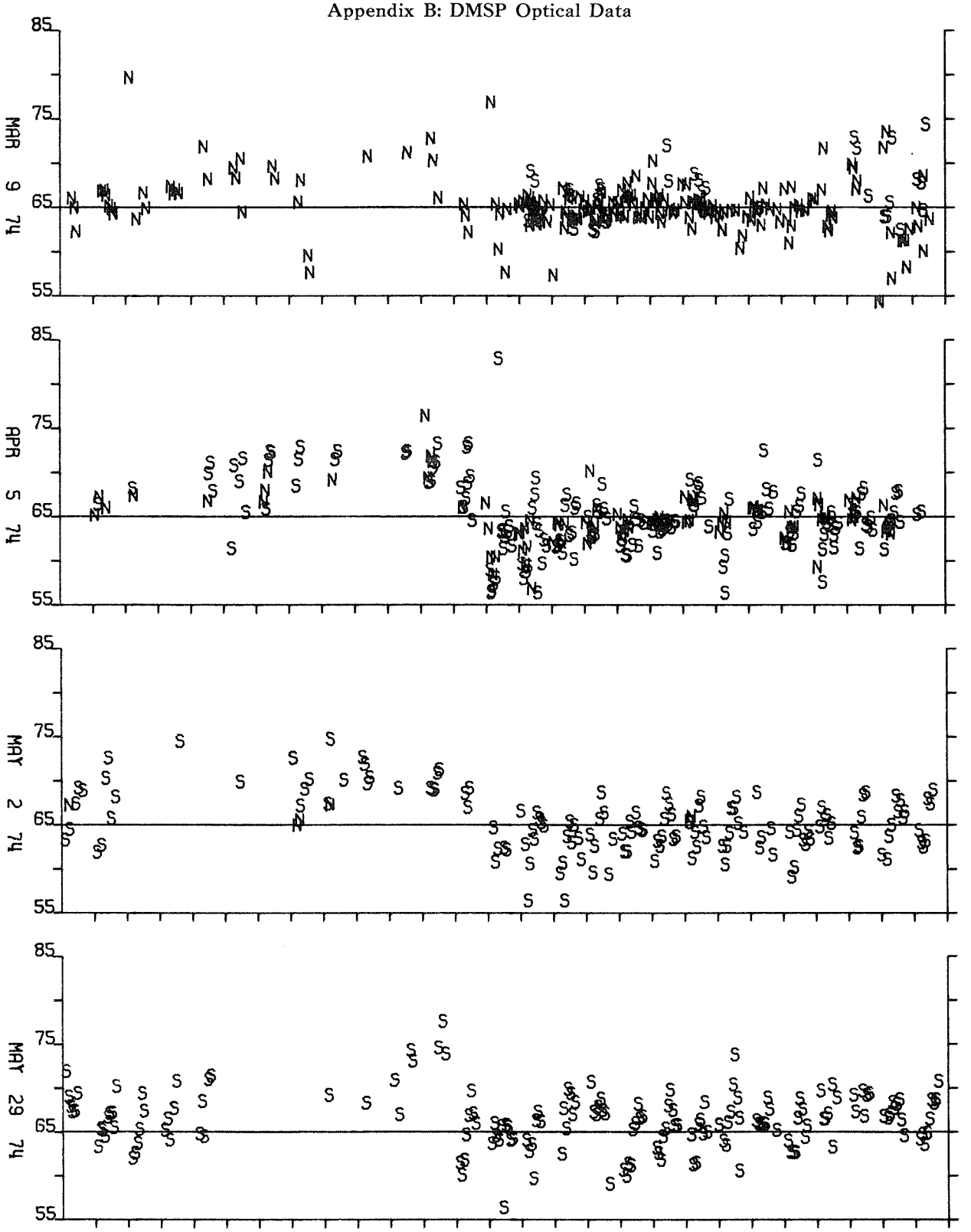
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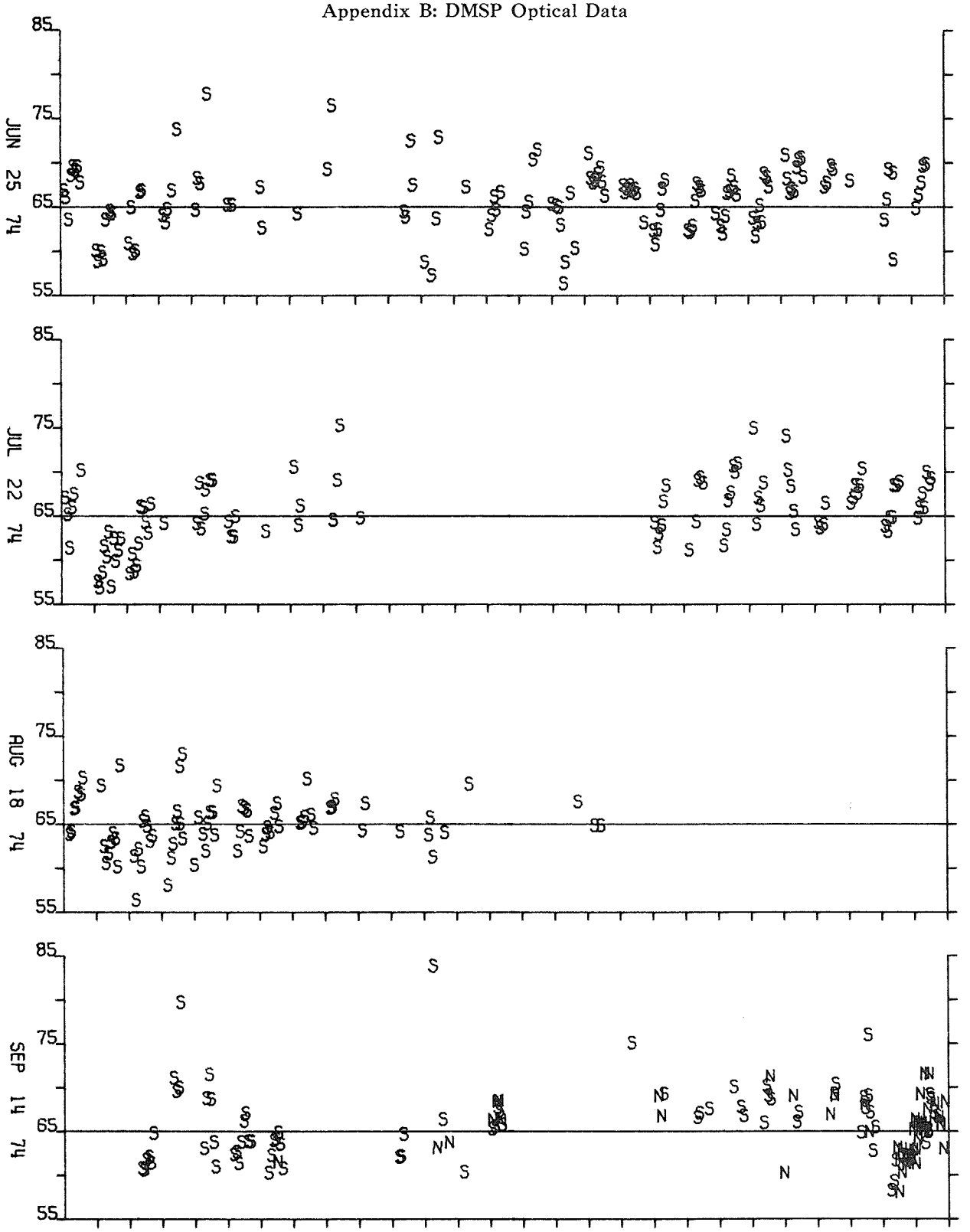
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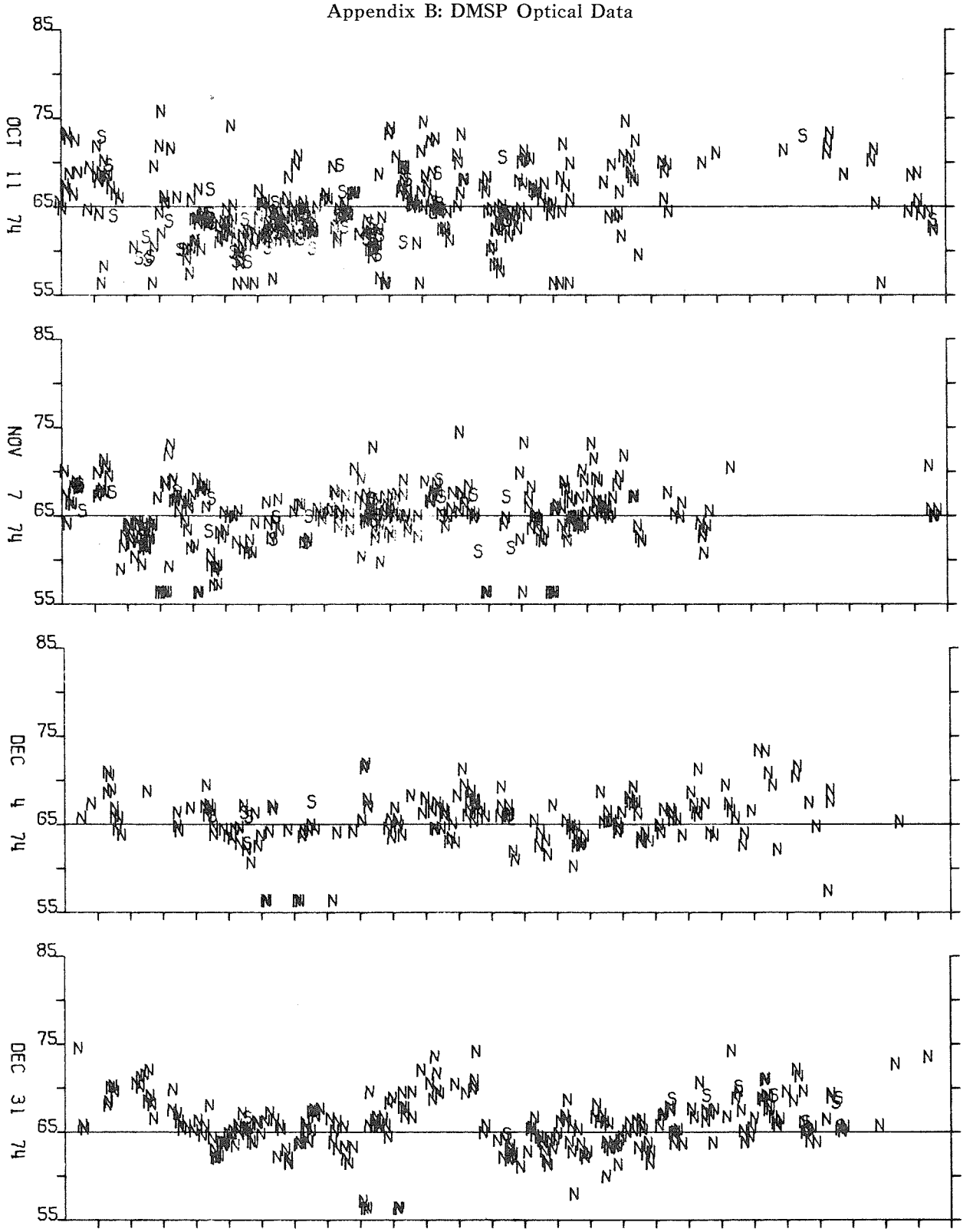
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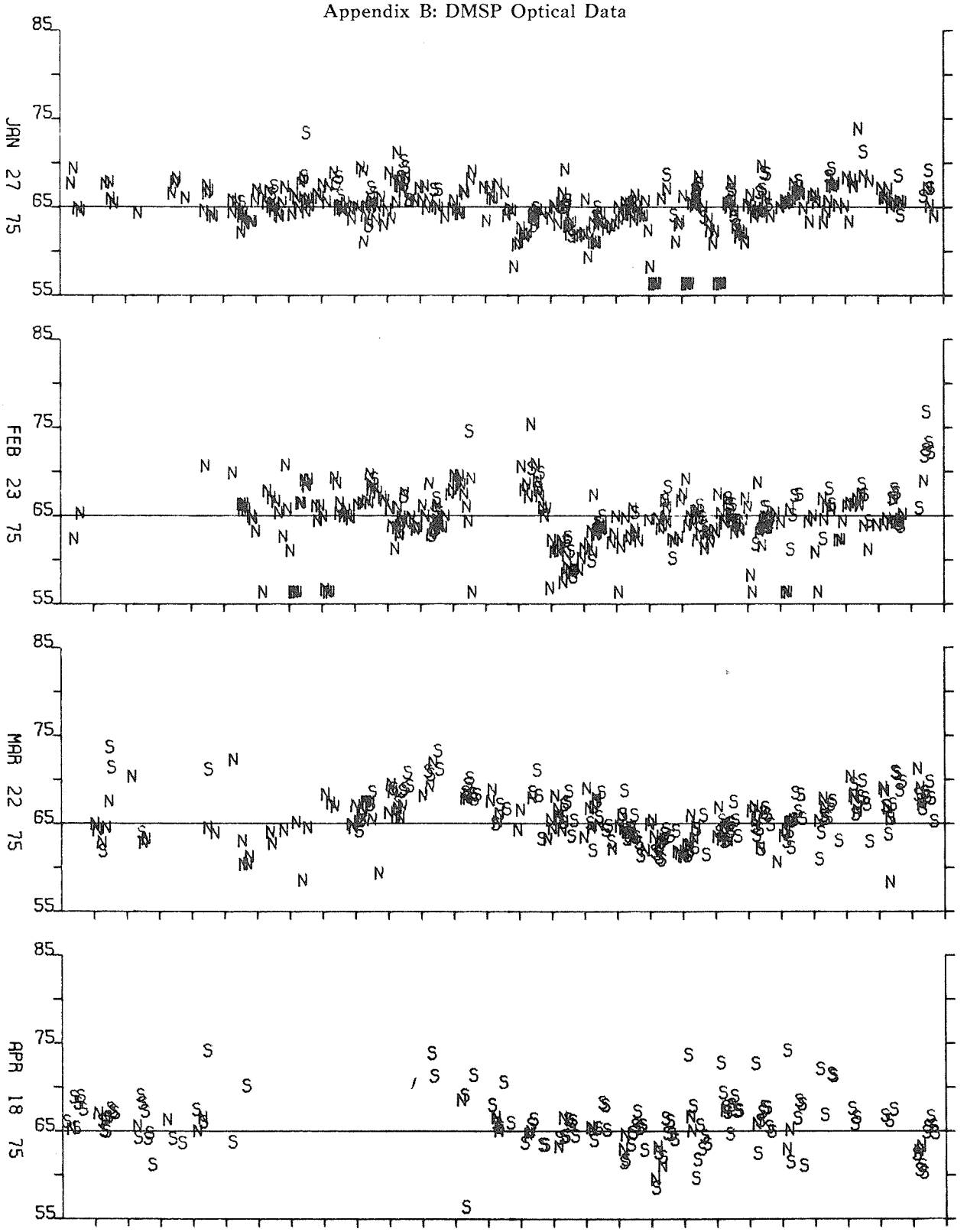
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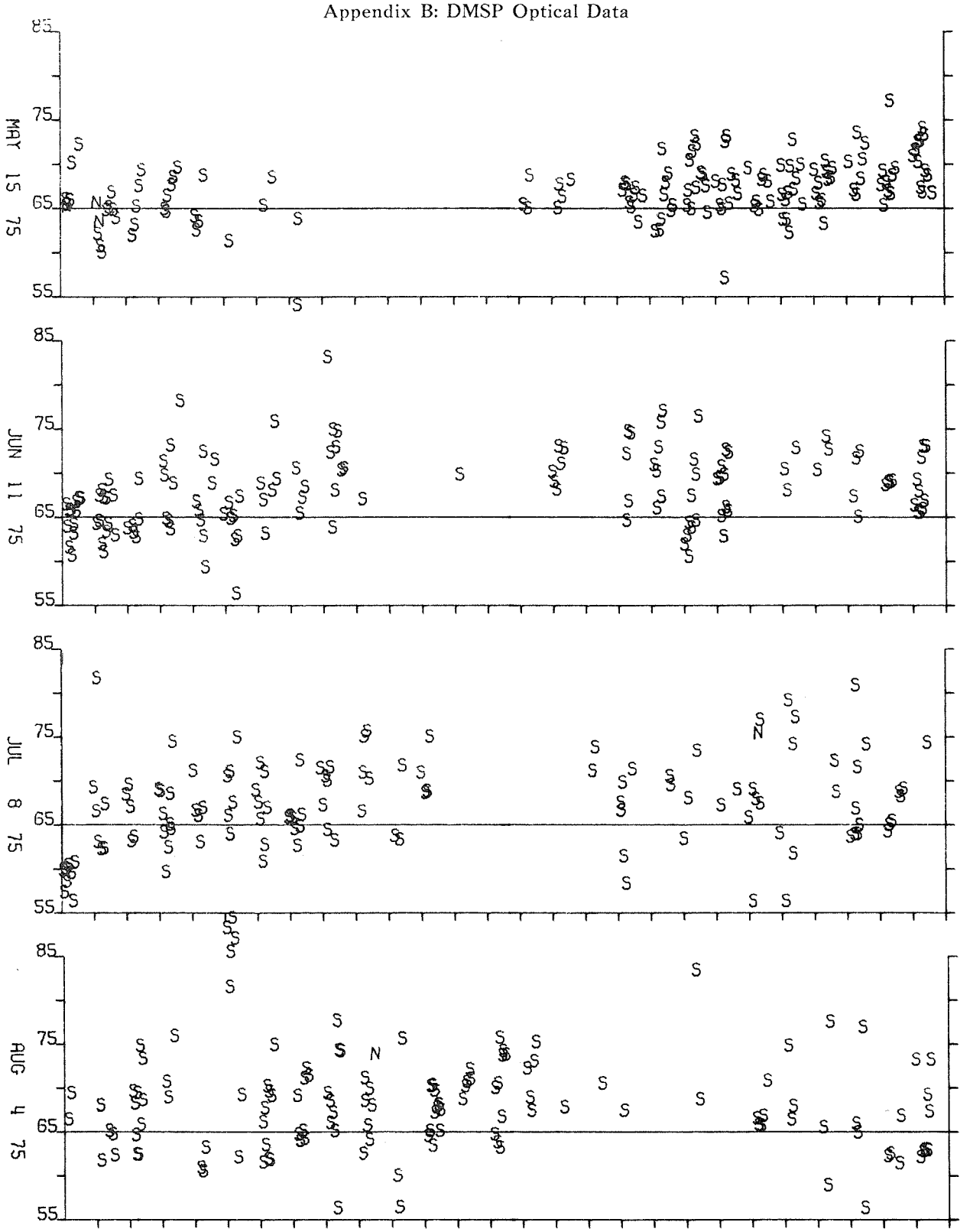
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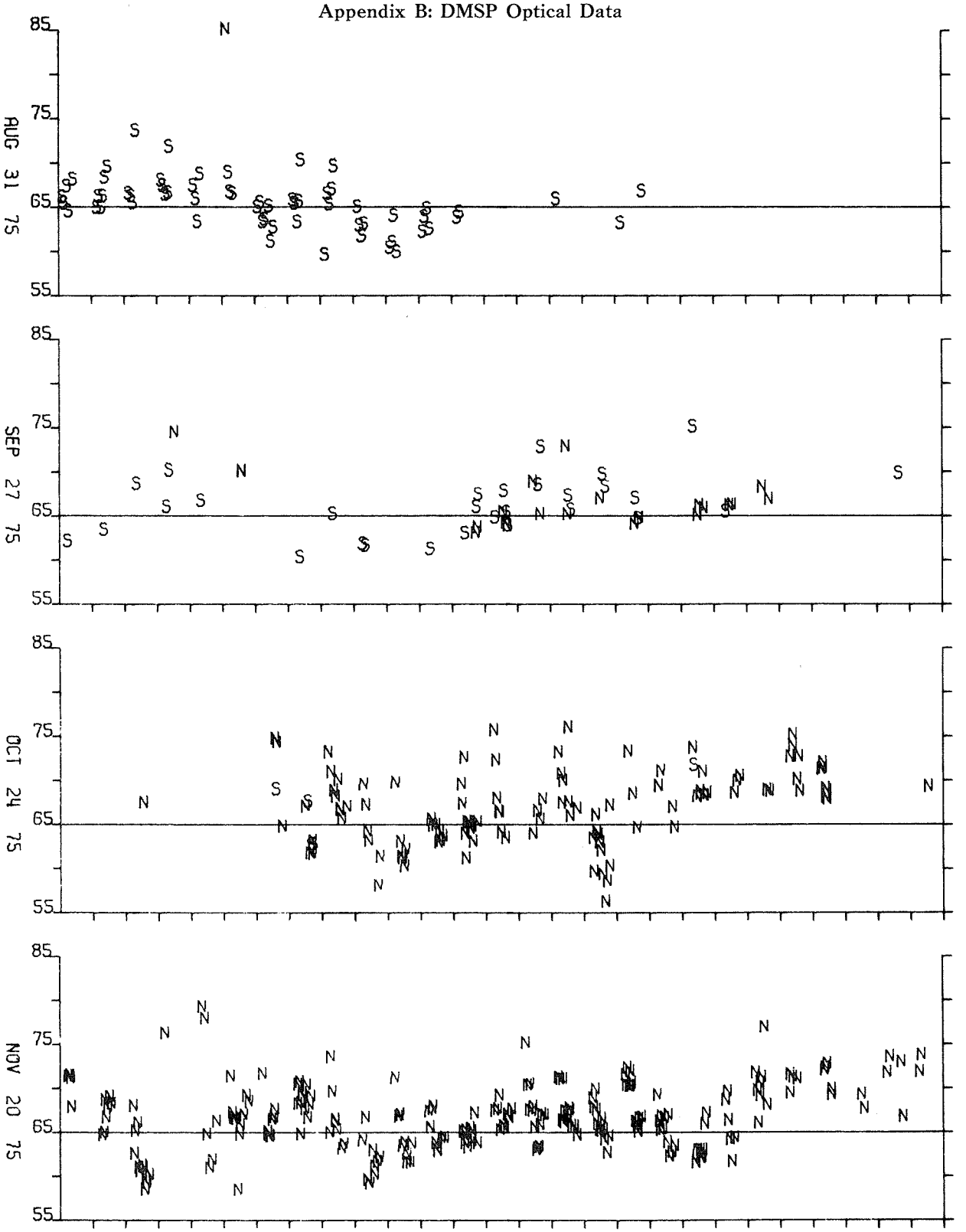

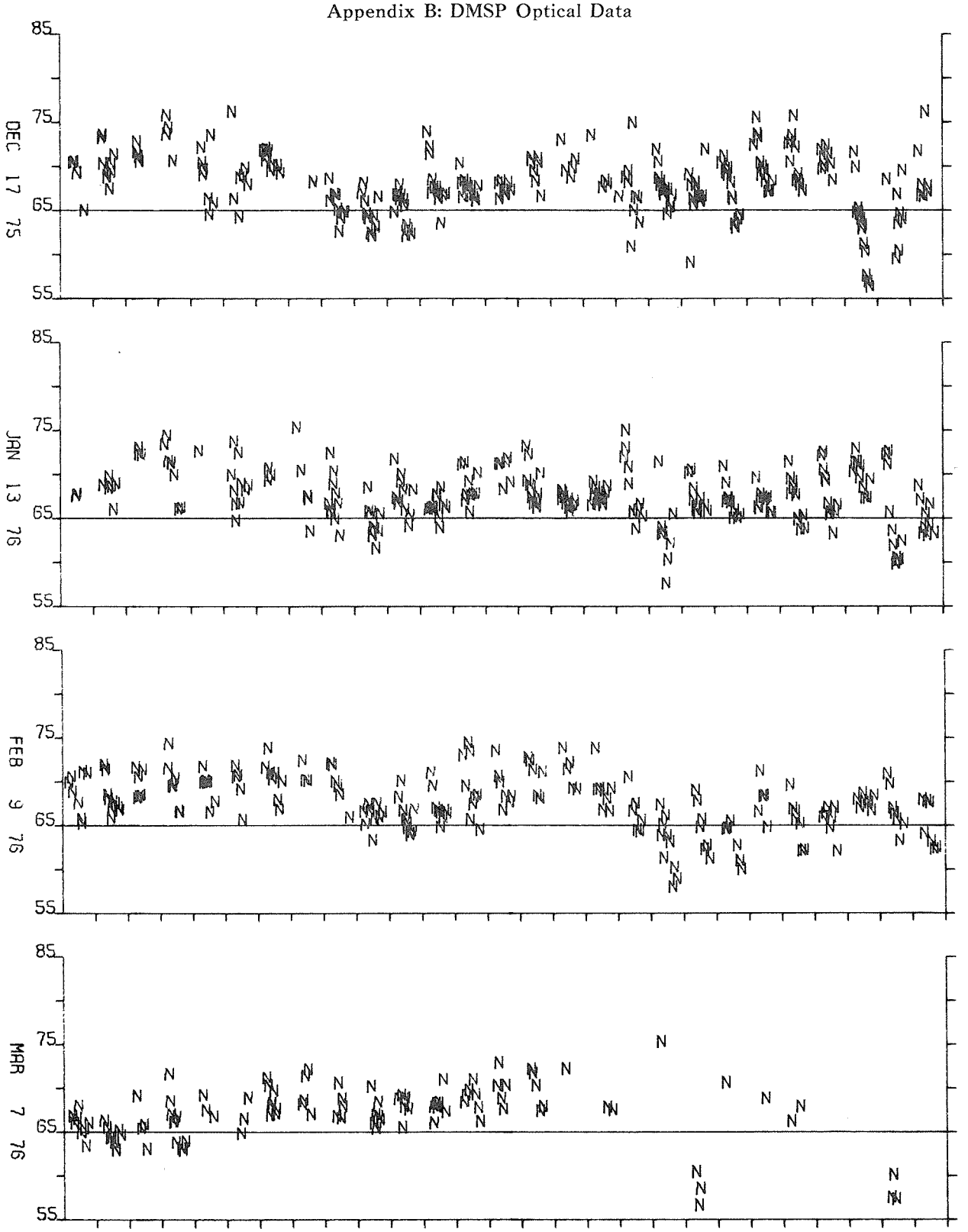
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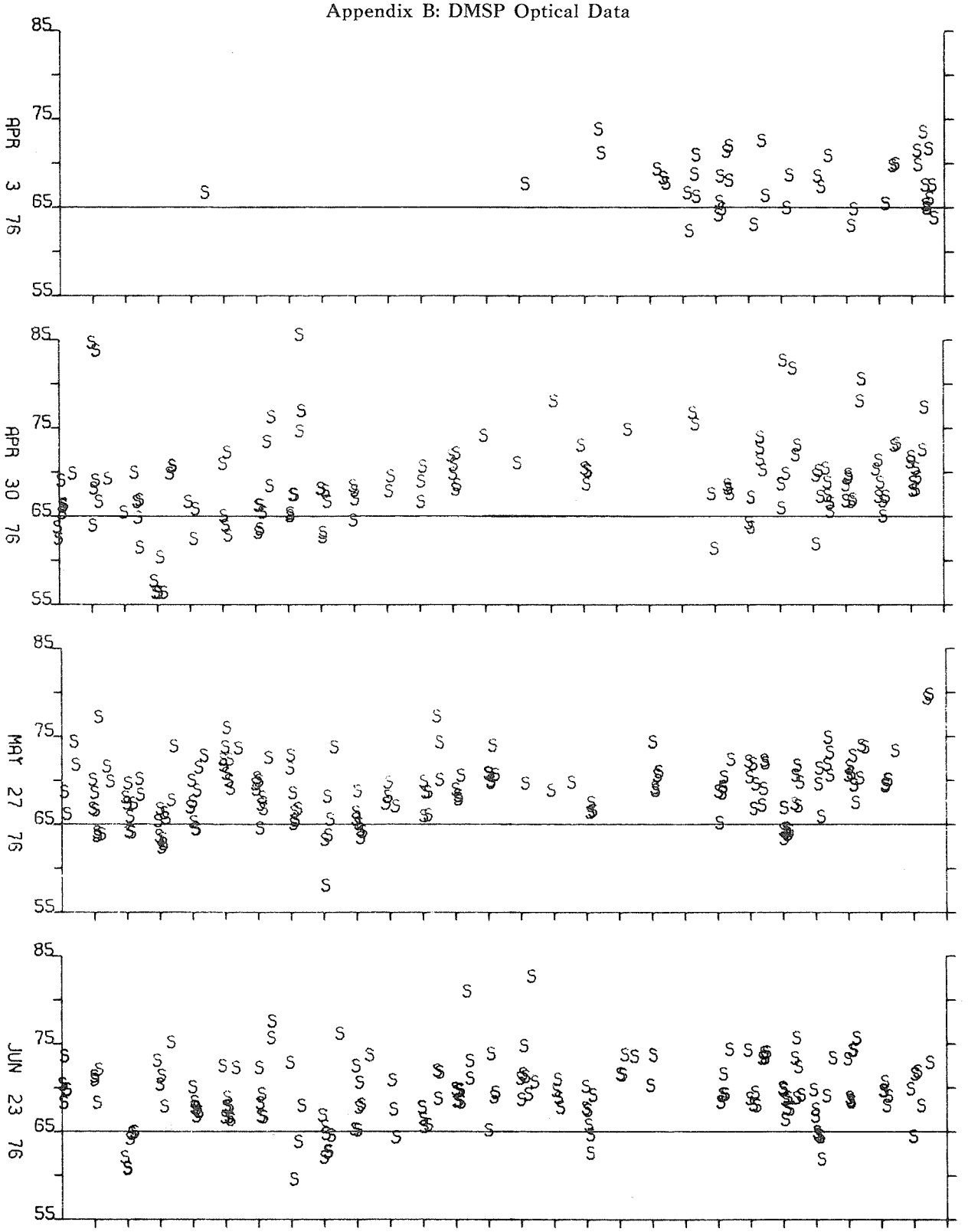
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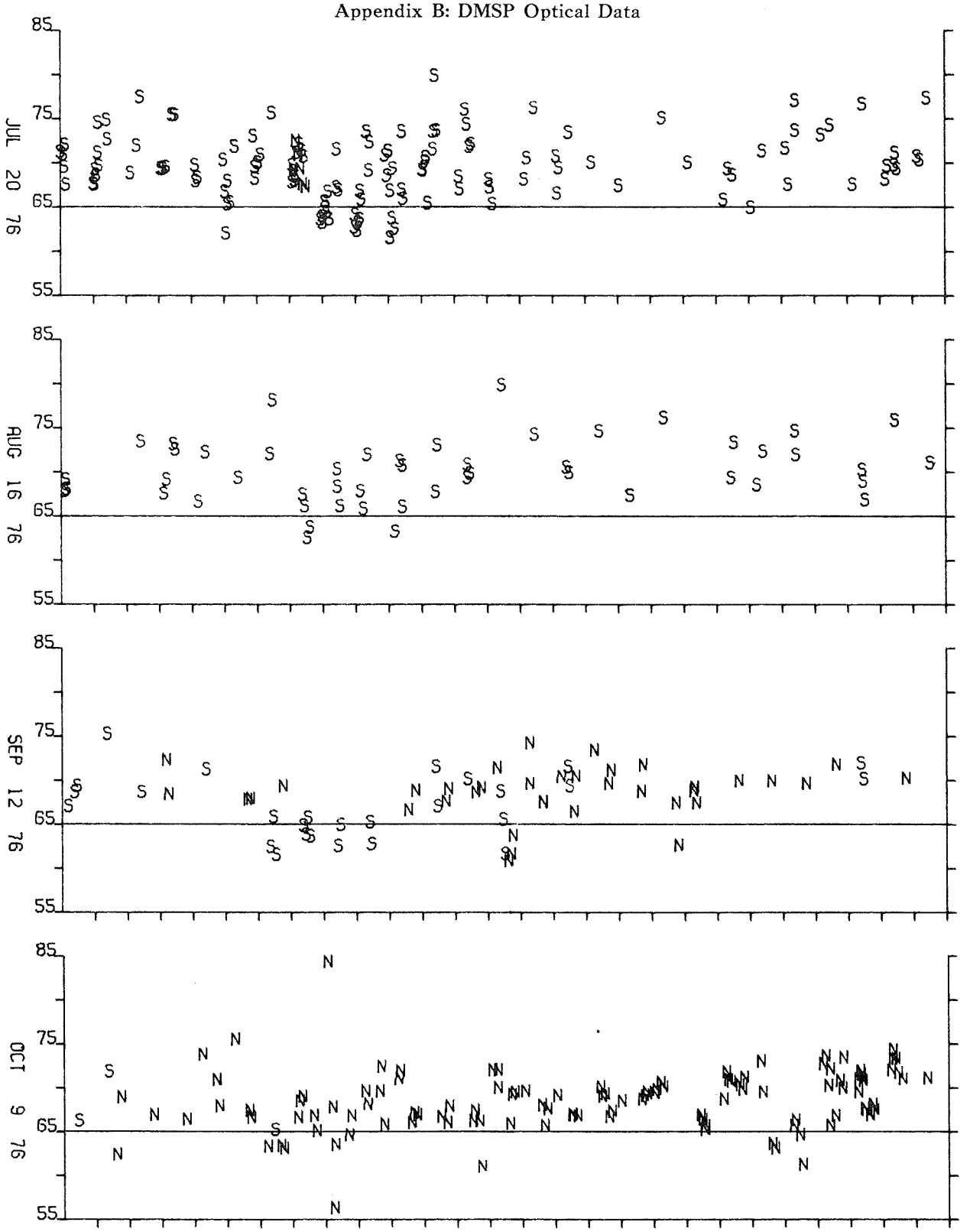
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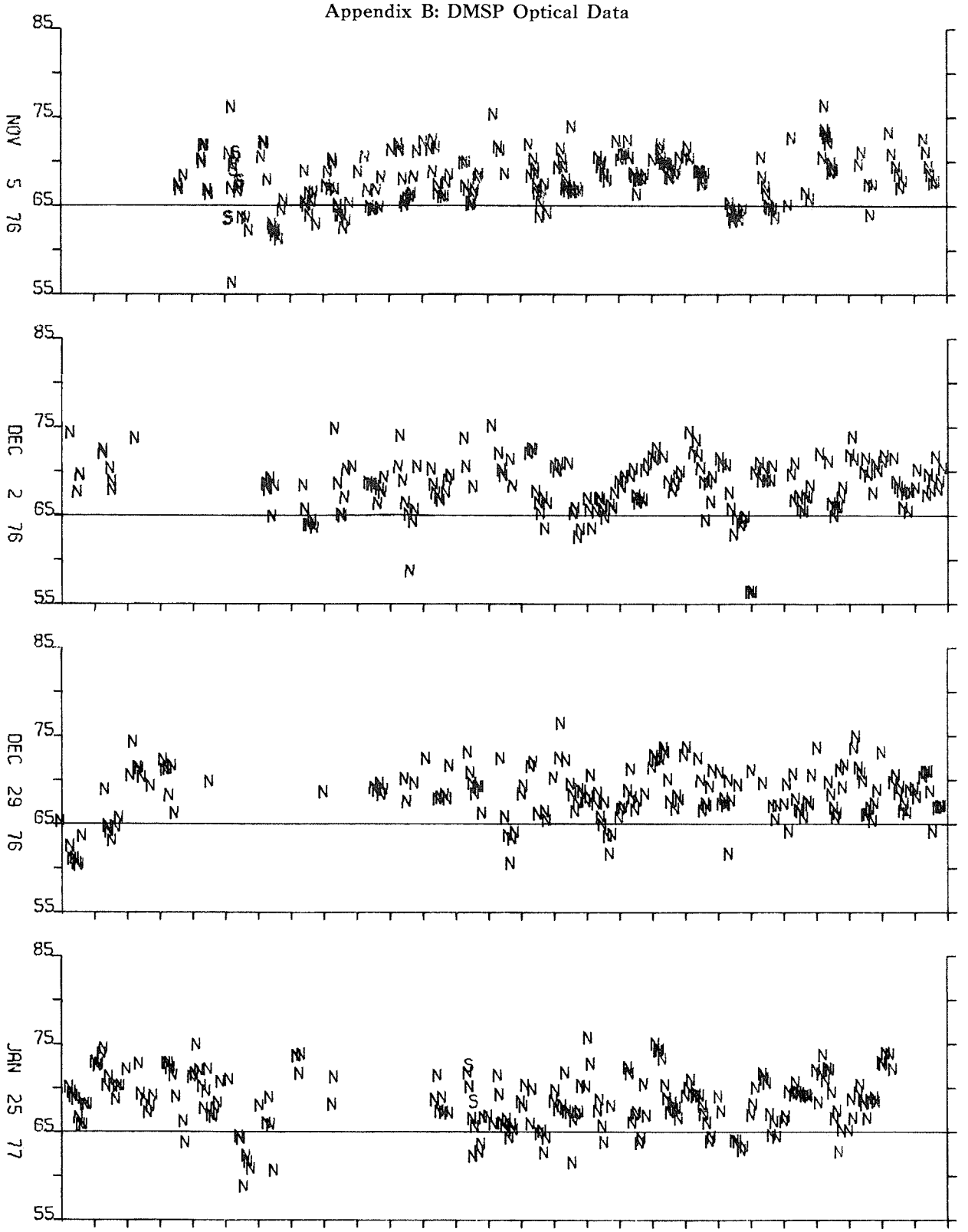
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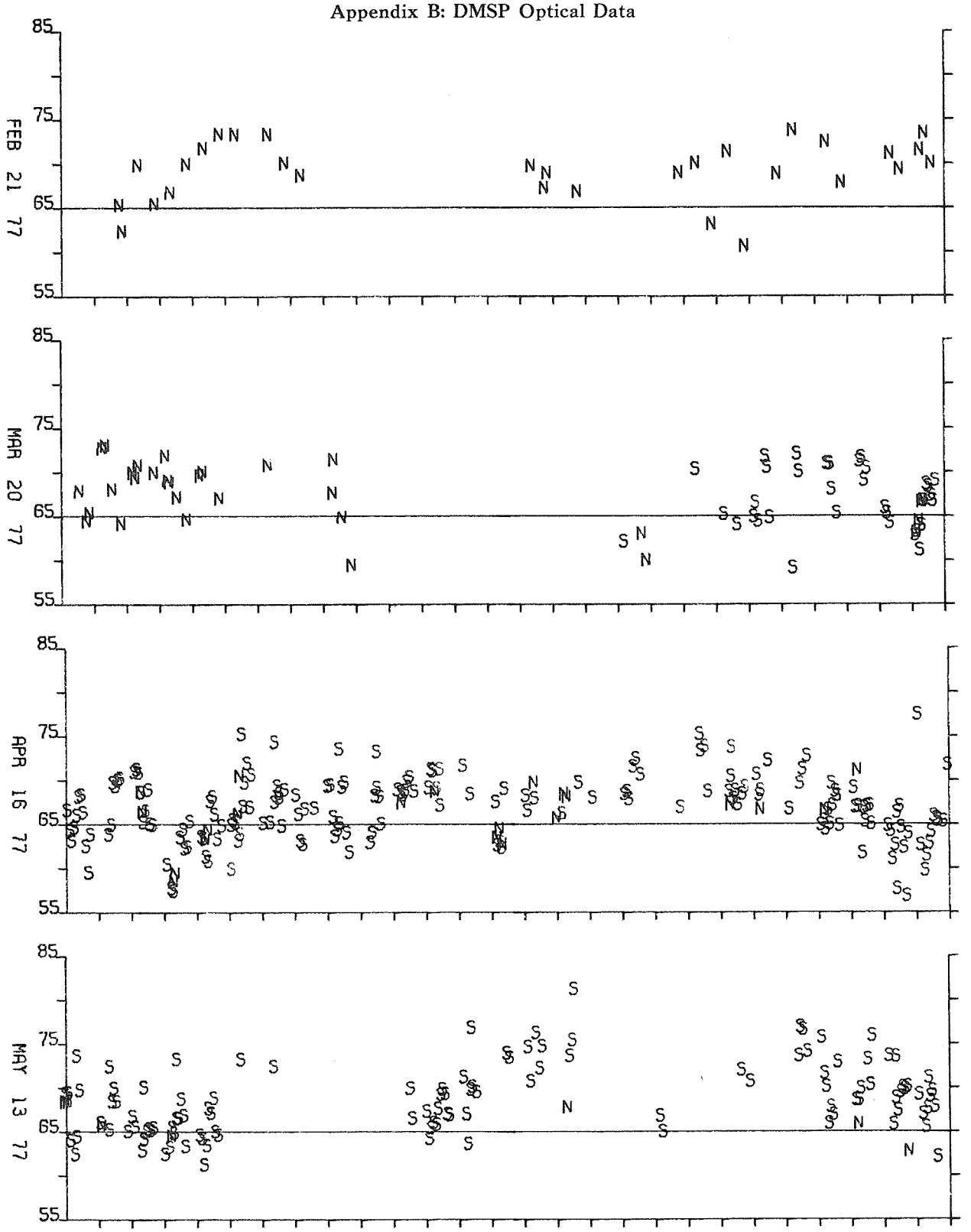
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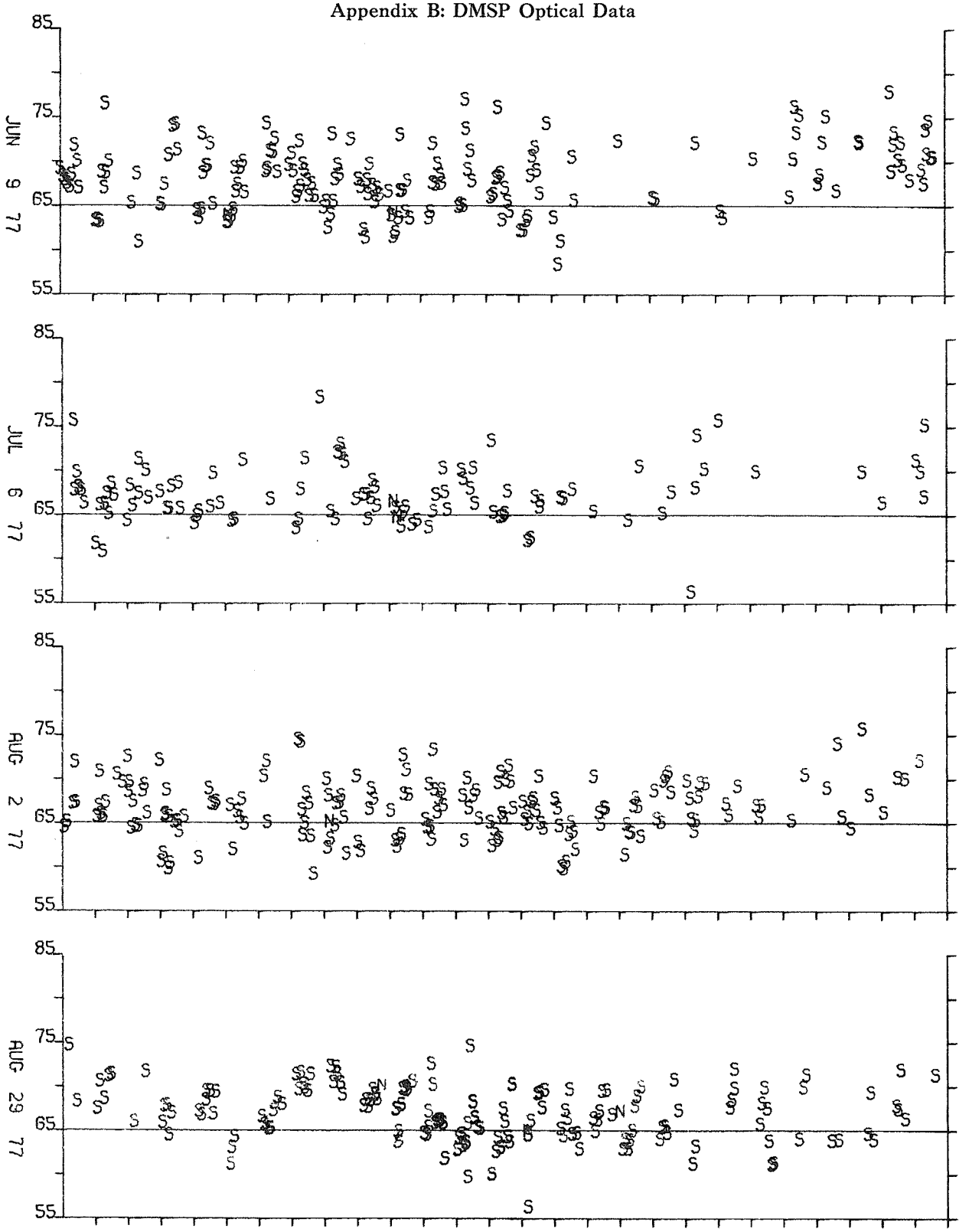
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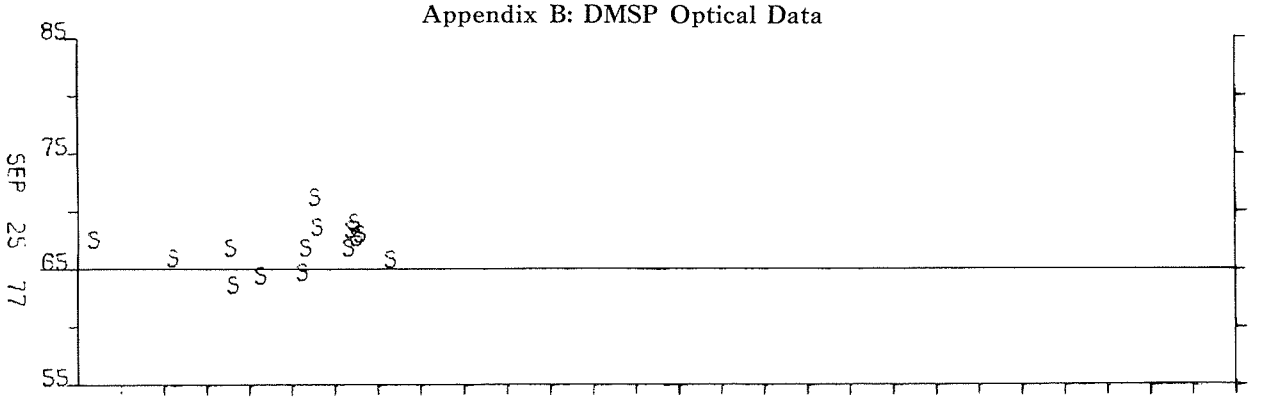

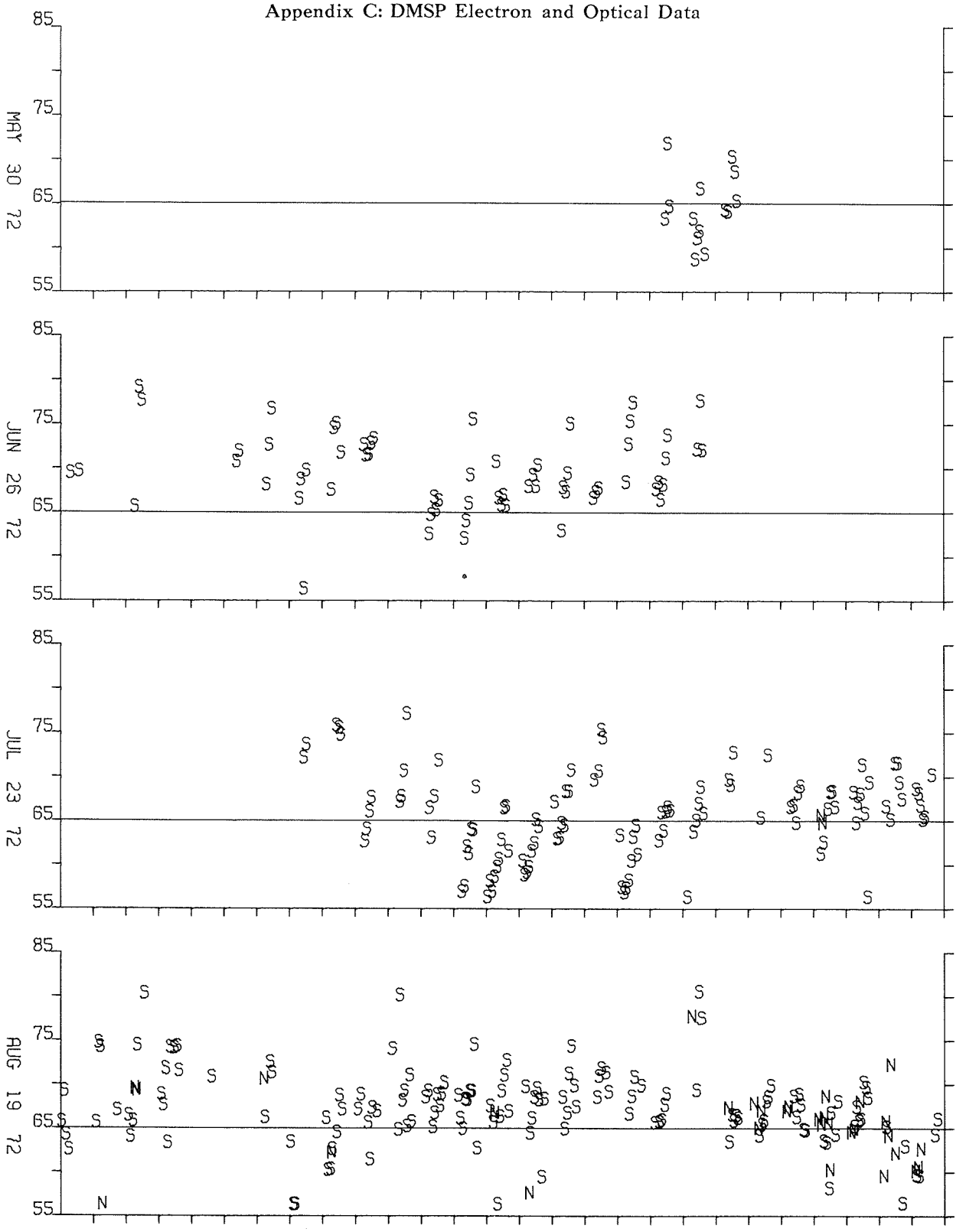
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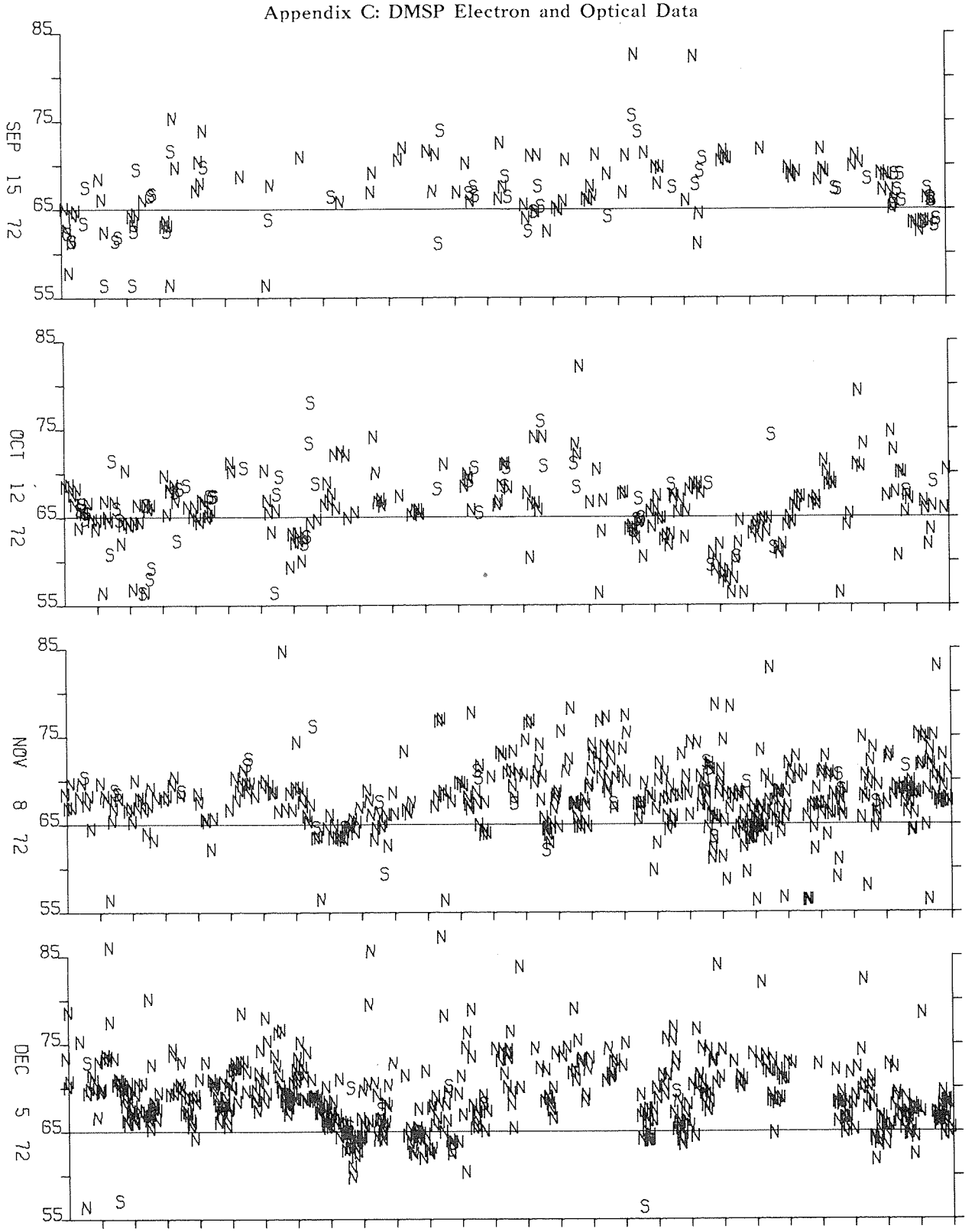
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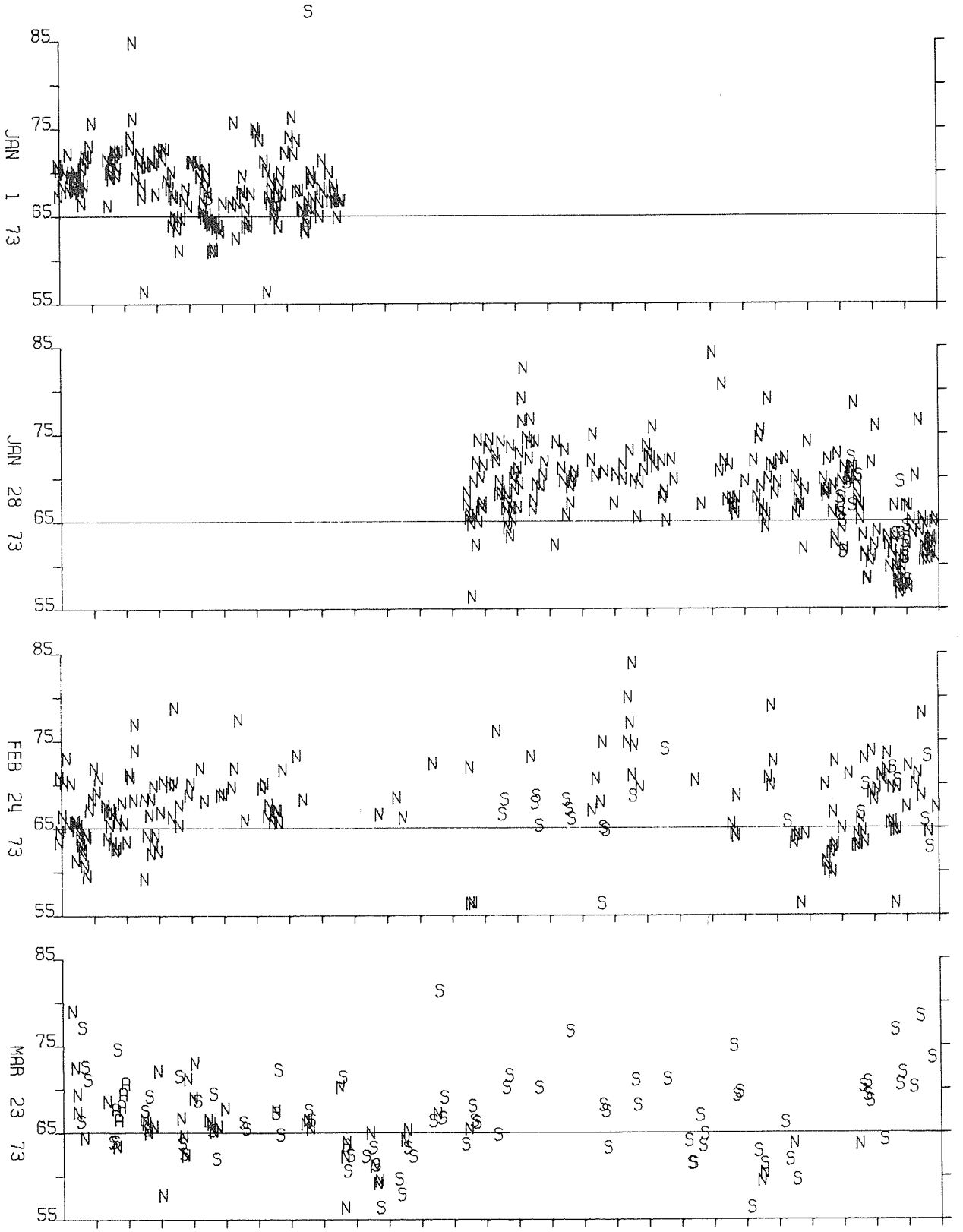
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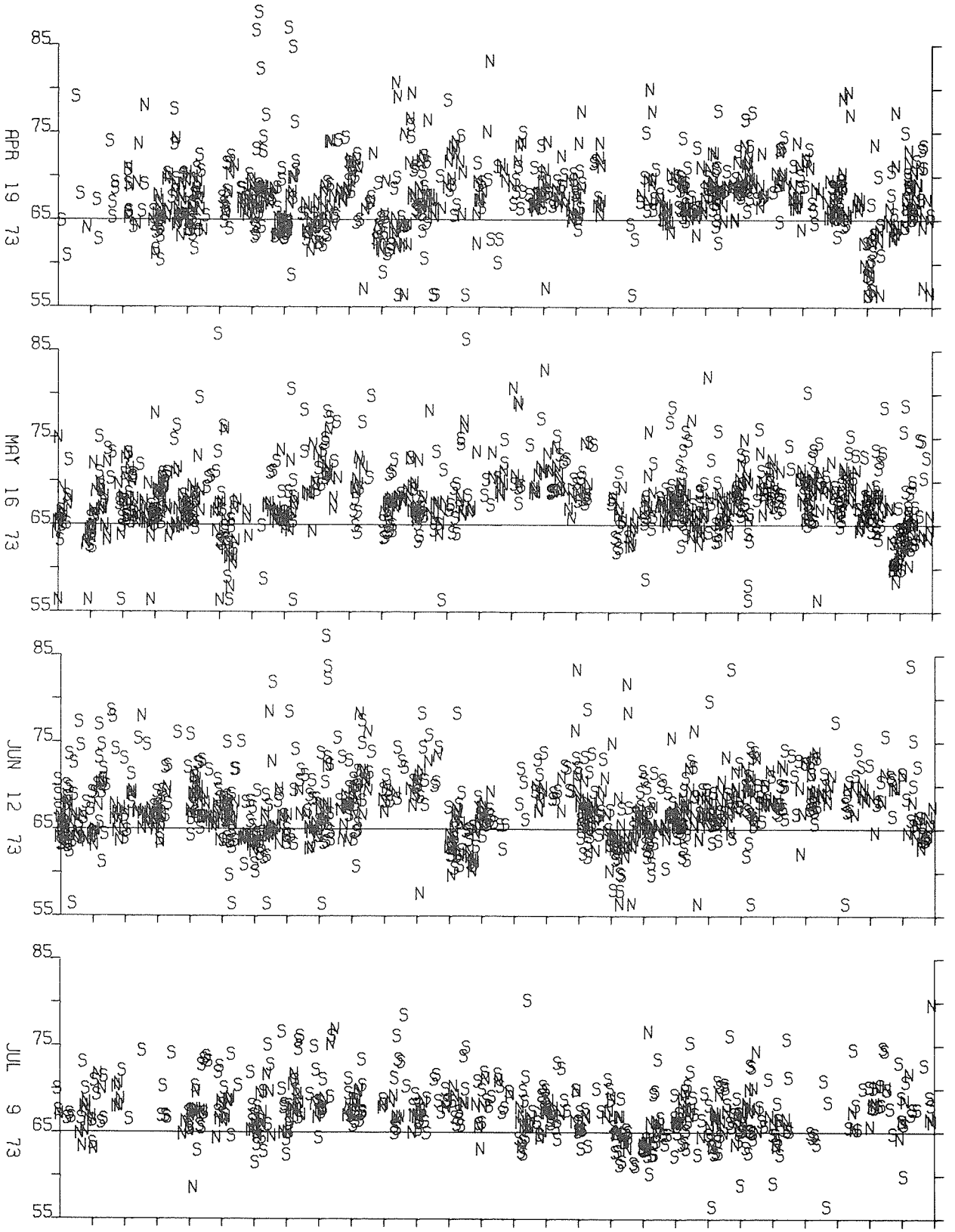
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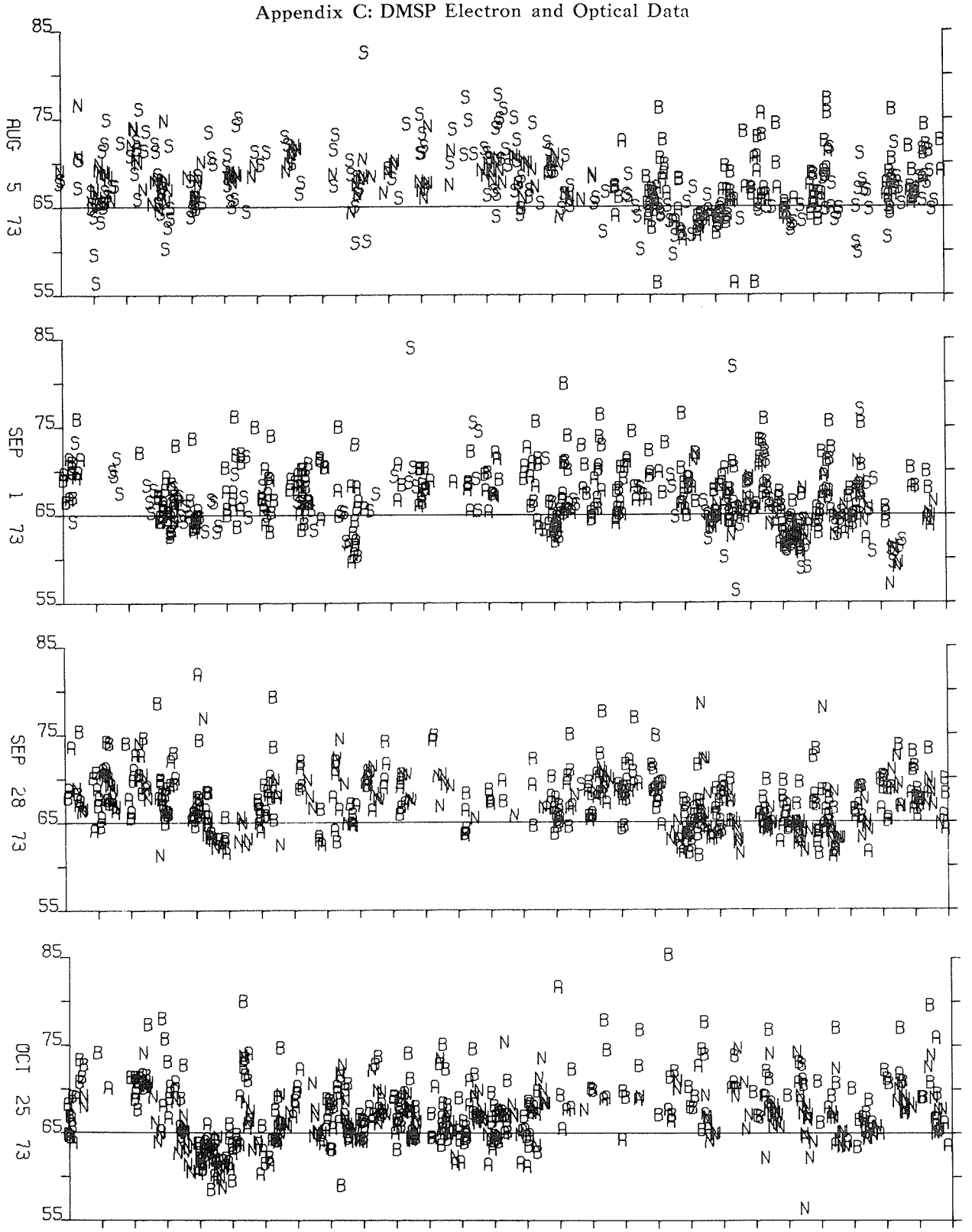
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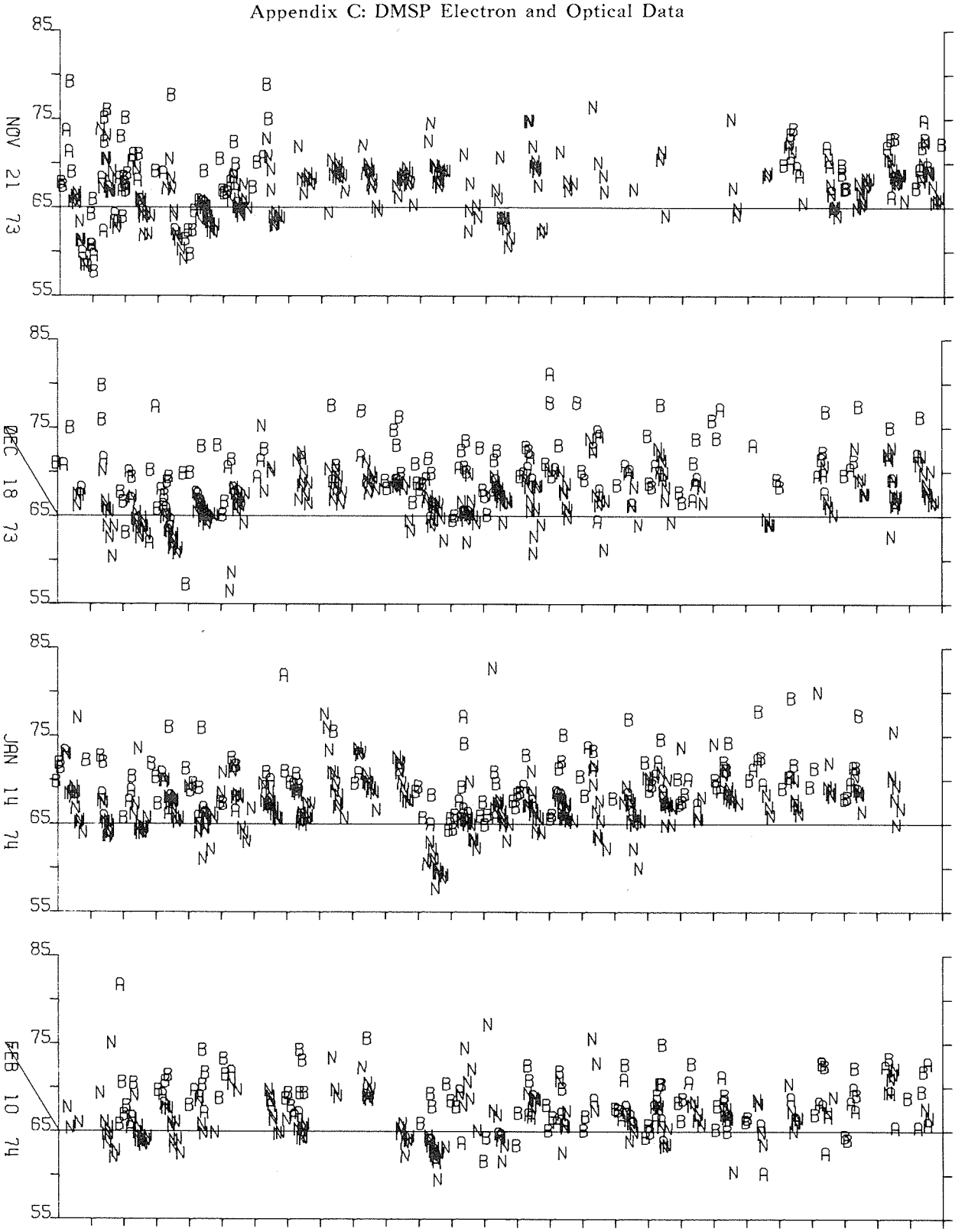
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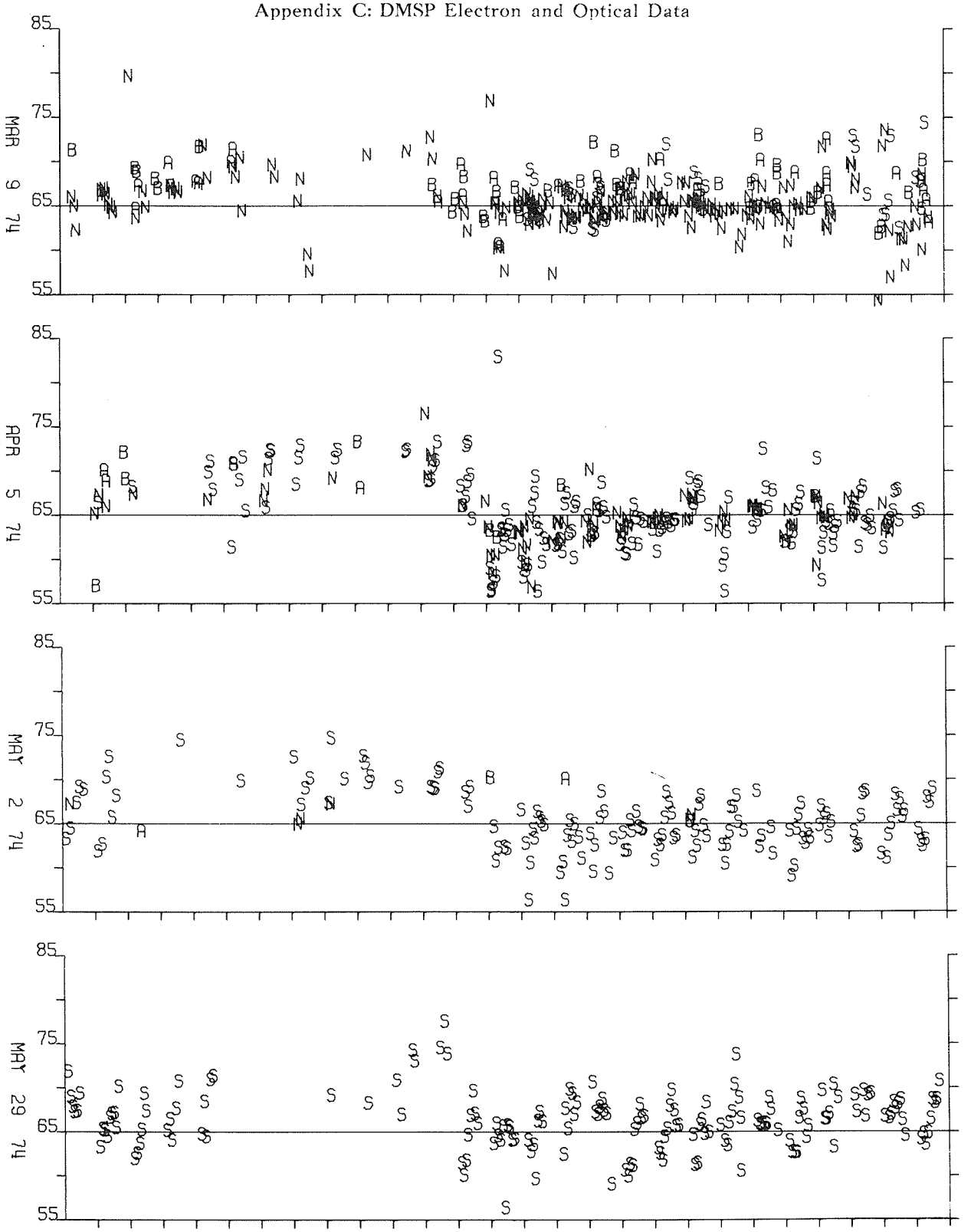
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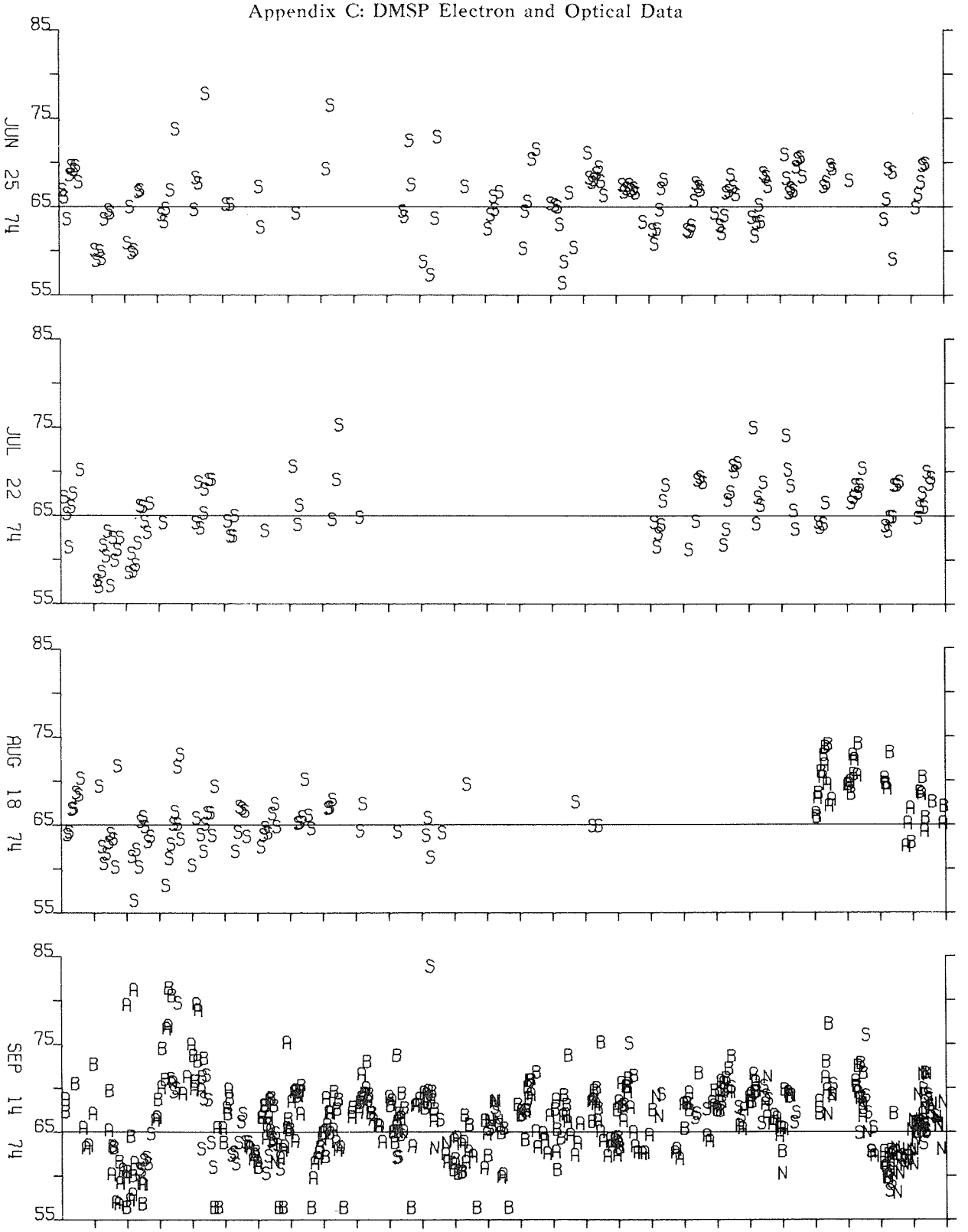
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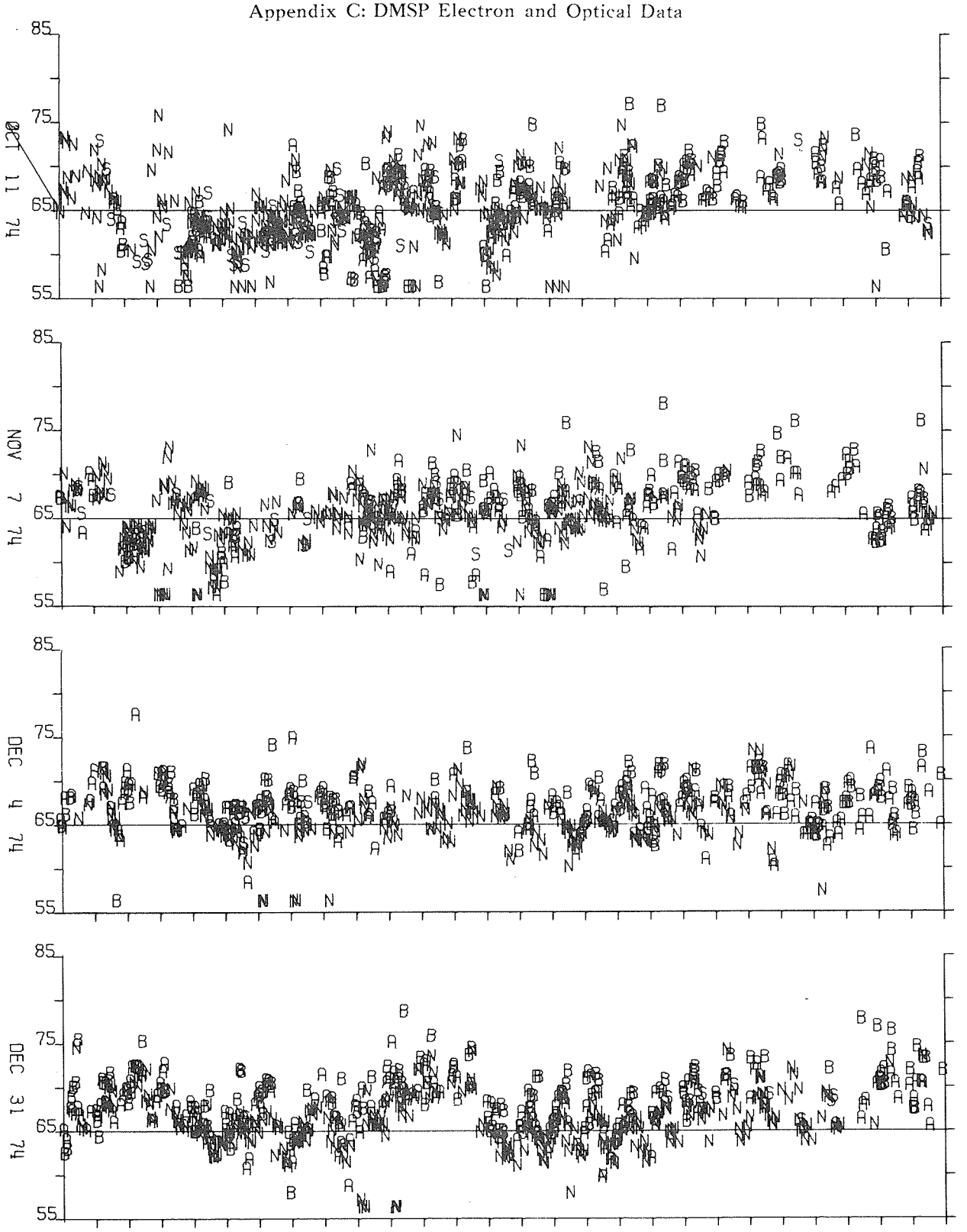
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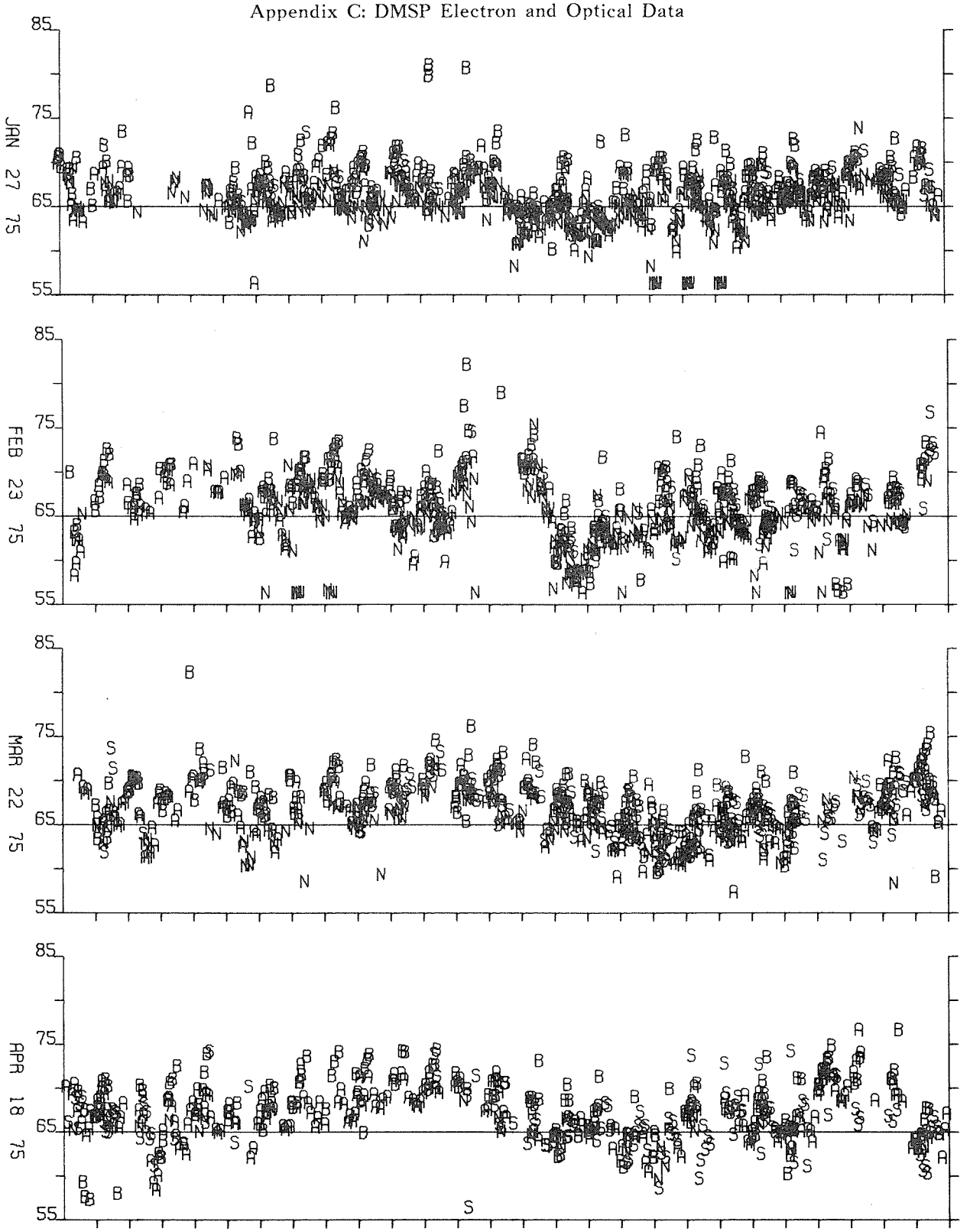
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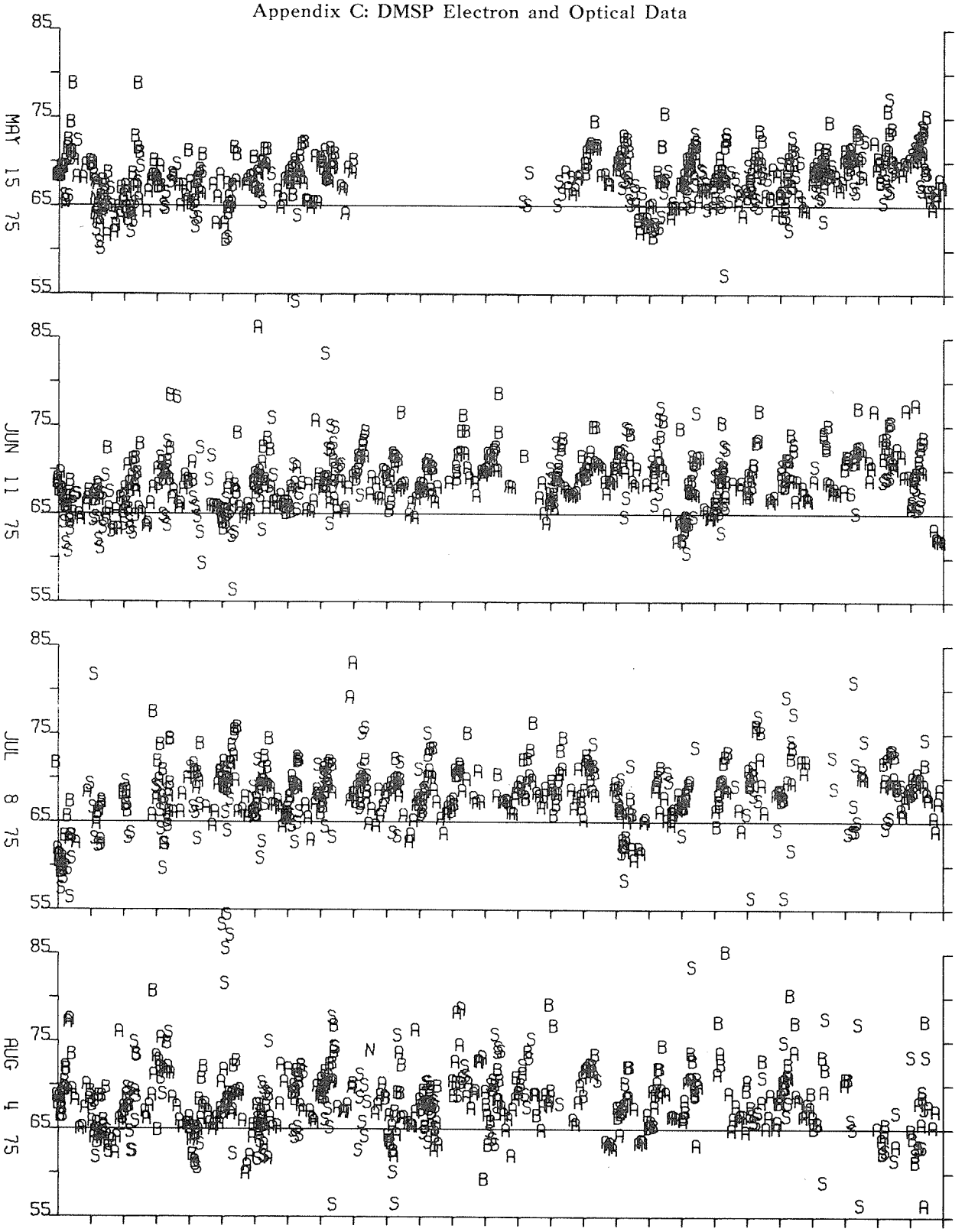
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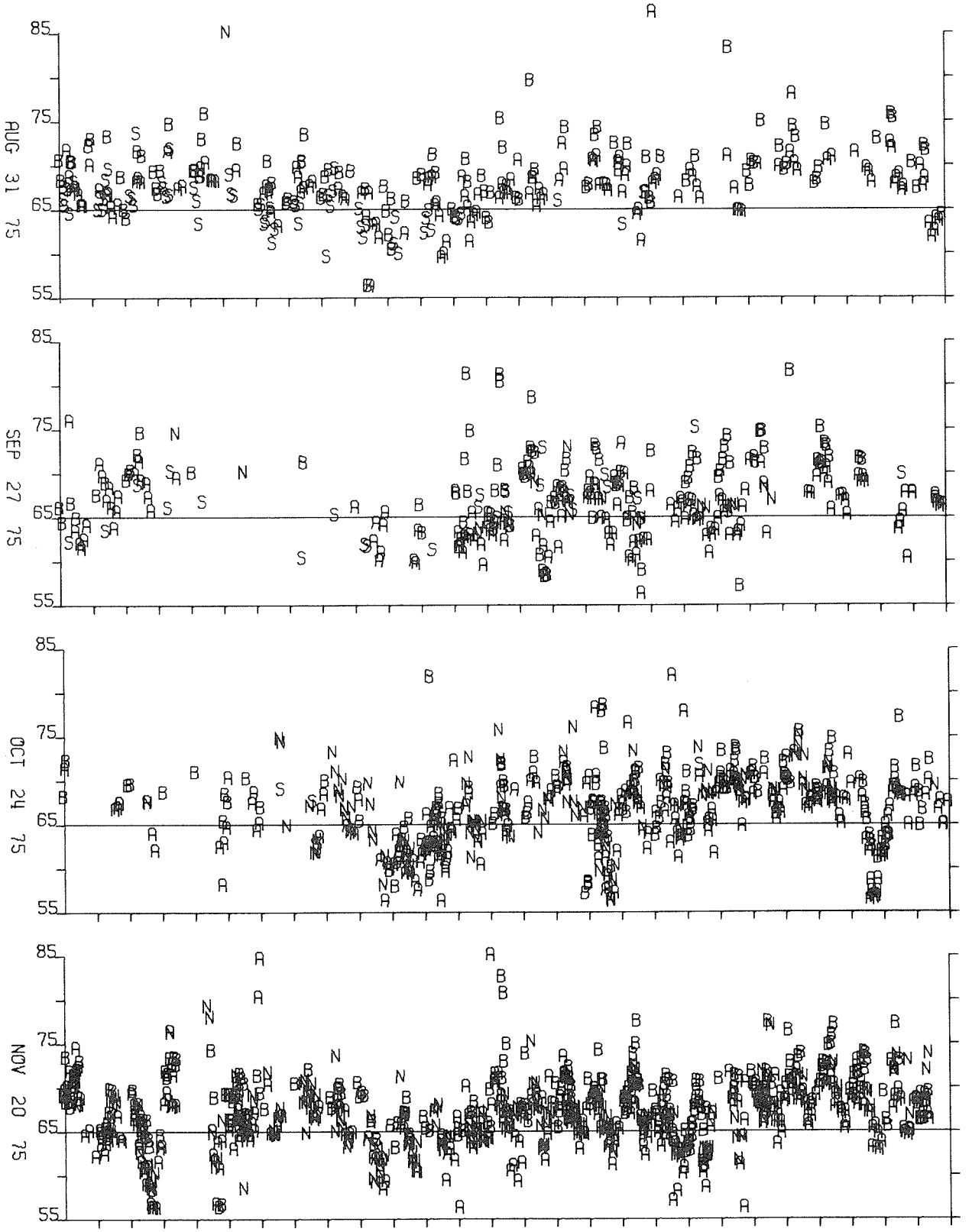
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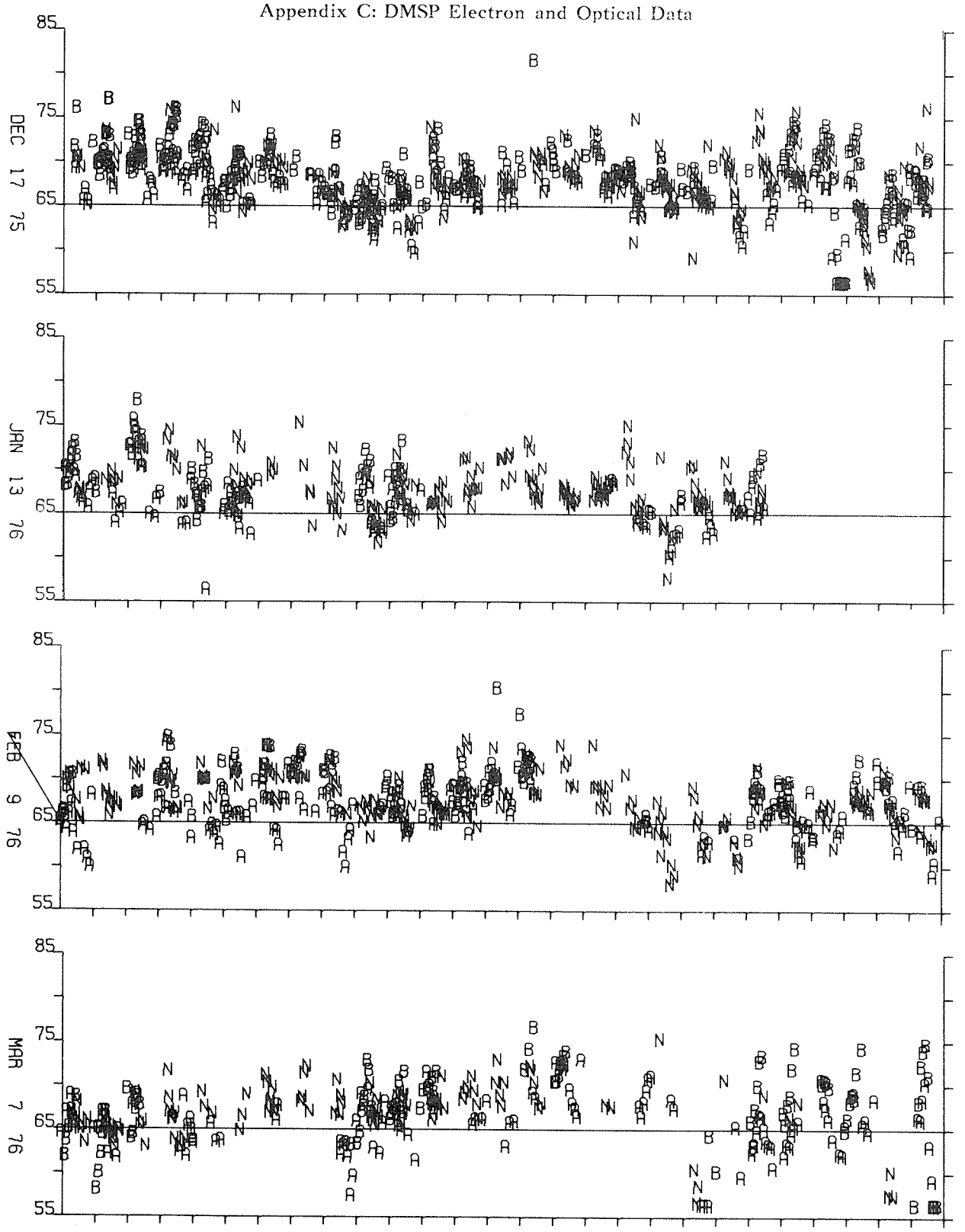
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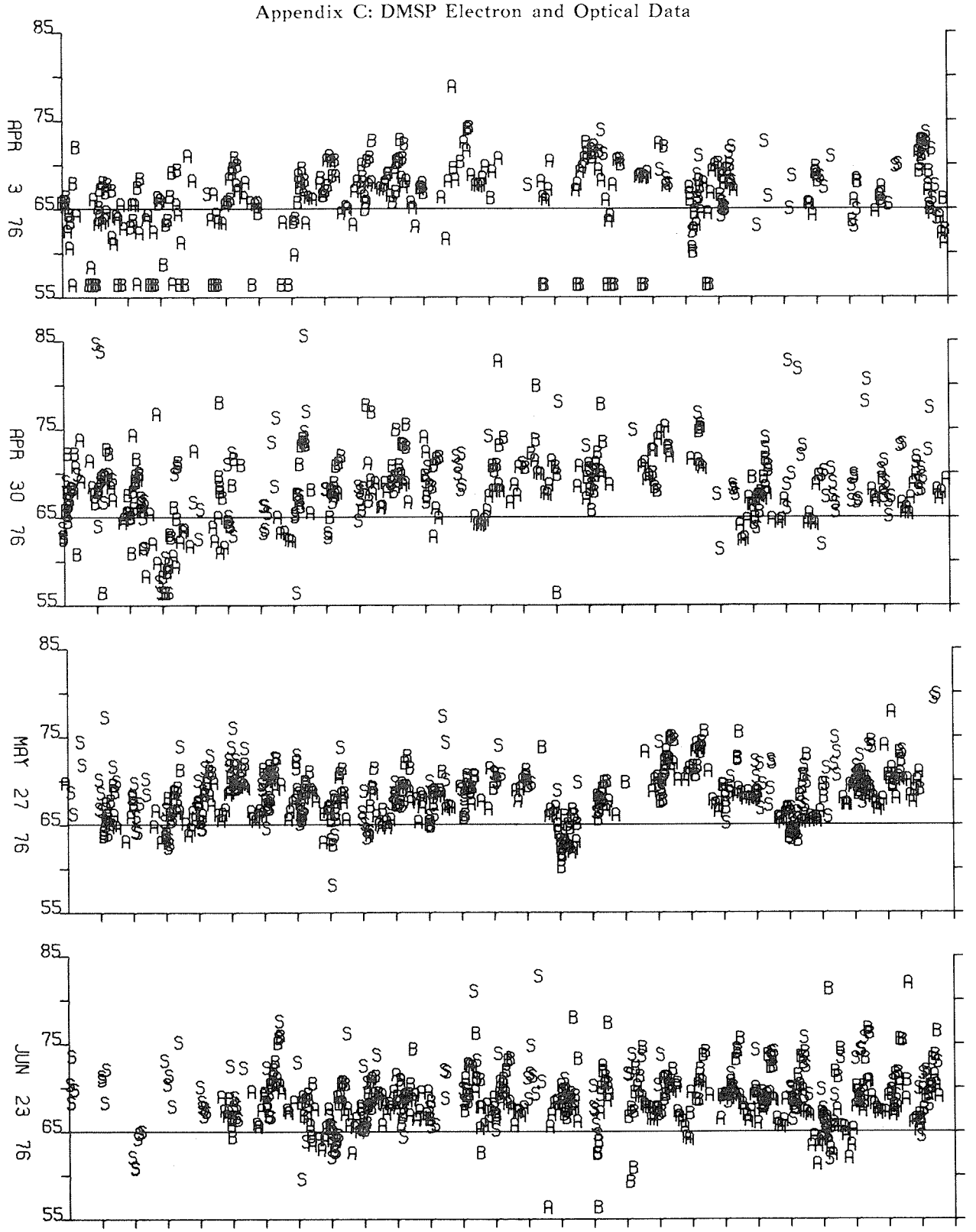
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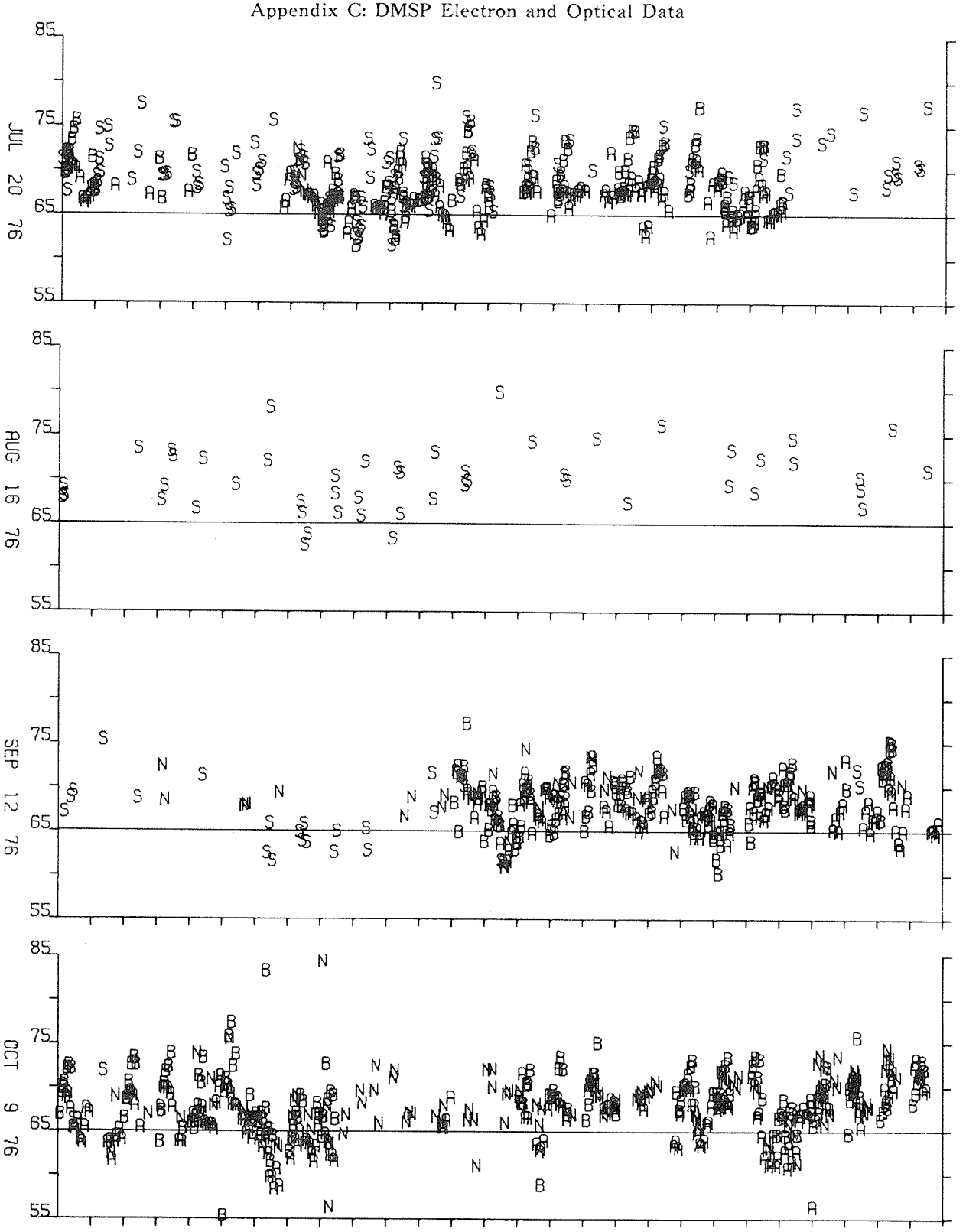
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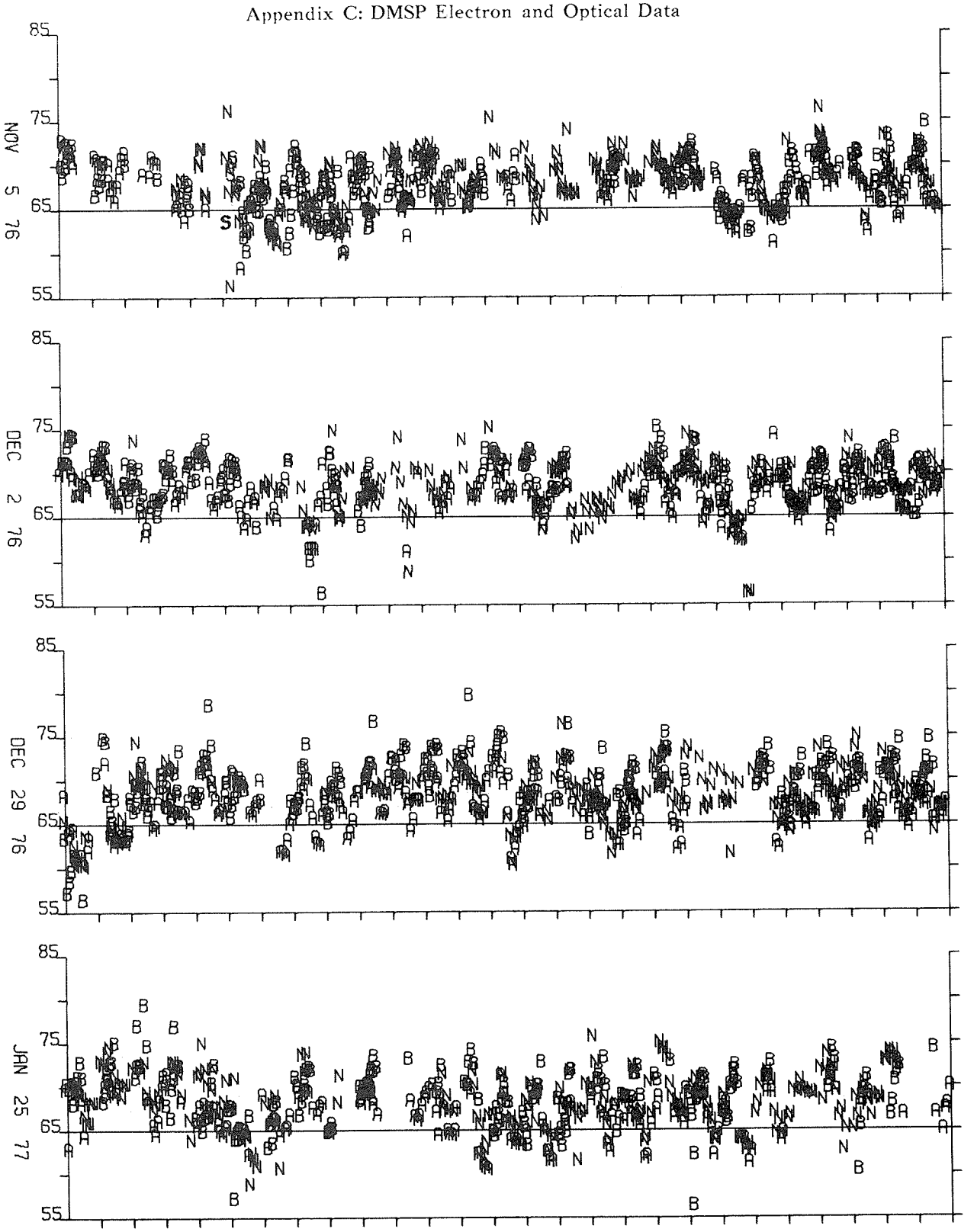
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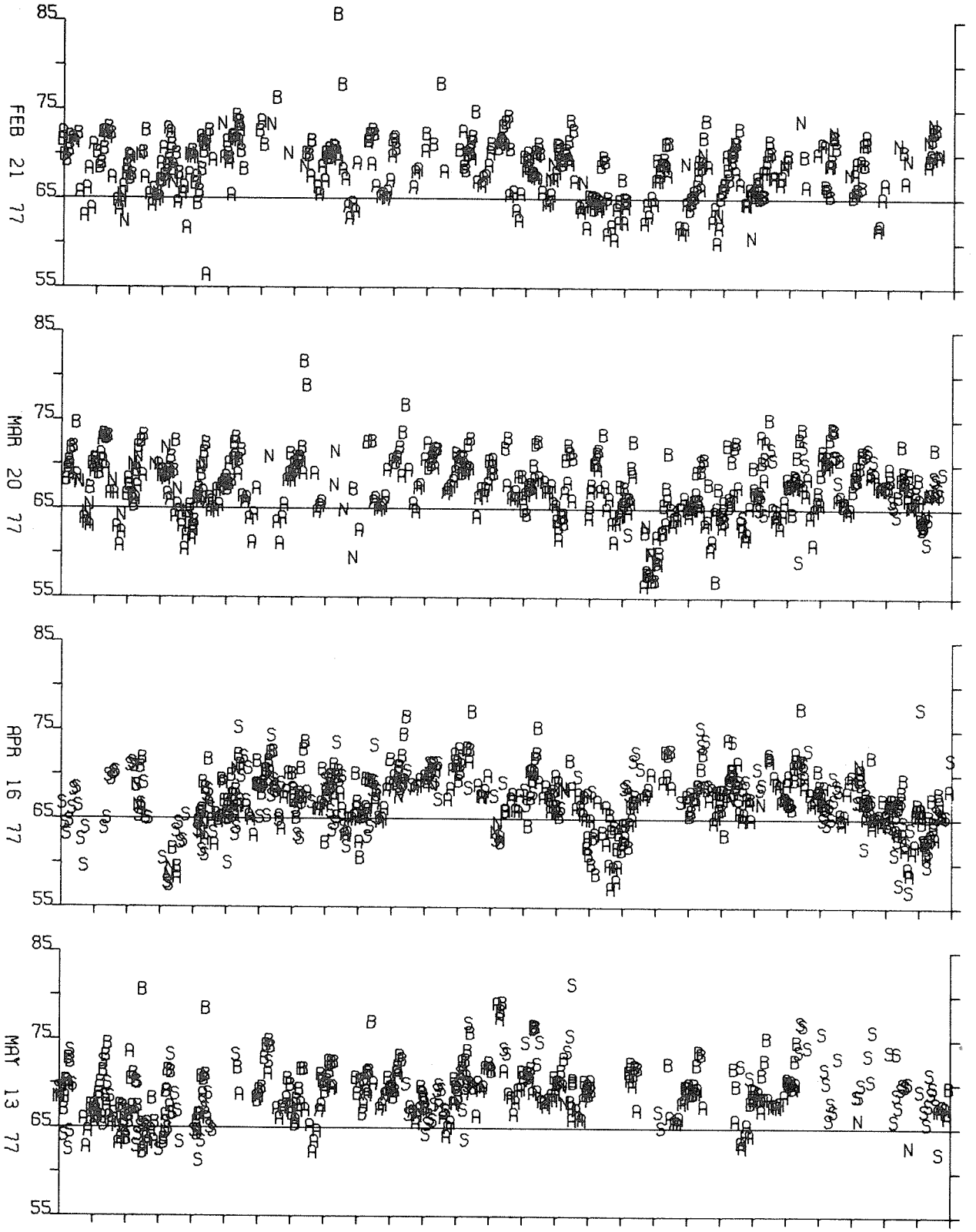
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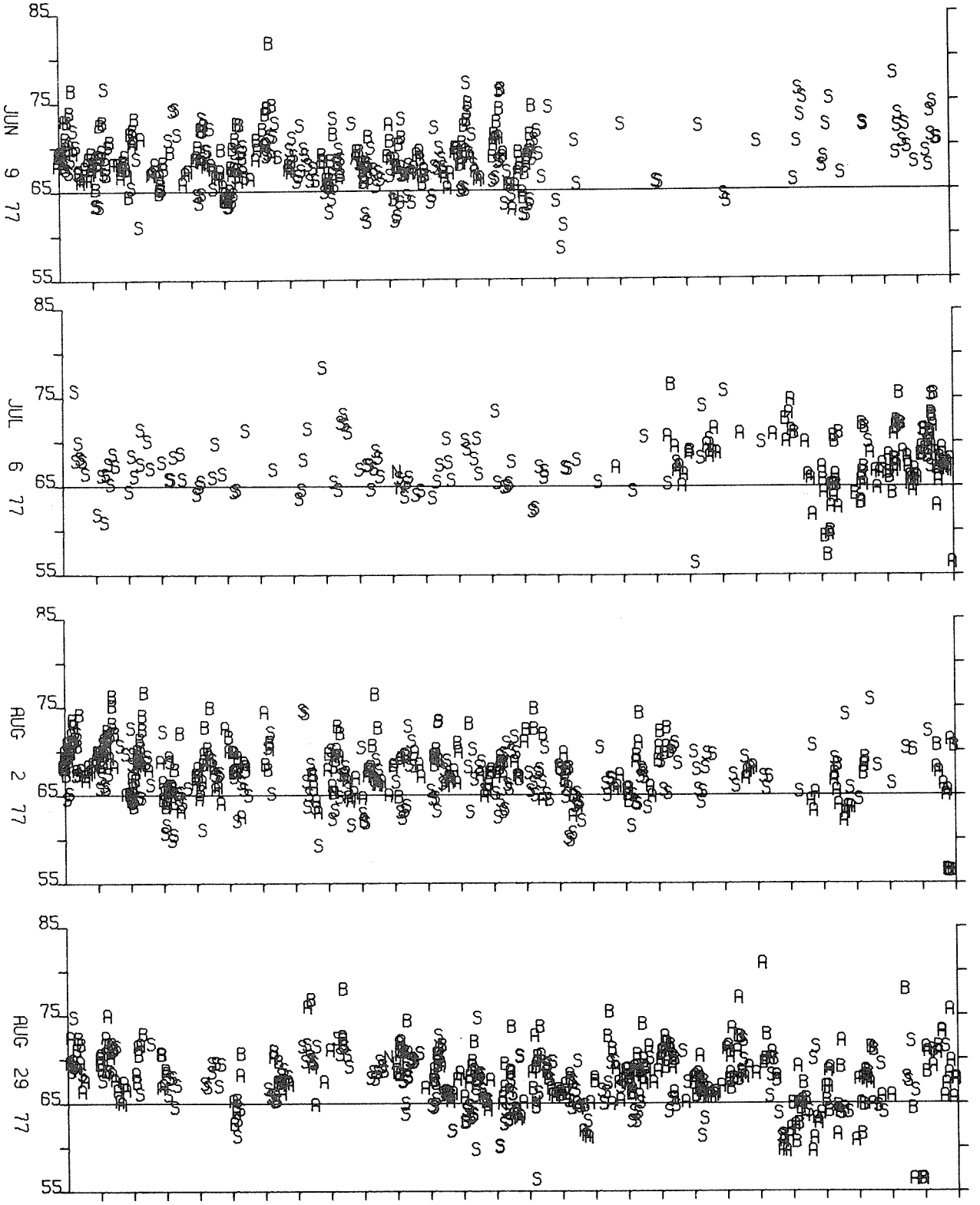
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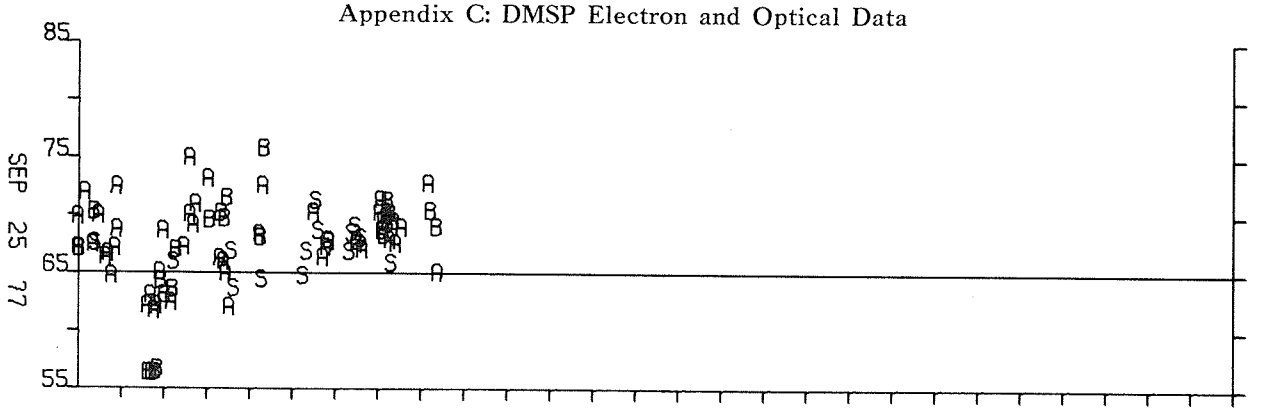
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