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STATISTICAL ASPECTS OF THE 1980 SOLAR FLARES: II. SOLAR CYCLE ACTIVITY RELATIONSHIPS AND ADDITIONAL REMARKS

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George C. Marshall Space Flight Center
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16. ABSTRACT

Based on 1349 Hα flares with X-ray counterparts, an investigation into the relationship between rise time, decay time, duration, latitude, Hα importance, and X-ray class with 2800-MHz radio emission (F_{2800}) has been accomplished. An important finding is that during 1980 both the number of Hα importance class 1 and number of X-ray class M (and M+X) flares appeared to be rather strongly related to F_{2800}, in a positive sense; i.e., number of class 1 and class M events increased as F_{2800} increased. This is the second part of a three-part study of the 1980 solar flares. This series gives associational aspects as related to flares occurring in 1980. No effort has been made to model flare frequency correlation and distribution based on more advanced statistical techniques.

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STATISTICAL ASPECTS OF THE 1980 SOLAR FLARES: II. SOLAR CYCLE ACTIVITY RELATIONSHIPS AND ADDITIONAL REMARKS

I. INTRODUCTION

In a preceding report [1], this author compiled a list of 1349 flares occurring in 1980 (the Solar Maximum Year) which met certain selection criteria; namely, these study flares had accurately known start, maximum brightness, and end times; latitudes; Hα importance; and X-ray classes. Thus, each flare was specified by a rise time, decay time, duration, latitude of occurrence, Hα importance (areal and relative brightness), and X-ray class. Frequency distributions of these parameters were tabulated and illustrated, and a number of conclusions, culminating in a brief description of the statistically typical study flare, were stated.

In this report (Part II) the author continues his analysis of these events, stressing correlations with solar cycle, as adjudged by the 2800-MHz radio flux (denoted, F_{2800}). While some of these were alluded to in the previous report, they will now be more fully discussed. A third and final report, highlighting relationships between pairs of specific study parameters, will conclude this series.

II. STUDY REMARKS

The 1349 flares meeting the study selection criteria are tabulated in the preceding report. They form the data base from which this statistical study and its conclusions are made. It is recalled that the data base flares represent a subset of all the flares reported in Preliminary Report and Forecast of Solar Geophysical Data, a NOAA (Boulder, Colorado) weekly publication.

Table 1 presents the monthly frequency (f), percent (p), running frequency (Rf), and running percent (Rp) by flare grouping (A, B, C), as well as the daily flare rates by grouping (A', B', C') and monthly sunspot number (R_z) and corrected 2800-MHz radio flux at 1 AU (i.e., astronomical unit). Category A represents those flares that meet the study criteria; hence, they are the data base flares. Category B refers to all flares in the NOAA publication which have a positional reference, and category C to all flare entries. Observe that prior to April 1980, there was no difference between groups B and C. Beginning in late April and continuing to the present, NOAA includes not only flares of known position but also those significant X-ray flares, which cannot be correlated with ground observations.

Table 2 shows the daily frequency of occurrence by flare group. Observe that category C began in late April on DOY (day of year) 119, or April 28. Figure 1 (a,b) displays the daily frequency, plotted from Table 2, of category A data base flares; Figure 2 (a,b) plots the category B daily flare frequency.

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TABLE 1. FREQUENCY (f), PERCENT (p), RUNNING FREQUENCY (Rf), AND RUNNING PERCENT (Rp) FOR CATEGORY A, B, AND C FLARES. CATEGORY A REPRESENTS THE STUDY FLARES. ALSO, DAILY FLARE RATES PER GROUP AND R_z AND F_{2800} VALUES PER MONTH

	A				B				C								
MON	f	p	Rf	Rp	f	p	Rf	Rp	f	p	Rf	Rp	A'	B'	C'	R_z	F_{2800}
JAN	69	5.1	69	5.1	352	7.0	352	7.0	352	5.8	352	5.8	2.23	11.35	11.35	162.2	199.6
FEB	73	5.4	142	10.5	300	5.9	652	12.9	300	5.0	652	10.8	2.52	10.34	10.34	159.3	195.1
MAR	96	7.1	238	17.6	277	5.5	929	18.4	277	4.6	929	15.4	3.10	8.94	8.94	126.5	166.5
APR	104	7.7	342	25.4	467	9.2	1396	27.6	486	8.1	1415	23.4	3.47	15.57	16.20	166.6	209.3
MAY	112	8.3	454	33.7	378	7.5	1774	35.1	513	8.5	1928	31.9	3.61	12.19	16.55	179.7	229.1
JUN	120	8.9	574	42.6	404	8.0	2178	43.1	550	9.1	2478	41.1	4.00	13.47	18.33	157.2	199.3
JUL	79	5.9	653	48.4	335	6.6	2513	49.7	469	7.8	2947	48.8	2.55	10.81	15.13	135.0	190.8
AUG	87	6.4	740	54.9	343	6.8	2856	56.5	451	7.5	3398	56.3	2.81	11.06	14.55	135.4	170.3
SEP	104	7.7	844	62.6	416	8.2	3272	64.8	513	8.5	3911	64.8	3.47	13.87	17.10	154.5	185.9
OCT	168	12.5	1012	75.0	636	12.6	3908	77.3	748	12.4	4659	77.2	5.42	20.52	24.13	162.9	202.9
NOV	192	14.2	1204	89.3	671	13.3	4579	90.6	789	13.1	5448	90.3	6.40	22.37	26.30	146.5	213.4
DEC	145	10.7	1349	100.0	474	9.4	5053	100.0	588	9.7	6036	100.0	4.68	15.29	18.97	176.1	218.8
TOTAL	1349				5053				6036								
AVG./MON	112.42				421.08				503.00								
AVG./DAY	3.69				13.81				16.49								

TABLE 2. DAILY FLARE COUNTS OF CATEGORY A, B, AND C FLARES

DOY	A	B	C
JAN			
1	2	4	4
2	1	4	4
3	1	5	5
4	0	5	5
5	2	17	17
6	6	27	27
7	3	12	12
8	4	21	21
9	1	7	7
10	3	14	14
11	2	4	4
12	1	9	9
13	2	17	17
14	5	10	10
15	0	2	2
16	2	10	10
17	1	4	4
18	1	9	9
19	4	6	6
20	0	3	3
21	1	7	7
22	1	1	1
23	8	17	17
24	5	25	25
25	4	31	31
26	0	18	18
27	0	9	9
28	3	14	14
29	2	17	17
30	2	9	9
31	2	14	14
FEB			
32	2	12	12
33	3	9	9
34	3	7	7
35	5	22	22
36	4	8	8
37	2	4	4
38	6	26	26
39	1	16	16
40	0	6	6
41	4	10	10
42	6	30	30
43	4	19	19
44	4	26	26
45	0	4	4
46	1	11	11
47	2	7	7
48	3	7	7
49	1	9	9
50	3	6	6

DOY	A	B	C
51	6	10	10
52	2	3	3
53	0	2	2
54	0	2	2
55	0	4	4
56	2	11	11
57	5	9	9
58	1	7	7
59	0	1	1
60	3	12	12
MAR			
61	1	6	6
62	4	10	10
63	2	4	4
64	1	1	1
65	1	3	3
66	0	4	4
67	1	5	5
68	4	4	4
69	2	4	4
70	1	3	3
71	0	2	2
72	1	1	1
73	2	10	10
74	3	11	11
75	1	5	5
76	0	0	0
77	0	0	0
78	3	10	10
79	3	19	19
80	3	14	14
81	2	7	7
82	3	11	11
83	1	6	6
84	5	8	8
85	10	20	20
86	9	21	21
87	3	13	13
88	7	19	19
89	12	31	31
90	8	17	17
91	3	8	8
APR			
92	3	10	10
93	5	11	11
94	3	8	8
95	4	20	20
96	3	14	14
97	1	14	14
98	5	21	21
99	4	25	25
100	3	23	23

DOY	A	B	C
101	7	25	25
102	5	21	21
103	6	27	27
104	8	30	30
105	6	21	21
106	3	10	10
107	3	26	26
108	1	7	7
109	0	7	7
110	0	8	8
111	2	6	6
112	1	15	15
113	2	4	4
114	0	10	10
115	3	13	13
116	3	13	13
117	6	20	20
118	3	14	14
119	8	28	32
120	2	7	15
121	4	9	16
MAY			
122	2	10	16
123	5	31	35
124	3	6	14
125	5	5	13
126	2	14	16
127	3	9	13
128	3	11	21
129	4	10	15
130	5	10	15
131	5	13	18
132	10	17	21
133	4	14	19
134	1	2	4
135	3	7	10
136	2	9	16
137	6	17	21
138	6	14	18
139	5	19	21
140	4	13	19
141	0	9	14
142	2	8	10
143	2	11	16
144	4	12	12
145	3	20	21
146	4	17	19
147	0	14	20
148	3	9	13
149	8	27	29
150	1	9	15
151	5	8	8

TABLE 2. (Continued)

DOY	A	B	C
152	2	3	8
JUN			
153	3	7	14
154	3	14	18
155	8	14	15
156	7	18	26
157	6	17	28
158	4	20	32
159	5	11	23
160	1	5	14
161	2	4	7
162	4	9	14
163	0	6	12
164	7	31	35
165	9	28	32
166	0	11	11
167	0	9	9
168	4	6	8
169	2	10	10
170	0	5	9
171	4	7	15
172	6	15	17
173	3	9	17
174	4	17	17
175	9	30	34
176	4	30	34
177	6	23	29
178	4	11	14
179	7	14	19
180	5	10	14
181	0	2	9
182	3	11	14
JUL			
183	1	5	9
184	1	4	6
185	4	8	12
186	0	3	3
187	6	13	17
188	2	9	18
189	3	5	16
190	1	6	19
191	5	8	15
192	2	16	28
193	8	15	19
194	10	27	29
195	7	17	18
196	2	10	13
197	2	11	14
198	1	5	9
199	3	7	8
200	2	44	46
201	2	14	14

DOY	A	B	C
202	4	20	21
203	0	8	14
204	3	13	14
205	2	20	27
206	2	13	17
207	1	8	14
208	2	10	13
209	1	8	16
210	0	3	7
211	1	3	8
212	0	1	2
213	1	1	3
AUG			
214	0	2	3
215	0	3	3
216	0	2	2
217	0	1	2
218	0	4	9
219	1	3	6
220	1	3	8
221	0	1	3
222	2	5	8
223	2	10	16
224	0	15	21
225	1	8	11
226	1	7	13
227	1	3	3
228	3	25	25
229	3	14	17
230	1	16	18
231	1	9	10
232	3	21	22
233	1	14	17
234	6	15	18
235	9	17	24
236	7	15	19
237	7	20	26
238	11	25	34
239	2	11	21
240	4	8	13
241	3	12	16
242	5	18	22
243	7	22	24
244	5	14	17
SEP			
245	9	32	38
246	4	30	35
247	11	26	31
248	6	23	26
249	3	11	15
250	1	6	9

DOY	A	B	C
251	2	11	20
252	5	14	20
253	2	16	20
254	4	12	13
255	2	10	13
256	2	6	12
257	5	10	13
258	5	8	11
259	3	7	14
260	3	16	20
261	2	12	14
262	5	20	21
263	3	11	15
264	3	8	13
265	2	7	8
266	3	5	9
267	4	13	15
268	3	25	26
269	0	12	14
270	4	16	21
271	4	16	17
272	1	11	13
273	2	8	11
274	1	14	16
OCT			
275	3	16	19
276	6	12	14
277	4	19	21
278	2	13	17
279	0	11	14
280	2	11	12
281	9	15	18
282	8	27	29
283	5	24	29
284	9	33	34
285	9	27	29
286	9	27	29
287	8	26	30
288	3	21	23
289	2	23	27
290	4	28	30
291	10	28	32
292	12	33	45
293	6	21	28
294	6	10	14
295	5	26	29
296	3	15	22
297	6	14	15
298	1	12	13
299	5	9	13
300	7	18	24

TABLE 2. (Concluded)

DOY	A	B	C
301	7	21	24
302	7	30	39
303	3	25	26
304	3	12	16
305	4	29	33
NOV			
306	4	40	43
307	10	23	26
308	7	24	26
309	6	31	37
310	5	42	46
311	10	43	50
312	10	44	46
313	12	40	44
314	14	34	39
315	8	34	40
316	14	28	29
317	11	29	32
318	3	10	17
319	8	20	22
320	7	15	20
321	8	20	28
322	7	21	27
323	5	16	21
324	6	20	24
325	5	13	14
326	5	6	11
327	4	17	18
328	5	15	17
329	2	18	22
330	4	7	15
331	3	3	10
332	1	11	11
333	2	15	17
334	3	14	14
335	3	18	23
DEC			
336	9	13	14
337	8	25	30
338	6	29	30
339	2	13	15
340	3	8	14
341	1	3	12
342	3	6	9
343	3	12	17
344	5	21	25
345	4	7	16
346	10	17	22
347	11	19	23
348	4	24	26
349	11	24	25
350	3	21	24
351	11	32	32
352	4	12	14
353	5	18	20
354	4	6	8
355	6	16	18
356	2	16	17
357	1	8	13
358	2	8	12
359	3	10	12
360	3	13	15
361	1	13	17
362	2	12	14
363	5	16	24
364	10	24	28
365	1	20	23
366	2	8	9

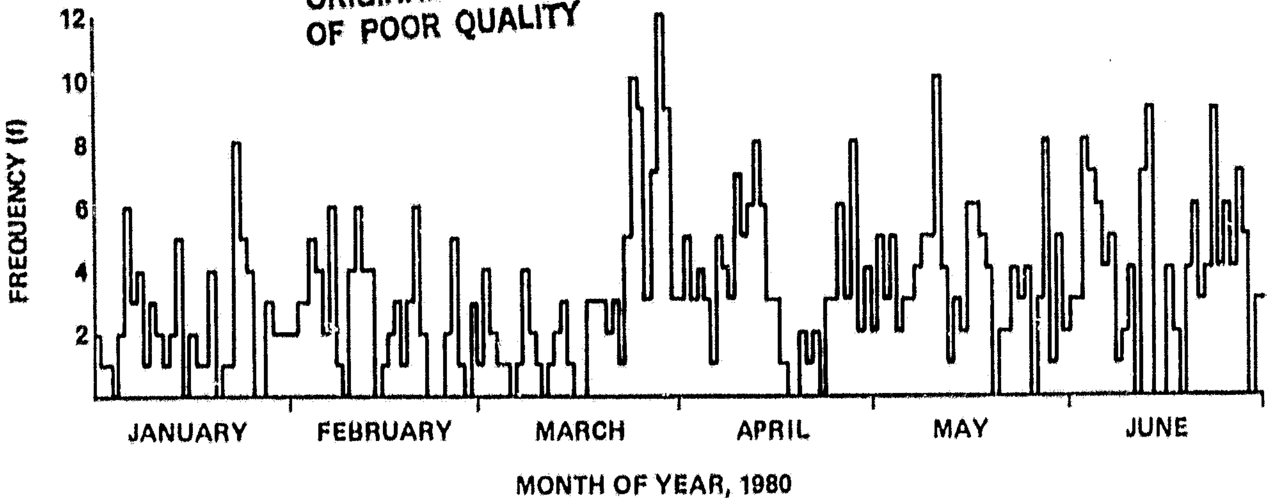

Figure 1a. Frequency of category A flares versus month of year, 1980: January through June.

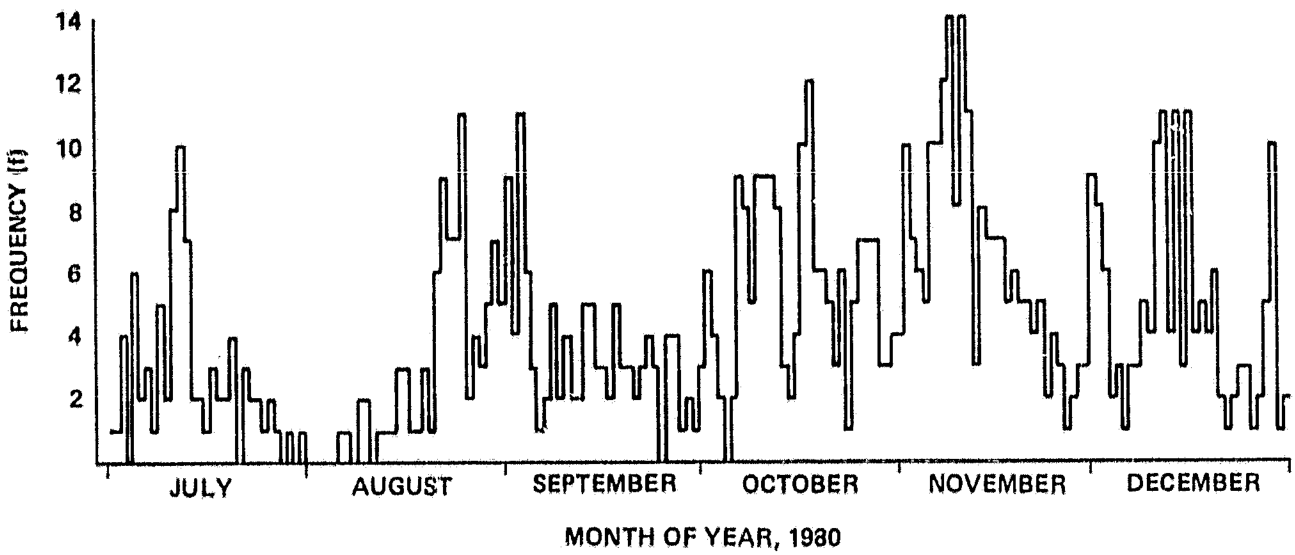

Figure 1b. Frequency of category A flares versus month of year, 1980: July through December.

While the ratio of category A to B flares (Table 2) is highly variable between 0 and 1, the average monthly value (Table 1) ratios are much more stable, being, on the average, 0.267 ± 0.08 (or 30-percent error bars). Thus, out of every 3.75 category B flares, on the average, one entry for category A is expected. A plot of monthly category A frequency versus category B frequency values is depicted in Figure 3. The line running diagonally from lower left to upper right depicts the average relationship between category A and B flares. Thus, during 1980 the category A study flares were related to the category B flares by the equation

$$f_A = 0.266 \, f_B \pm 0.04 \, f_B \quad , \tag{1}$$

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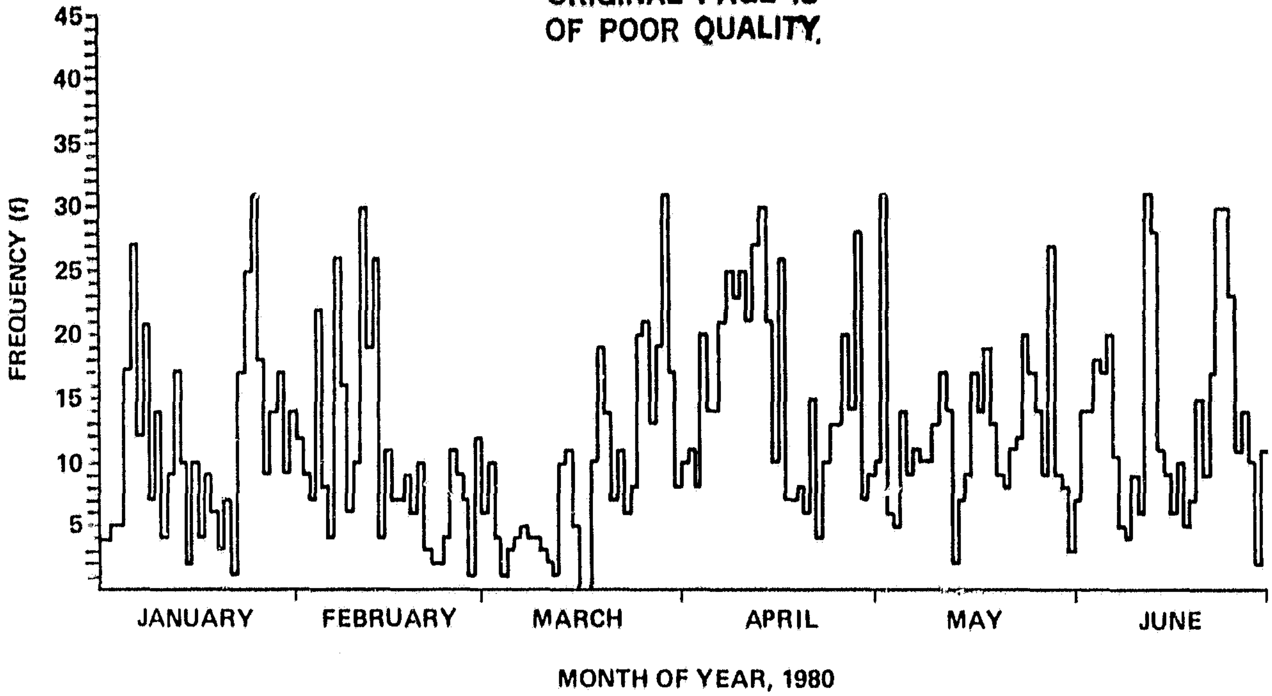

Figure 2a. Frequency of category B flares versus month of year, 1980: January through June.

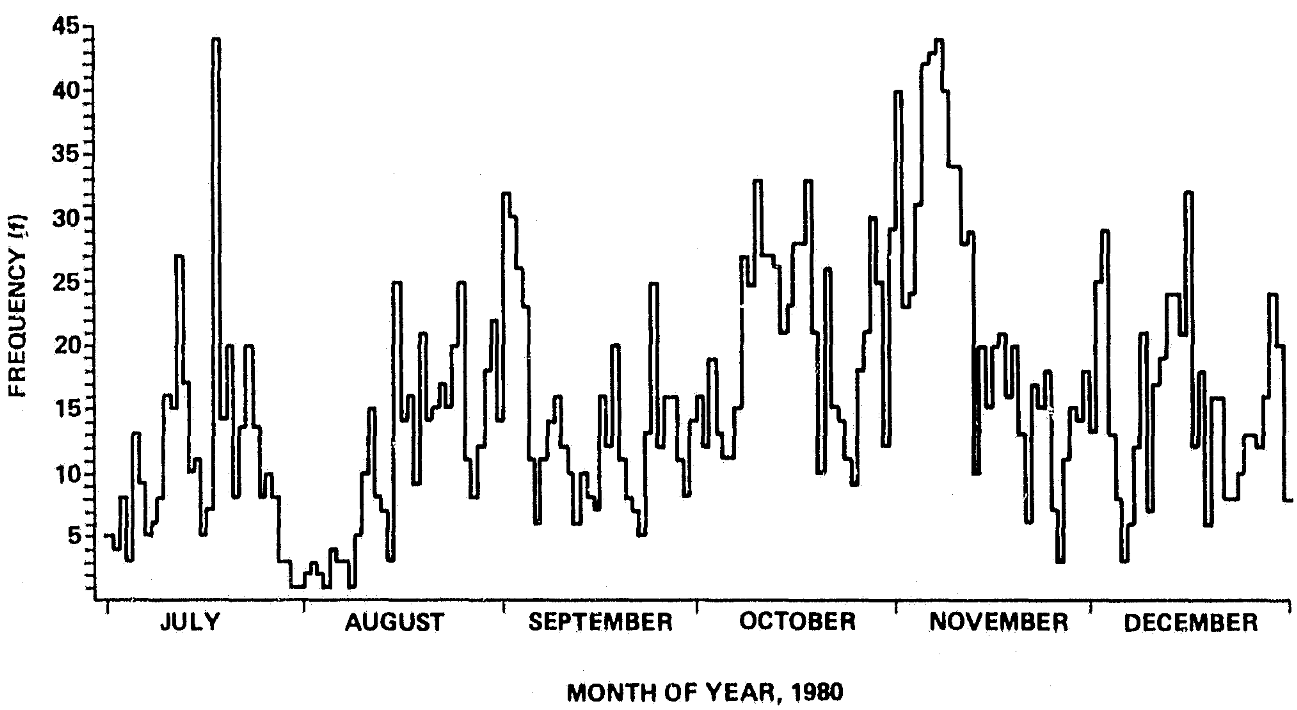

Figure 2b. Frequency of category B flares versus month of year, 1980: July through December.

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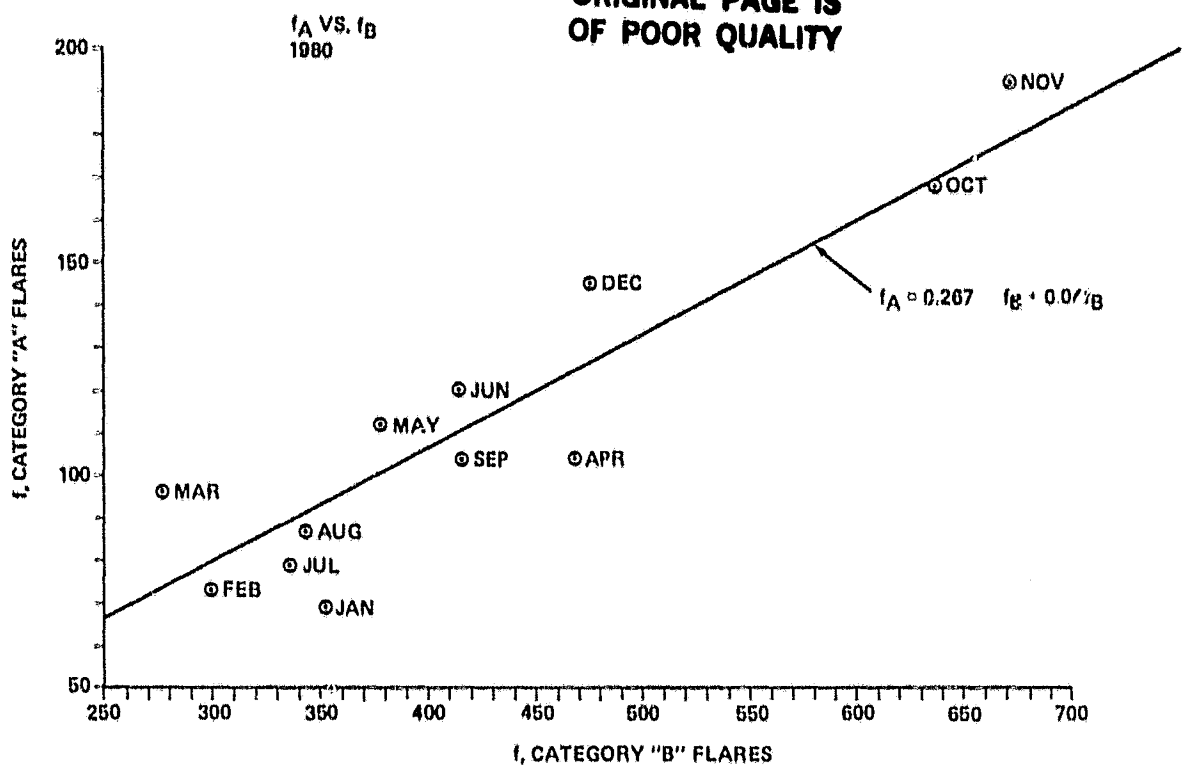

Figure 3. Frequency of category A flares (f_A) versus frequency of category B flares (f_B).

where f_A is the frequency (or number) of category A flares and f_B the frequency of category B flares.

Often it is desirable to compare time-dependent parameters (such as flare frequency) with some solar activity indicator (such as R_z or F_{2800}). In fact, such comparisons form the basis for this report. However, prior to discussing the results of such analyses, it may be of interest to show the relationship between the two commonly used indicators of solar activity. Using Table 1, generate ratios of R_z to F_{2800} versus time and plot the results (Fig. 4). Observe that, indeed, there is a close relationship between R_z and F_{2800}; i.e., the points tend to be distributed along a diagonal band associating high R_z with high F_{2800} and low R_z with low F_{2800}. While the average value of R_z/F_{2800} for 1980 is $0.782 \begin{smallmatrix}+0.049\\-0.090\end{smallmatrix}$, where the lower bound is rather large due to the inclusion of the July and November data points, a better defined relation is R_z/F_{2800} equal to $0.799 \begin{smallmatrix}+0.032\\-0.039\end{smallmatrix}$, which excludes the July and November data points. Thus, equations relating R_z and F_{2800} are

$$R_z = 0.799\ F_{2800} \pm 0.04\ F_{2800} \quad , \tag{2}$$

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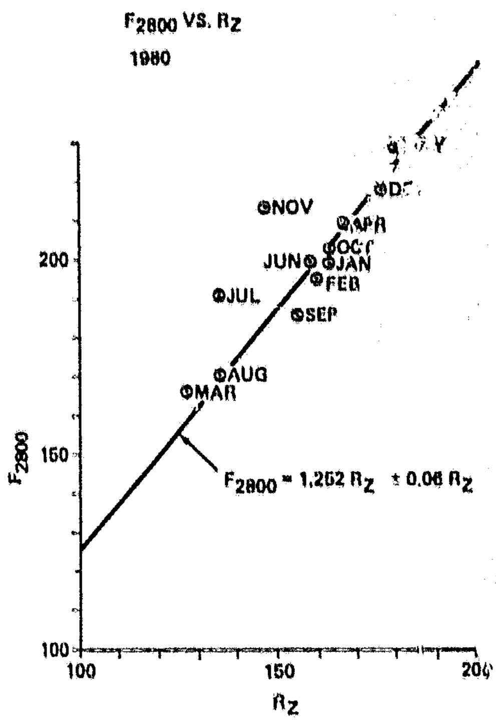

NOTE: LINE EQUATION EXCLUDES JUL AND NOV DATA POINTS

Figure 4. F_{2800} versus R_z. Line equation excludes July and November data points.

and

$$F_{2800} = 1.252\ R_z \pm 0.06\ R_z \tag{3}$$

Wilson [2] has investigated sunspot variation, particularly for sunspot cycle 21, the present cycle, and has deduced a number of relationships between smoothed sunspot number and smooth numbers of flares, gradual-rise-and-fall radio events, and 2800 MHz radio flux. The equation relating smoothed sunspot number ($\bar{R}_{13}$) and smoothed 2800-MHz radio flux ($\bar{F}_{13}$) was deduced to be

$$\bar{F}_{13} = 0.89\ \bar{R}_{13} + 63 \quad , \tag{4}$$

implying that

$$\bar{R}_{13} = 1.124\ \bar{F}_{13} - 70.8 \quad . \tag{5}$$

Equations (2) and (3) relate monthly averages of sunspot number and 2800-MHz radio flux. On the other hand, equations (4) and (5) relate smoothed sunspot numbers and smoothed 2800-MHz radio flux, which are based on a particular smoothing scheme (Wilson [2] or Howard [3]).

Figure 4 depicts the relation between R_z and F_{2800}, and the diagonal line running from lower left to upper right is that representation of equation (3). It is seen that the July and November data points appear anomalously high, possibly suggesting either that the R_z numbers are too low or that the F_{2800} numbers are too high. (Throughout the remainder of this report, the author has arbitrarily chosen to use F_{2800} as the solar activity indicator for comparisons.)

Figure 5 graphs the daily flare rates for categories A and B versus time, as well as their ratio (f'_A/f'_B) and F_{2800}. Observe that, while the category A flares do not always mimic the rise and fall of F_{2800}, the category B flare curve does tend to follow, in an approximate way, the ups and downs of F_{2800}. Thus, there appears to be a somewhat crude relationship between flare frequency and solar cycle. That is, usually high R_z implies high F_{2800} which implies high f_B; conversely, low R_z means low F_{2800} which implies low f_B. (Wilson [2] has deduced approximate relationships between smoothed sunspot number and smoothed number of flares.) Since the study flares are related to the category B flares which are approximately related with F_{2800}, the study flares themselves can yield relationships pertaining directly to phase of solar cycle. (In Figure 5, $\bar{x}$ is the mean.)

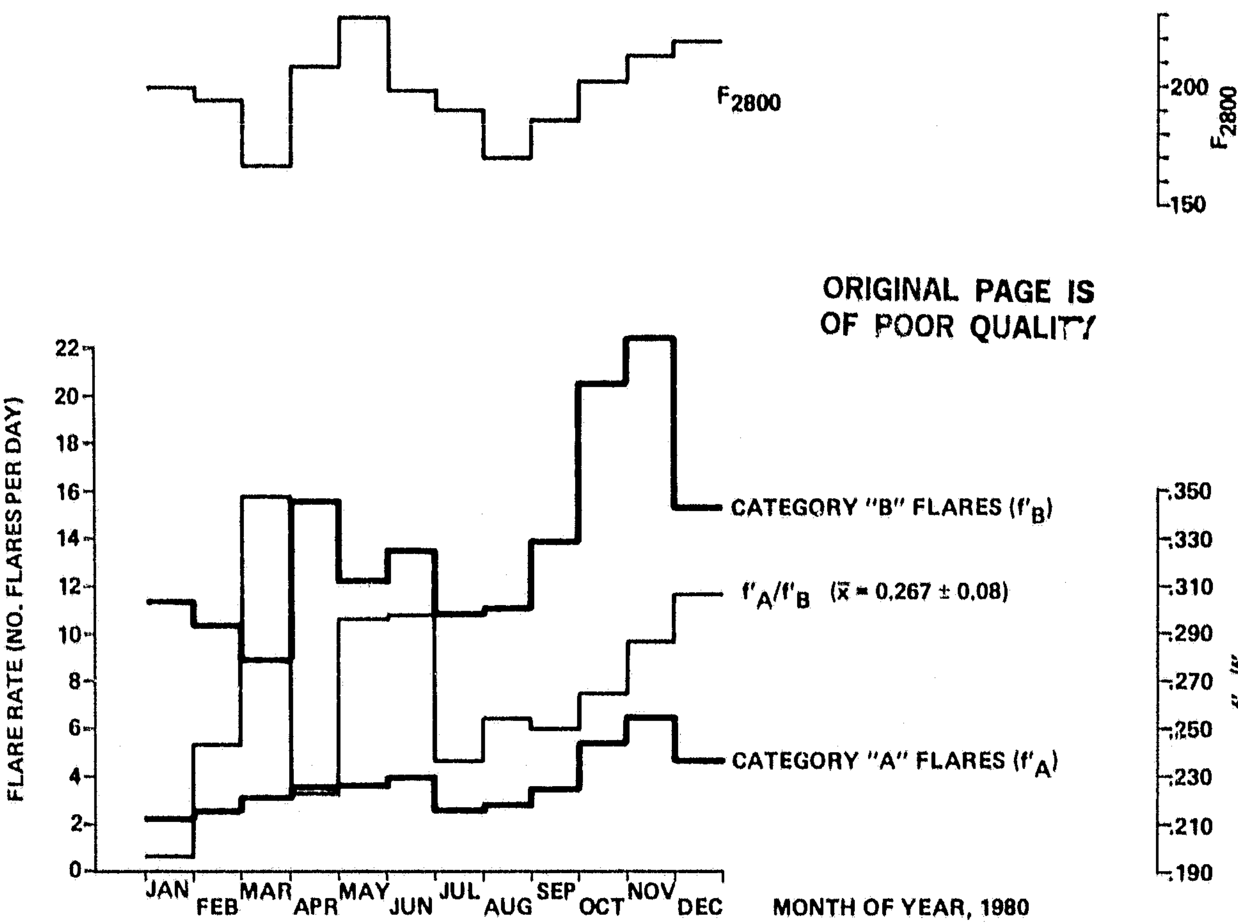

Figure 5. Variation of category A, B, and A/B daily flare rate (i.e., number of flares per month divided by number of days per month) and month of year 1980. Also, variation of F_{2800} over year.

Figure 6 plots F_{2800} versus category B daily flare rates (f'_B, or B' using Table 1), as well as R_z versus f'_B. (F_{2800} versus f'_B is plotted as the ⊙ and R_z versus f'_B as ●.) The dark diagonal line running from lower left to upper right depicts an eye-ball approximation between F_{2800} and f'_B, using all data points, and is given by the equation

$$F_{2800} = 3.059\ f'_B + 155.76 \quad . \tag{6}$$

If the average ratio numbers (F_{2800}/f'_B) are used, we determine the dashed line given by the equation

$$F_{2800} = 15.192\ f'_B \pm 5.65\ f'_B \quad , \tag{7}$$

since $F_{2800}/f'_B = 15.192 \begin{smallmatrix} +3.676 \\ -5.652 \end{smallmatrix}$ for the year. Unfortunately, the highest f'_B value did not correspond to the highest F_{2800} value, hence the wide error bars. If the

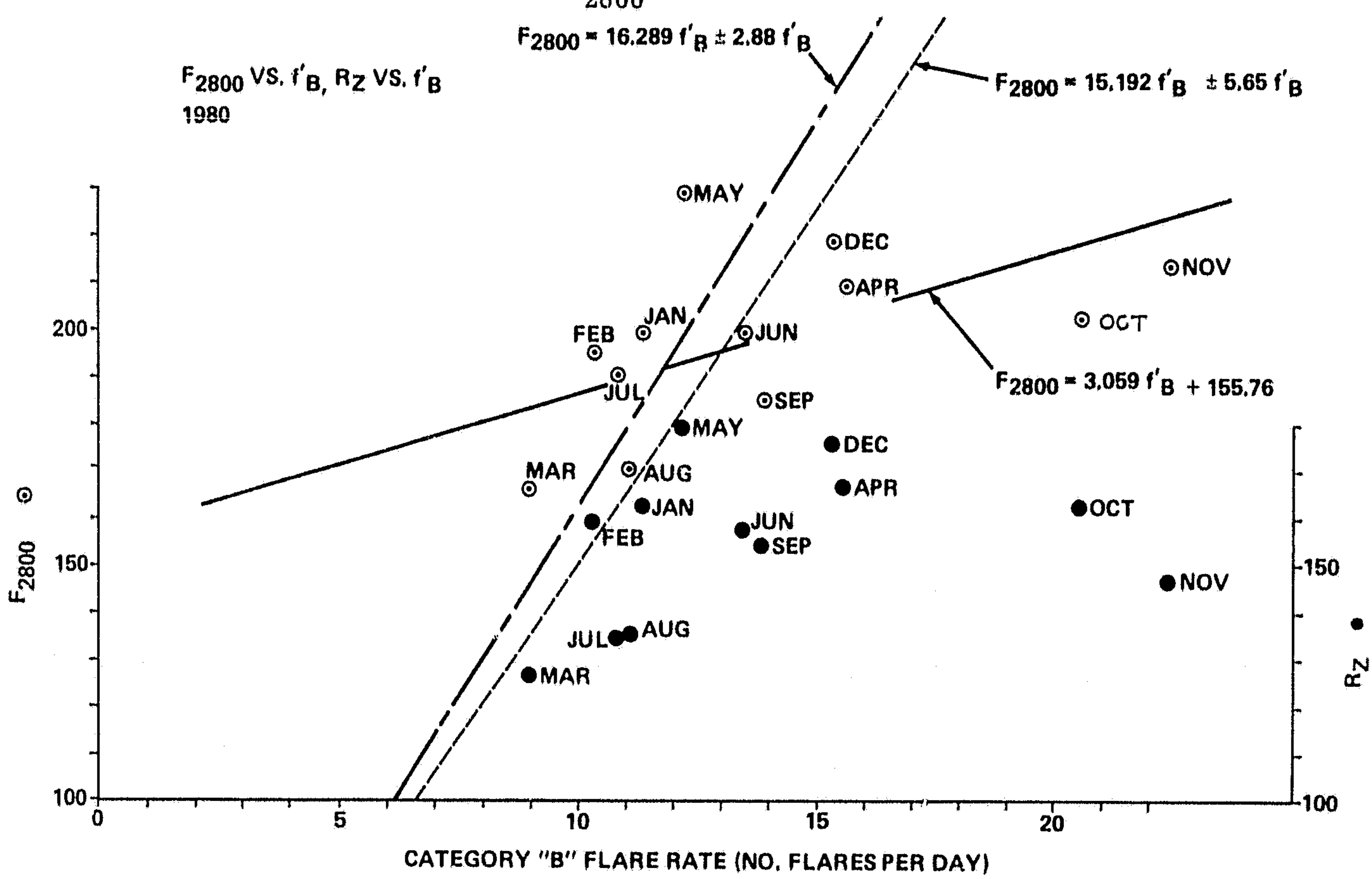

Figure 6. F_{2800} versus category B daily flare rate (⊙). R_z versus category B daily flare rate (●). Dark solid-line is visual approximation to F_{2800} data points. Dashed-lines refer to mean-slope lines using all data points (right-most dashed line) and excluding October and November data points (left-most dashed line).

October and November F_{2800}/f'_B are arbitrarily removed from the average, since they are substantially low, then the relation is deduced to be

$$F_{2800} = 16.287\ f'_B \pm 2.88\ f'_B \quad , \tag{8}$$

since $F_{2800}/f'_B = 16.287\ {}^{+2.581}_{-2.884}$. Caution must be emphasized regarding these relationships, since the daily flare rates have not been corrected for actual observing time.

Table 3 tabulates various X-ray and importance ratios, and Figure 7 illustrates some of the more interesting ones. Observe that the three ratios plotted, although not directly suggestive of a one-to-one relation, appear to be associated in some way to F_{2800}. In fact, as discussed in Section III, M class X-ray flares and, to a lesser extent, class 1 Hα flares are proportional to F_{2800} values. Similarly, periods of bright flares may correspond to periods of high F_{2800} values, although the relation may be somewhat complicated.

As an explanation for the legend of Table 3, consider the ratios for November. Ratio 1 results from dividing the number of C class X-ray flares by the number of study flares for the month; hence, C/f_A. These numbers (for this ratio and ratios 2 through 18) are tabularized in Table 11 b,c in part I of this study [1]). (Actually, they are Tables 1 b,c through 12 b,c representing January 1980 through December 1980; Table 15 b,c summarizes the full year.) Since there were 110 C class study flares in November and 192 study flares, ratio 1 is 110/192 = 0.573. Ratios 2 through 18 are computed in similar fashion. YEAR represents the resulting ratio quotients based on yearly counts of study flares.

In Figure 7, three ratios are plotted in detail: ratio 17 (B/N), ratio 4 (M/C), and ratio 10 (1/S). Three other ratios are plotted as individual points, showing their highest ratio values: ratio 5 (X/C, plotted as A), ratio 11 (2/S, plotted as ⊙), and ratio 16 (F/N, plotted as ⊡). The two large peaks in the ratio 17 curve are 1.8 and 1.5 times, respectively, the ratio's yearly value.

Table 4 gives the mean values for each of the parameters -- RT (rise time), DT (decay time), D (duration, D = RT + DT), LAT (latitude of occurrence), XR (X ray class), and IMP (Hα importance) -- by month and year based on the 1349 study flares. XR was deduced by adding the peak energy outputs of all flares and dividing by the total number of flares for the time period of interest. IMP was deduced by giving each flare a number, representing a product of an area (S = 1, 1 = 2, 2 = 3, 3 = 4, 4 = 5) and a relative brightness (F = 1, N = 2, B = 3), and dividing the sum of the products by the total number of flares for the period of interest. As an example, an SN flare is equal to 2 (= 1 × 2 = SN); an 1B flare is equal to 6 (= 2 × 3 = 1B); and so on. Also given in Table 4 are the mean RT to mean DT ratio ($\overline{RT}/\overline{DT}$), mean area ($\bar{A}$), mean relative brightness ($\overline{RB}$), their product (which is proportional to $\overline{IMP}$), mean X-ray energy for C flares ($\overline{XR}_C$), mean X-ray energy for M flares ($\overline{XR}_M$), mean X-ray energy for X flares ($\overline{XR}_X$), and R_z and F_{2800} values. Figure 8 a,b,c graphically displays these mean value tabulations, where the numbers in the parentheses are the yearly mean values. An apparent relation between mean flare area ($\bar{A}$) and mean relative brightness ($\overline{RB}$) is observed, given by the equation

TABLE 3. MONTHLY X-RAY AND IMPORTANCE RATIOS

	X-RAY RATIOS						IMPORTANCE RATIOS											
							SIZE						BRIGHTNESS					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
JAN	.768	.232		.302			.862	.159	.014	.193	.018	.091	.188	.551	.261	.342	.474	.722
FEB	.822	.178		.217			.699	.233	.068	.333	.098	.294	.151	.507	.342	.297	.676	.440
MAR	.938	.063		.667			.802	.188	.010	.234	.013	.056	.302	.479	.219	.630	.457	1.381
APR	.788	212		.268			.712	.269	.019	.378	.027	.071	.173	.548	.279	.316	.509	.621
MAY	.741	.232	.027	.313	.036	.015	.696	.259	.045	.372	.064	.172	.161	.500	.339	.321	.679	.474
JUN	.742	.242	.017	.326	.022	.069	.775	.192	.033	.247	.043	.174	.217	.317	.467	.684	1.474	.464
JUL	.722	.241	.038	.333	.053	.158	.608	.354	.038	.533	.063	.107	.114	.342	.544	.333	1.593	.269
AUG	.862	.138		.160			.759	.195	.046	.258	.061	.235	.126	.391	.483	.324	1.235	.262
SEP	885	.115		.130			.779	.202	.019	.259	.025	.095	.240	.413	.346	.581	.837	.694
OCT	.833	.155	.012	.186	.014	.077	.732	.232	.030	.317	.041	.128	.119	.446	.435	.267	.973	.274
NOV	.573	.401	.026	.700	.045	.065	.563	.344	.094	.611	.167	.273	.115	.380	.505	.301	1.329	.227
DEC	.807	.193		.239			.752	.207	.041	.275	.055	.200	.172	.490	.338	.352	.690	.510
YEAR	.777	.212	.011	.273	.014	.052	.715	.242	.042	.339	.058	.171	.168	.441	.391	.382	.886	.431

LEDGEND: (1) C/f_A (5) X/C (9) $2/f_A$ (13) F/f_A (17) B/N

(2) M/f_A (6) X/M (10) 1/S (14) N/f_A (18) F/B

(3) X/f_A (7) S/f_A (11) 2/S (15) B/f_A

(4) M/C (8) $1/f_A$ (12) 2/1 (16) F/N

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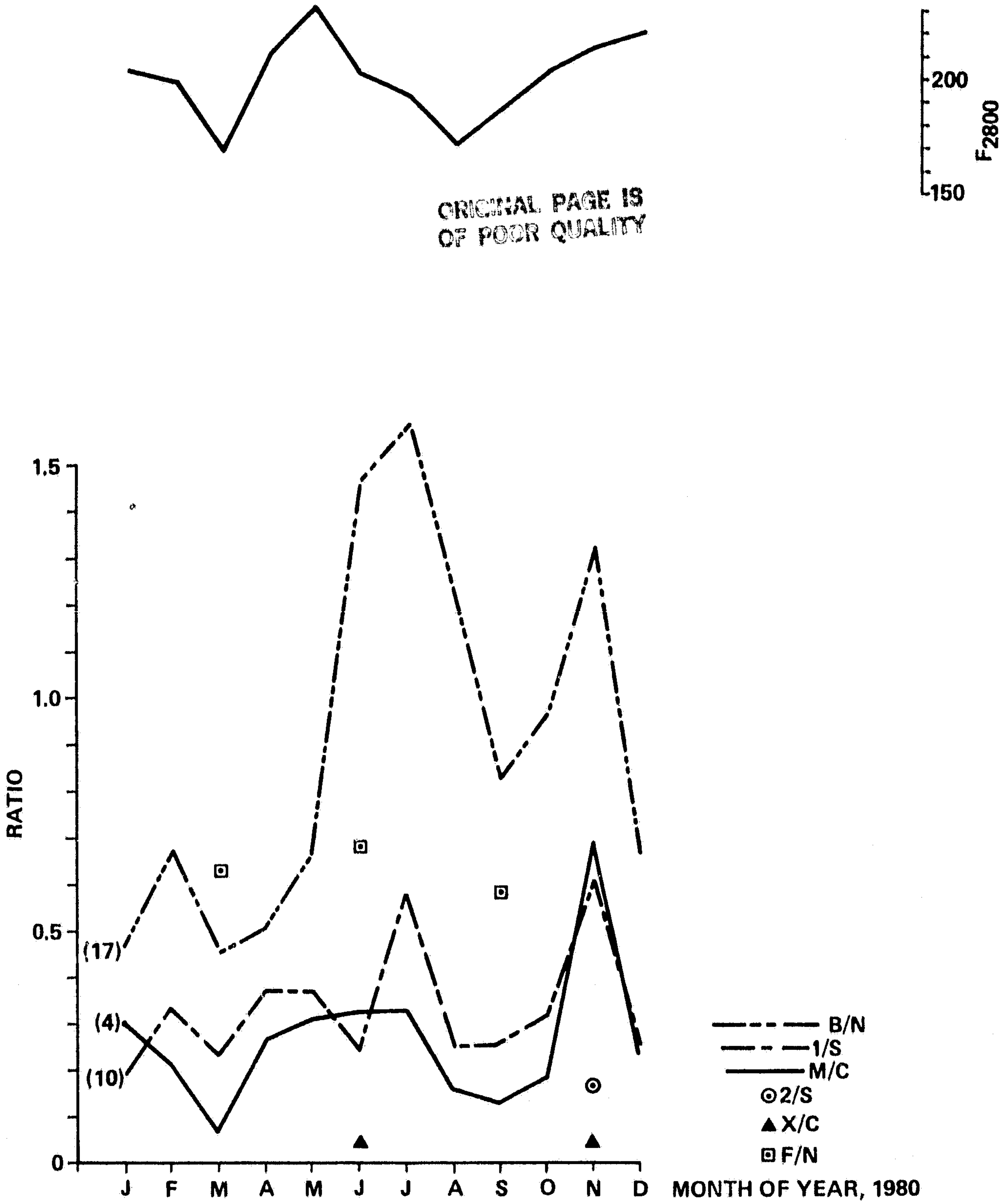

Figure 7. Selected ratios versus month of year 1980. Also, F_{2800} versus month of year. Symbols refer to peak values of defined ratios.

TABLE 4. MONTHLY MEAN VALUES OF SELECTED PARAMETERS

	N	$\overline{RT}$	$\overline{DT}$	$\overline{D}$	$\overline{LAT}$	$\overline{XR}$ (10^{-3})	$\overline{IMP}$	$\overline{RT/DT}$	$\overline{A}$	$\overline{RB}$	$\overline{AxRB}$	$\overline{XR}_C$	$\overline{XR}_M$	$\overline{XR}_X$	R_Z	F_{2800}	
JAN	69	11.26	22.94	34.20	14.26	9.83	2.55	0.491	1.19	2.07	2.46	4.11	2.88		162.2	199.6	JAN
FEB	73	6.42	21.90	28.32	13.27	3.16	3.12	0.102	1.37	2.19	3.00	3.42	1.77		159.3	195.1	FEB
MAR	96	4.71	16.81	21.52	19.22	4.09	2.41	0.280	1.21	1.92	2.32	2.58	2.67		126.5	166.5	MAR
APR	104	5.47	22.48	27.95	18.04	9.64	2.86	0.243	1.31	2.11	2.76	4.04	3.05		166.6	209.3	APR
MAY	112	5.96	19.88	25.74	17.16	12.0	3.03	0.300	1.35	2.18	2.94	3.41	2.15	1.67	179.7	229.1	MAY
JUN	120	7.41	19.11	26.52	18.08	11.9	2.92	0.388	1.26	2.25	2.84	4.28	2.24	2.00	157.2	199.3	JUN
JUL	79	8.14	28.78	36.92	17.01	14.5	3.61	0.283	1.43	2.43	3.47	4.02	2.74	1.33	135.0	190.8	JUL
AUG	87	8.43	22.33	30.76	14.45	6.07	3.16	0.378	1.29	2.36	3.04	3.31	2.33		135.4	170.3	AUG
SEP	104	5.28	21.10	26.38	13.31	4.81	2.73	0.250	1.24	2.11	2.62	2.28	2.42		154.5	185.9	SEP
OCT	168	8.68*	19.27	27.95*	14.77	9.48	3.11	0.450	1.31	2.32	3.04	3.95	1.69	3.00	162.9	202.9	OCT
NOV	192	10.40	27.71	38.11	12.68	20.6	3.78	0.375	1.53	2.39	3.66	4.41	2.31	3.40	146.5	213.4	NOV
DEC	145	7.75	22.01	29.76	13.52	6.97	2.90	0.352	1.29	2.17	2.80	3.42	2.18		176.1	218.8	DEC
YEAR	1349	7.66*	22.10	29.76*	15.29	10.4	3.06	0.347	1.33	2.22	2.95	3.60	2.33	2.40			YEAR

*Excludes the anomalous event of October (see Wilson [1]).

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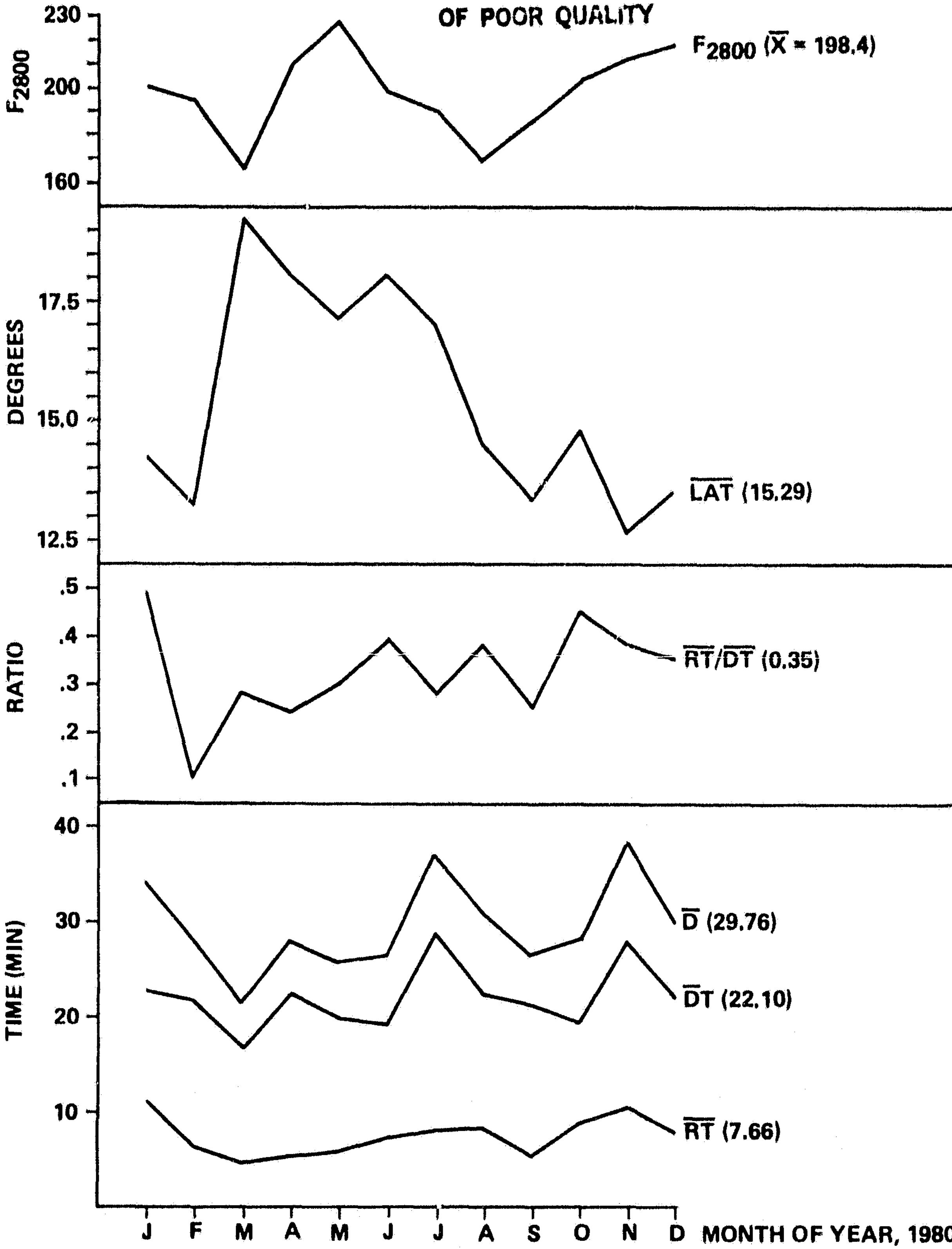

Figure 8a. Variation of monthly mean values of latitude ($\overline{LAT}$), rise time divided by decay time ($\overline{RT}/\overline{DT}$), rise time ($\overline{RT}$), decay time ($\overline{DT}$), and duration ($\overline{D}$) with month of year 1980. Also, F_{2800} versus month of year.

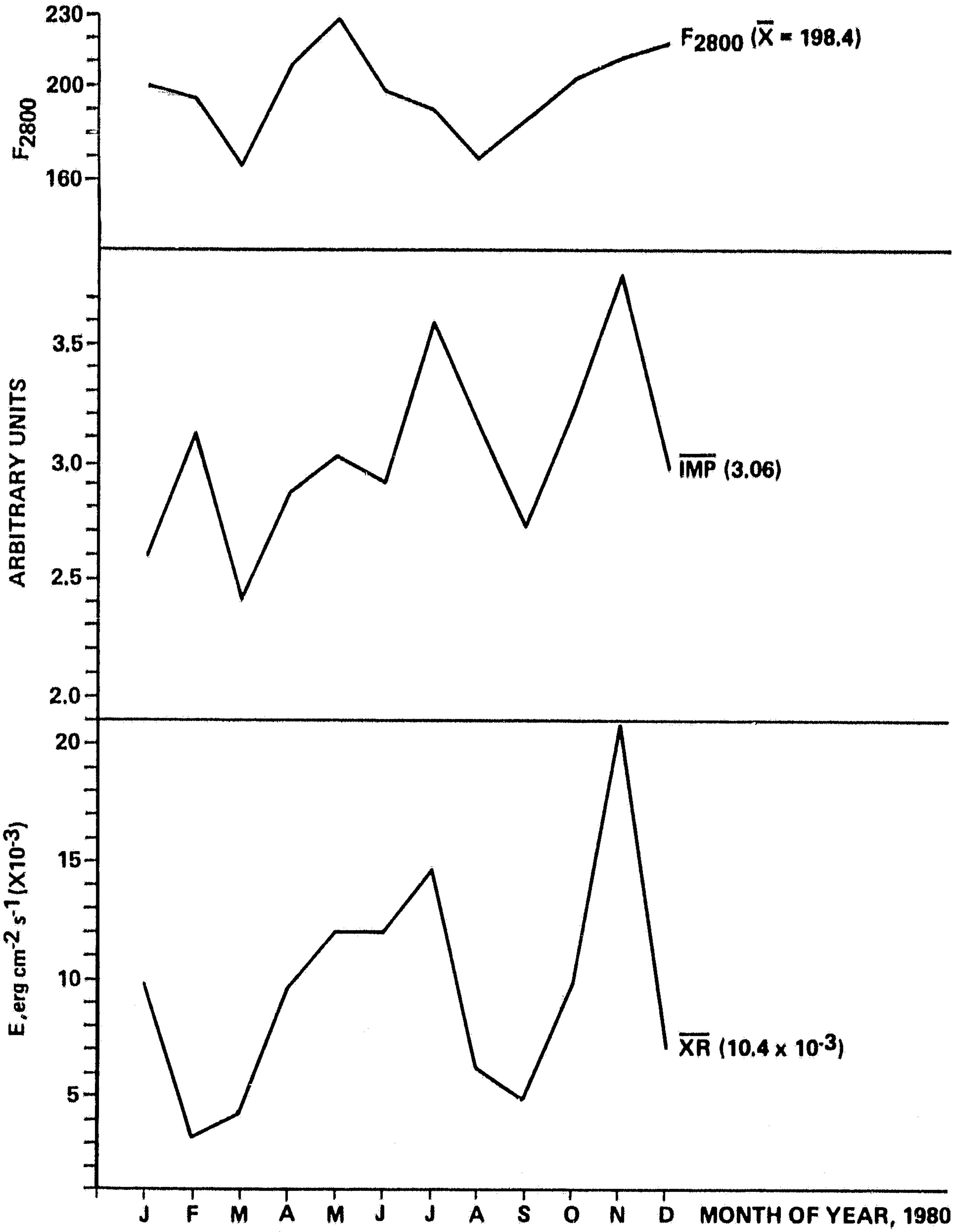

Figure 8b. Variation of monthly mean values of importance class ($\overline{IMP}$) and X-ray class ($\overline{XR}$). See text for method of computation. Also, F_{2800} versus month of year.

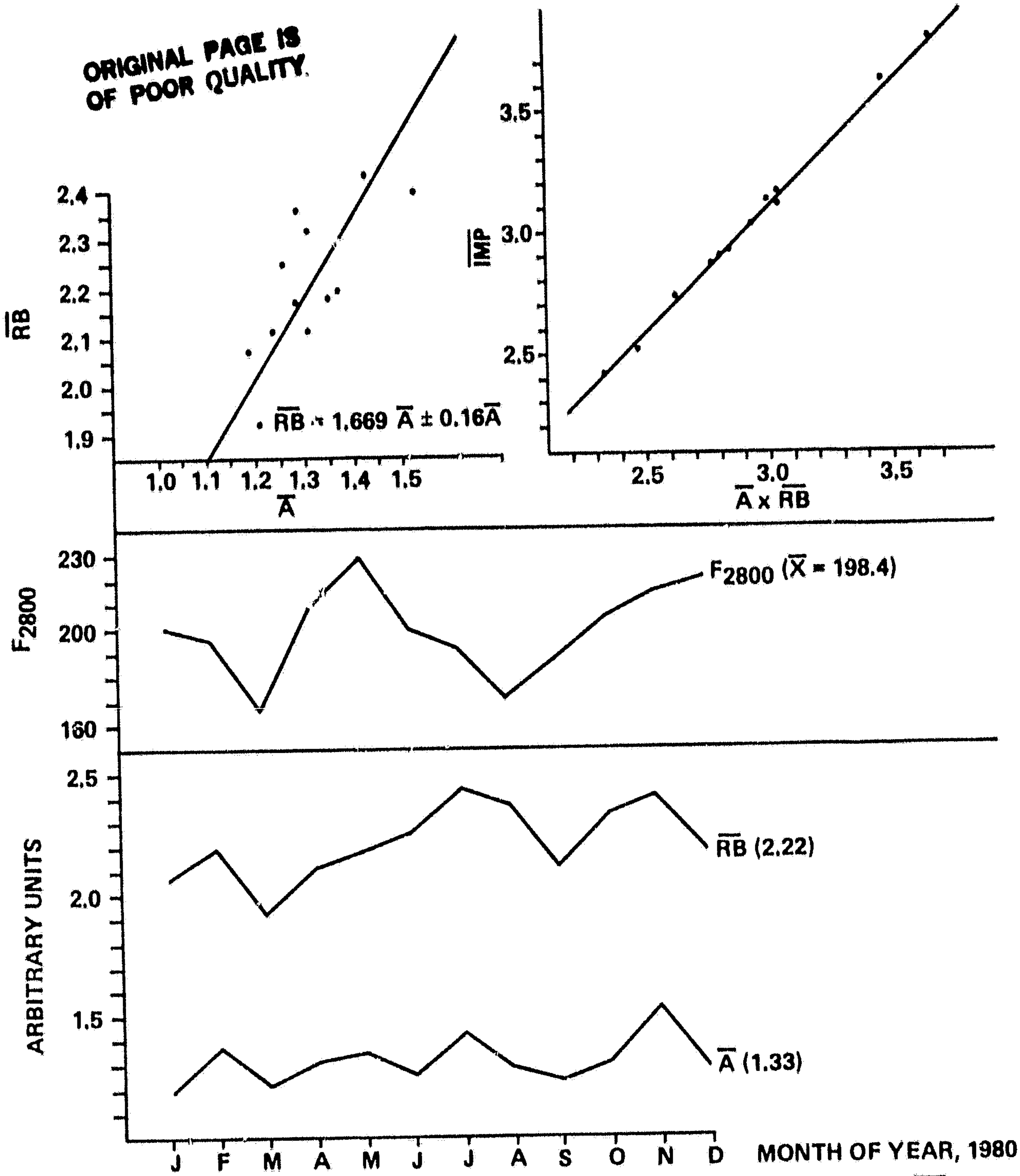

Figure 8c. Variation of monthly mean values of relative brightness ($\overline{RB}$) and area ($\overline{A}$). See text for method of computation. Also, F_{2800} versus month of year, $\overline{RB}$ versus $\overline{A}$ and $\overline{IMP}$ versus $\overline{A} \times \overline{RB}$.

$$\overline{RB} = 1.669\ \overline{A} \pm 0.16\ \overline{A} \quad , \qquad (9)$$

since $\overline{RB}/\overline{A} = 1.669\ ^{+0.10}_{-0.09}$.

The upper left-hand portion of Figure 8c plots the $\overline{RB}$ versus $\overline{A}$ monthly values and graphically depicts the relation formulated in equation (9). The upper right-hand portion of Figure 8c displays $\overline{IMP}$ versus $\overline{A} + \overline{RB}$, which is a 45 degree diagonal (slightly displaced).

III. DISCUSSION

A. R_z and F_{2800}

While the author has arbitrarily chosen to use F_{2800} for all parameters versus solar activity comparisons, it should not be assumed that it is the "best" indicator. (Historically, sunspot number has been utilized extensively.) In fact, both R_z and F_{2800} show considerable variability from day to day. In 1980, the average yearly R_z was $155.16\ ^{+24.54}_{-28.66}$ (a spread of $\sim$ 18 percent), based on monthly R_z values (Table 4). In terms of daily values, R_z ranged from a low of 36 on March 16 to a high of 262 on January 9; thus, its all-inclusive average is $155.16\ ^{+106.84}_{-119.16}$ (a spread of $\sim$ 77 percent). The peak R_z monthly average was 179.7 in May, and the smallest R_z monthly average was 126.5 in March.

Similarly, the average F_{2800} was $198.42\ ^{+30.68}_{-31.92}$ ($\sim$16 percent spread), based on monthly F_{2800} values. However, daily F_{2800} values ranged from a low of 130.9 on August 4 to a high of 292.8 on May 25, yielding an all-inclusive average of 198.42 $^{+94.38}_{-67.52}$ ($\sim$48 percent spread). The peak F_{2800} monthly average was 229.1 in May, and the lowest F_{2800} monthly average was 166.5 in March. Thus, the ratio of average yearly R_z to F_{2800} is $0.782\ ^{+0.049}_{-0.095}$. It is observed that while specific details sometimes disagree (especially based on daily data), the general trends are in agreement (based on monthly averages). Although equations have been given in the previous section for a definite value of R_z or F_{2800}, it should be remembered that the actual values really pertain to a range of values, typically ±16 percent wide (for F_{2800}).

B. Mean Values

Figure 8a illustrates the monthly variation of $\overline{RT}$, $\overline{DT}$, $\overline{D}$, $\overline{RT}/\overline{DT}$, $\overline{LAT}$, and F_{2800} during 1980. Observe that $\overline{RT}$, $\overline{DT}$, $\overline{D}$, and $\overline{RT}/\overline{DT}$ showed upward trends during the year, while $\overline{LAT}$ showed a downward trend. Thus, as the year progressed, the study flares contained more and more flares of longer rise time and decay time (and duration since rise time plus decay time equals duration). In addition, since the ratio of mean rise time to mean decay time also showed an upward trend to higher ratio numbers, the relative proportion of long rise time events to long decay time events was higher. The downward trend of $\overline{LAT}$ may be an expected result since as the solar cycle progresses from early cycle to late cycle the mean latitude of occurrence of sunspots (or more correctly active regions) goes from higher latitude to lower latitude; since flares are associated directly with active regions (regions of enhanced magnetic field), they should show a similar variation. (However, 12 data points or 1-year's worth of data are insufficient to describe the relationship.)

Figure 8b shows the monthly variation of $\overline{IMP}$, $\overline{XR}$, and F_{2800} during 1980. The $\overline{IMP}$ and $\overline{XR}$ curves both suggest upward trends. Therefore, study flares late in the year (about 1 year past solar maximum) were not only more numerous than early year study flares, but also more energetic. The mean X-ray energy curve is somewhat similar in structure to the F_{2800} curve, suggesting a possible relationship.

Figure 8c displays the $\overline{RB}$, $\overline{A}$, and F_{2800} variations. The curves suggest an apparent upward trend for both $\overline{RB}$ and $\overline{A}$; thus, study flares were proportionately brighter and larger late in the year as compared to earlier in the year.

C. Rise Times

The left-most portion of Figure 9 is a scatter plot relating $\overline{RT}$ and F_{2800}. The small dotted circles (⊙) represent the data points. The number beside each circle is the month of occurrence, where 1 is January, 2 is February, and so on. The line passing through the data points is of the form

$$F_{2800} = 28.170\ \overline{RT} \pm 10.4\ \overline{RT} \quad , \tag{10}$$

since $F_{2800}/\overline{RT} = 28.170 {}^{+10.27}_{-10.44}$, based on Table 4. This implies that

$$\overline{RT} = 0.038\ F_{2800} \pm 0.02\ F_{2800} \quad , \tag{11}$$

since $\overline{RT}/F_{2800} = 0.038 {}^{+0.018}_{-0.012}$. Table 5 identifies the frequency of occurrence (f) and percent occurrence (p) for the parameter RT from elapsed time duration < 1 min to 10 min and the sum ≤10 min for each month and the year. Also given is the monthly F_{2800} value and the total number of study flare occurrences (N). F_{2800}/f values for a few selected RT are:

$$\left.\begin{array}{ll} (\mathrm{RT} < 1\ \mathrm{min}) & F_{2800}/f = 24.170 {}^{+25.730}_{-\ 9.943} \\[2ex] (\mathrm{RT} = 1\ \mathrm{min}) & F_{2800}/f = 17.943 {}^{+20.217}_{-10.584} \\[2ex] (\mathrm{RT} = 2\ \mathrm{min}) & F_{2800}/f = 14.520 {}^{+13.320}_{-\ 4.858} \end{array}\right\} \tag{12}$$

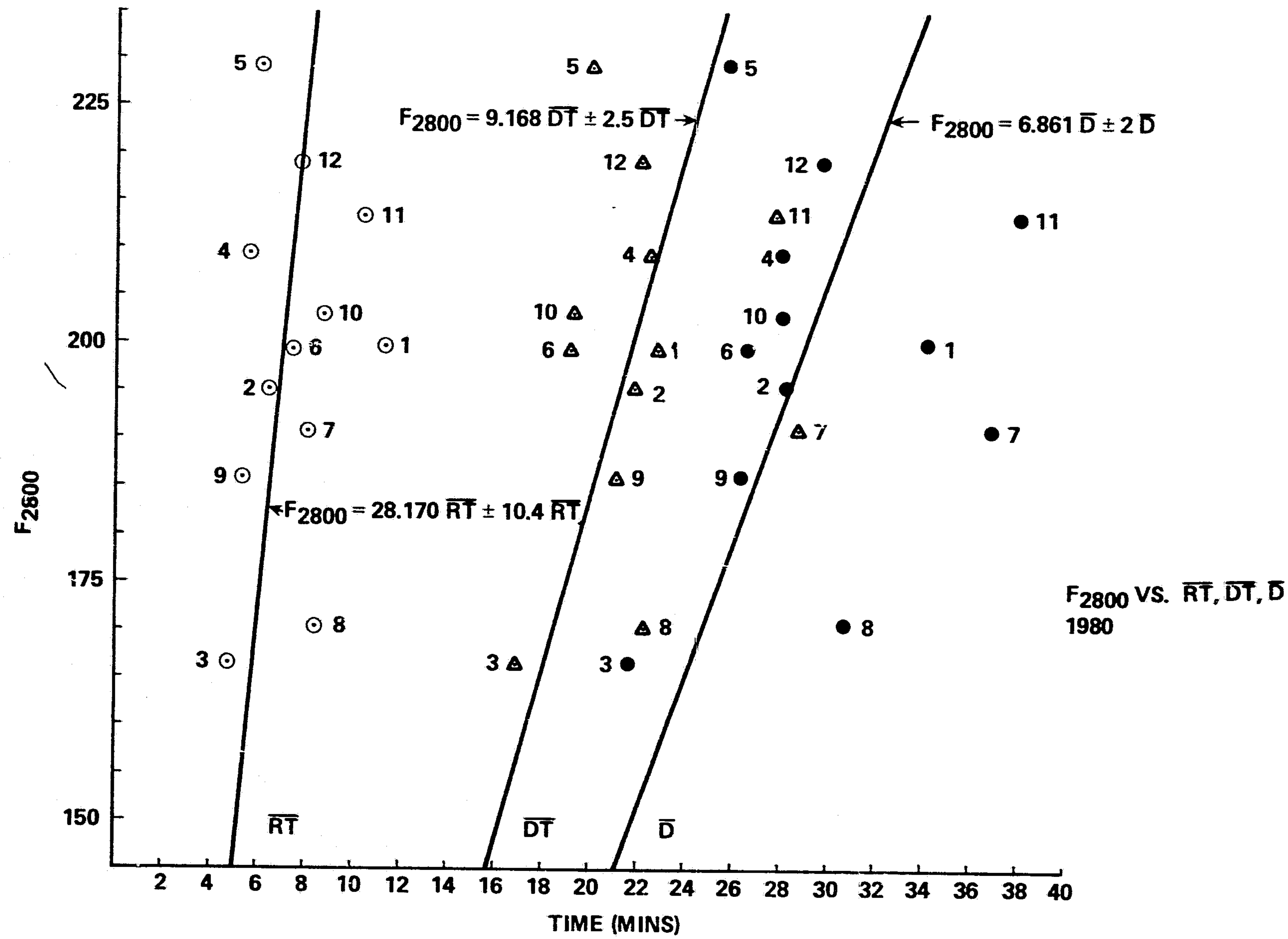

Figure 9. F_{2800} versus $\overline{RT}$, $\overline{DT}$, and $\overline{D}$. Elapsed time duration (called TIME) given in minutes.

TABLE 5. FREQUENCY (f) AND PERCENT (p) VALUES PER MONTH PER RISE TIME (RT) GROUPING

		RISE TIME (RT), minutes																							
		<1		1		2		3		4		5		6		7		8		9		10		≤10		
	N	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	F_{2800}
JAN	69	4	5.8	7	10.1	9	13.0	4	5.8	8	11.6	5	7.2	4	5.8	5	7.2	2	2.9	1	1.4	1	1.4	50	72.5	199.6
FEB	73	8	11.0	12	16.4	15	20.5	3	4.1	4	5.5	7	9.6	6	8.2	1	1.4	6	8.2	1	1.4	2	2.7	65	89.0	195.1
MAR	96	11	11.5	13	13.5	6	6.3	22	22.9	6	6.3	11	11.5	5	5.2	3	3.1	2	2.1	6	6.3	3	3.1	88	91.7	166.5
APR	104	14	13.5	9	8.7	17	16.3	16	15.4	5	4.8	5	4.8	7	6.7	6	5.8	3	2.9	3	2.9	1	1.0	86	82.7	209.3
MAY	112	10	8.9	22	19.6	19	17.0	13	11.6	12	10.7	6	5.4	2	1.8	2	1.8	1	0.9	4	3.6	2	1.8	93	83.0	229.1
JUN	120	8	6.7	17	14.2	19	15.8	18	15.0	12	10.0	5	4.2	13	10.8	3	2.5	4	3.3	2	1.7	1	0.8	102	85.0	199.3
JUL	79	9	11.4	5	6.3	9	11.4	14	17.7	4	5.1	5	6.3	1	1.3	8	10.1	3	3.8	0	0.0	1	1.3	59	74.7	190.8
AUG	87	6	6.9	6	6.9	16	18.4	13	14.9	6	6.9	6	6.9	2	2.3	4	4.6	4	4.6	4	4.6	4	4.6	71	81.6	170.3
SEP	104	9	8.7	17	16.3	17	16.3	20	19.2	5	4.8	4	3.8	5	4.8	3	2.9	1	1.0	2	1.9	4	3.8	87	83.7	185.9
OCT	168	12	7.1	19	11.3	21	12.5	12	7.1	18	10.7	10	6.0	7	4.2	11	6.5	5	3.0	2	1.2	8	4.8	125	74.4	202.9
NOV	192	15	7.8	29	15.1	18	9.4	14	7.3	12	6.3	13	6.8	8	4.2	16	8.3	15	7.8	5	2.6	10	5.2	155	80.7	213.4
DEC	145	6	4.1	13	9.0	18	12.4	22	15.2	19	13.1	10	6.9	13	9.0	7	4.8	7	4.8	4	2.8	5	3.4	124	85.5	218.8
YEAR	1349	112	8.3	169	12.5	184	13.6	171	12.7	111	8.2	87	6.4	73	5.4	69	5.1	53	3.9	34	2.5	42	3.1	1105	81.9	

$$\left.\begin{array}{ll} (RT = 3\ \mathrm{min}) & F_{2800}/f = 20.542\ {}^{+44.491}_{-12.974} \\ (RT = 4\ \mathrm{min}) & F_{2800}/f = 27.739\ {}^{+21.036}_{-16.467} \\ \text{and} & \\ (RT > 10\ \mathrm{min}) & F_{2800}/f = 2.356\ {}^{+1.636}_{-0.979} \end{array}\right\} \quad , \tag{12 Conc.}$$

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using all data points. If the lowest and highest ratio values are removed, the ratios have the following values:

$$\left.\begin{array}{ll} (RT < 1\ \mathrm{min}) & F_{2800}/f = 22.591\ {}^{+13.876}_{-\ 7.641} \\ (RT = 1\ \mathrm{min}) & F_{2800}/f = 16.980\ {}^{+11.534}_{-\ 6.566} \\ (RT = 2\ \mathrm{min}) & F_{2800}/f = 13.684\ {}^{+8.495}_{-3.195} \\ (RT = 3\ \mathrm{min}) & F_{2800}/f = 17.391\ {}^{+32.509}_{-\ 8.096} \\ (RT = 4\ \mathrm{min}) & F_{2800}/f = 27.278\ {}^{+20.422}_{-15.762} \\ \text{and} & \\ (RT > 10\ \mathrm{min}) & F_{2800}/f = 2.290\ {}^{+0.944}_{-0.667} \end{array}\right\} \tag{13}$$

D. Decay Time

The middle portion of Figure 9 is a scatter plot relating $\overline{DT}$ and F_{2800}. These data are represented by dotted triangles ($\dot{\Delta}$). Again, the number beside each data point indicates the month of occurrence. The line passing through the data points is of the form

$$F_{2800} = 9.168\ \overline{DT} \pm 2.5\ \overline{DT} \quad , \tag{14}$$

since $F_{2800}/\overline{DT} = 9.168\ {}^{+2.356}_{-2.538}$, based on Table 4. This implies that

$$\overline{DT} = 0.112\ F_{2800} \pm 0.04\ F_{2800} \quad . \tag{15}$$

since $\overline{DT}/F_{2800} \simeq 0.112 \begin{smallmatrix}+0.039\\-0.025\end{smallmatrix}$. Table 6 identifies the frequency of occurrence (f) and percent occurrence (p) for the parameter DT from elapsed time duration < 1-3 min to 28-30 min, and the sum ≤30 min for each month and the year. Also given is the monthly F_{2800} value and the total number of study flare occurrences (N). F_{2800}/f values for a few selected DT are:

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$$\left.\begin{array}{ll}
(DT < 1\text{-}3 \text{ min}) & F_{2800}/f = 73.172 \begin{smallmatrix}+136.128\\-\ 61.940\end{smallmatrix} \\[2ex]
(DT = 4\text{-}6 \text{ min}) & F_{2800}/f = 23.465 \begin{smallmatrix}+19.110\\-13.059\end{smallmatrix} \\[2ex]
(DT = 7\text{-}9 \text{ min}) & F_{2800}/f = 19.026 \begin{smallmatrix}+19.134\\-\ 8.537\end{smallmatrix} \\[2ex]
(DT = 10\text{-}12 \text{ min}) & F_{2800}/f = 17.305 \begin{smallmatrix}+9.952\\-8.483\end{smallmatrix} \\[2ex]
(DT = 13\text{-}15 \text{ min}) & F_{2800}/f = 22.120 \begin{smallmatrix}+17.800\\-11.441\end{smallmatrix} \\[2ex]
(DT = 16\text{-}18 \text{ min}) & F_{2800}/f = 20.725 \begin{smallmatrix}+10.258\\-10.563\end{smallmatrix} \\[2ex]
\text{and} & \\[1ex]
(DT \leq 30 \text{ min}) & F_{2800}/f = 2.489 \begin{smallmatrix}+1.277\\-0.997\end{smallmatrix}
\end{array}\right\} , \tag{16}$$

using all data points. Discarding the highest and lowest ratio values yields:

$$\left.\begin{array}{ll}
(DT < 1\text{-}3 \text{ min}) & F_{2800}/f = 65.753 \begin{smallmatrix}+133.847\\-\ 53.072\end{smallmatrix} \\[2ex]
(DT = 4\text{-}6 \text{ min}) & F_{2800}/f = 22.859 \begin{smallmatrix}+17.061\\-\ 9.778\end{smallmatrix} \\[2ex]
(DT = 7\text{-}9 \text{ min}) & F_{2800}/f = 17.996 \begin{smallmatrix}+14.551\\-\ 6.031\end{smallmatrix} \\[2ex]
(DT = 10\text{-}12 \text{ min}) & F_{2800}/f = 17.158 \begin{smallmatrix}+7.230\\-5.539\end{smallmatrix} \\[2ex]
(DT = 13\text{-}15 \text{ min}) & F_{2800}/f = 21.484 \begin{smallmatrix}+16.676\\-\ 9.172\end{smallmatrix}
\end{array}\right\} \tag{17}$$

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TABLE 6. FREQUENCY (f) AND PERCENT (p) VALUES PER MONTH PER DECAY TIME (DT) GROUPING

		DECAY TIME (DT), minutes																					
		<1-3		4-6		7-9		10-12		13-15		16-18		19-21		22-24		25-27		28-30		≤30		
	N	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	F_{2800}
JAN	69	1	1.4	5	7.2	9	13.0	11	15.9	5	7.2	9	13.0	4	5.8	4	5.8	1	1.4	4	5.8	53	76.8	199.6
FEB	73	1	1.4	8	11.0	6	8.2	8	11.0	7	9.6	10	13.7	7	9.6	3	4.1	2	2.7	3	4.1	55	75.3	195.1
MAR	96	4	4.2	16	16.7	13	13.5	11	11.5	12	12.5	7	7.3	10	10.4	8	8.3	3	3.1	4	4.2	88	91.7	166.5
APR	104	1	1.0	16	15.4	9	8.7	11	10.6	17	16.3	9	8.7	1	1.0	6	5.8	7	6.7	5	4.8	82	78.8	203.3
MAY	112	4	3.6	15	13.4	12	10.7	13	11.6	10	8.9	13	11.6	6	5.4	8	7.1	5	4.5	5	4.5	91	81.3	229.1
JUN	120	11	9.2	14	11.7	19	15.3	12	10.0	14	11.7	7	5.8	13	10.8	4	3.3	3	2.5	1	0.8	98	81.7	199.3
JUL	79	4	5.1	5	6.3	5	6.3	7	8.9	5	6.3	9	11.4	3	3.8	3	3.8	4	5.1	6	7.6	51	64.6	190.9
AUG	87	5	5.7	4	4.6	12	13.8	7	8.0	7	8.0	7	8.0	7	8.0	8	9.2	5	5.7	3	3.4	65	74.7	179.3
SEP	104	8	7.7	10	9.6	13	12.5	16	15.4	6	5.8	6	5.8	7	6.7	7	6.7	5	4.8	6	5.8	84	80.8	185.9
OCT	168	16	9.5	11	6.5	17	10.1	23	13.7	19	11.3	15	8.9	9	5.4	9	5.4	11	6.5	6	3.6	136	81.0	202.9
NOV	192	19	9.9	14	7.3	17	8.9	17	8.9	16	8.3	21	10.9	15	7.8	5	2.6	6	3.1	9	4.7	139	72.4	213.4
DEC	145	8	5.5	7	4.8	13	9.0	18	12.4	13	9.0	16	11.0	12	8.3	8	5.5	14	9.7	3	2.1	112	77.2	218.9
YEAR	1349	82	6.1	125	9.3	145	10.7	154	11.4	131	9.7	129	9.6	94	7.0	73	5.4	66	4.9	55	4.1	1054	73.1	

$$(DT = 16\text{-}18 \text{ min}) \qquad F_{2800}/f = 20.755 \begin{smallmatrix}+7.716\\-7.228\end{smallmatrix}$$

and (17) (Conc.)

$$(DT \geq 30 \text{ min}) \qquad F_{2800}/f = 2.461 \begin{smallmatrix}+1.280\\-0.926\end{smallmatrix} \quad .$$

E. Duration

The right-most portion of Figure 9 is a scatter plot relating $\bar{D}$ and F_{2800}. These data are represented by solid circles (●). As before, the number beside each data point indicates the month of occurrence. The line passing through the data points is of the form

$$F_{2800} = 6.861\ \bar{D} \pm 2.0\ \bar{D} \quad , \tag{18}$$

since $F_{2800}/\bar{D} = 6.861 \begin{smallmatrix}+2.040\\-1.693\end{smallmatrix}$, based on Table 4. This implies that

$$\bar{D} = 0.149\ F_{2800} \pm 0.04\ F_{2800} \quad , \tag{19}$$

since $\bar{D}/F_{2800} = 0.149 \begin{smallmatrix}+0.044\\-0.037\end{smallmatrix}$. Table 7 identifies the frequency of occurrence (f) and percent occurrence (p) for the parameter D from elapsed time duration ≤1-5 min to 56-60 min and the sum ≤60 min for each month and the year. Also given is the monthly F_{2800} value and the total number of study flare occurrences (N). F_{2800}/f values for a few selected D are:

$$\left.\begin{array}{ll}
(D \leq 1\text{-}5 \text{ min}) & F_{2800}/f = 64.741 \begin{smallmatrix}+134.859\\-\ 43.928\end{smallmatrix} \\[2ex]
(D = 6\text{-}10 \text{ min}) & F_{2800}/f = 16.192 \begin{smallmatrix}+23.728\\-\ 7.984\end{smallmatrix} \\[2ex]
(D = 11\text{-}15 \text{ min}) & F_{2800}/f = 12.656 \begin{smallmatrix}+5.489\\-4.540\end{smallmatrix} \\[2ex]
(D = 16\text{-}20 \text{ min}) & F_{2800}/f = 13.524 \begin{smallmatrix}+13.733\\-\ 6.527\end{smallmatrix} \\[2ex]
(D = 21\text{-}25 \text{ min}) & F_{2800}/f = 18.460 \begin{smallmatrix}+16.423\\-\ 7.520\end{smallmatrix} \\[2ex]
(D = 26\text{-}30 \text{ min}) & F_{2800}/f = 41.515 \begin{smallmatrix}+158.085\\-\ 30.283\end{smallmatrix}
\end{array}\right\} \tag{20}$$

TABLE 7. FREQUENCY (f) AND PERCENT (p) VALUES PER MONTH PER DURATION (D) GROUPING

		DURATION (D), minutes																									
		0-5		6-10		11-15		16-20		21-25		26-30		31-35		36-40		41-45		46-50		51-55		56-60		≤60		F_{2800}
	N	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	
JAN	69	1	1.4	5	7.2	11	15.9	14	20.3	9	13.0	1	1.4	4	5.8	5	7.2	5	7.2	1	1.4	0	0.0	3	4.3	59	85.5	193.6
FEB	73	2	2.7	10	13.7	11	15.1	14	19.2	9	12.3	3	4.1	7	9.6	5	6.8	1	1.4	2	2.7	2	2.7	0	0.0	66	90.4	195.1
MAR	96	8	8.3	12	12.5	20	20.8	14	14.6	15	15.6	10	10.4	7	7.3	2	2.1	3	3.1	0	0.0	1	1.0	1	1.0	93	96.9	165.5
APR	104	3	2.9	19	18.3	18	17.3	16	15.4	6	5.8	6	5.8	11	10.6	4	3.8	6	5.8	4	3.8	1	1.0	3	2.9	97	93.3	209.3
MAY	112	3	2.7	20	17.9	18	16.1	21	18.8	10	8.9	5	4.5	10	8.9	5	4.5	4	3.6	4	3.6	2	1.8	1	0.9	103	92.0	229.1
JUN	120	9	7.5	24	20.0	14	11.7	17	14.2	15	12.5	12	10.0	5	4.2	3	2.5	3	2.5	4	3.3	4	3.3	3	2.5	113	94.2	199.3
JUL	79	0	0.0	8	10.1	11	13.9	7	8.9	8	10.1	6	7.6	7	8.9	6	7.6	4	5.1	2	2.5	6	7.6	1	1.3	66	83.5	190.3
AUG	87	4	4.6	8	9.2	13	14.9	10	11.5	8	9.2	9	10.3	4	4.6	10	11.5	5	5.7	4	4.6	1	1.1	1	1.1	77	88.5	170.3
SEP	104	8	7.7	16	15.4	20	19.2	11	10.6	12	11.5	6	5.8	8	7.7	4	3.8	3	2.9	4	3.8	1	1.0	1	1.0	94	90.4	185.9
OCT	168	6	3.6	19	11.3	25	14.9	29	17.3	16	9.5	14	8.3	16	9.5	7	4.2	9	5.4	8	4.8	4	2.4	3	1.9	156	92.9	202.9
NOV	192	4	2.1	26	13.5	22	11.5	29	15.1	19	9.9	19	9.9	9	4.7	9	4.7	9	4.7	6	3.1	6	3.1	7	3.6	165	85.9	213.4
DEC	145	3	2.1	15	10.3	19	13.1	20	13.8	20	13.8	18	12.4	9	6.2	7	4.8	7	4.8	6	4.1	9	6.2	2	1.4	135	93.1	218.3
YEAR	1349	51	3.8	182	13.5	202	15.0	202	15.0	147	10.9	109	8.1	97	7.2	67	5.0	59	4.4	45	3.3	37	2.7	26	1.9	1224	90.7	

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and

$$(D \leq 60 \text{ min}) \qquad F_{2800}/f = 2.131 \begin{smallmatrix} +1.252 \\ -0.838 \end{smallmatrix} \quad , \qquad (20) \text{ (Conc.)}$$

using all data points. Removing the highest and lowest ratio values yields:

$$\left.\begin{array}{ll}
(D \leq 1\text{-}5 \text{ min}) & F_{2800}/f = 54.638 \begin{smallmatrix} +42.912 \\ -32.494 \end{smallmatrix} \\[2ex]
(D = 6\text{-}10 \text{ min}) & F_{2800}/f = 14.618 \begin{smallmatrix} +9.232 \\ -6.314 \end{smallmatrix} \\[2ex]
(D = 11\text{-}15 \text{ min}) & F_{2800}/f = 12.561 \begin{smallmatrix} +5.175 \\ -3.266 \end{smallmatrix} \\[2ex]
(D = 16\text{-}20 \text{ min}) & F_{2800}/f = 12.803 \begin{smallmatrix} +4.227 \\ -5.444 \end{smallmatrix} \\[2ex]
(D = 21\text{-}25 \text{ min}) & F_{2800}/f = 17.569 \begin{smallmatrix} +6.281 \\ -6.469 \end{smallmatrix} \\[2ex]
(D = 26\text{-}30 \text{ min}) & F_{2800}/f = 28.735 \begin{smallmatrix} +36.298 \\ -16.579 \end{smallmatrix} \\[2ex]
\text{and} & \\[1ex]
(D \leq 60 \text{ min}) & F_{2800}/f = 2.089 \begin{smallmatrix} +0.867 \\ -0.788 \end{smallmatrix}
\end{array}\right\} \quad . \qquad (21)$$

F. Latitude

The ratio $F_{2800}/\overline{LAT}$ for the 1349 study flares of 1980 equals $13.088 \begin{smallmatrix} +3.742 \\ -4.425 \end{smallmatrix}$. Therefore,

$$F_{2800} = 13.088 \ \overline{LAT} \pm 4.4 \ \overline{LAT} \quad , \qquad (22)$$

based on Table 4, or

$$\overline{LAT} = 0.079 \ F_{2800} \pm 0.04 \ F_{2800} \quad , \qquad (23)$$

since $\overline{LAT}/F_{2800} = 0.079 \begin{smallmatrix} +0.036 \\ -0.020 \end{smallmatrix}$. Table 8 identifies the frequency of occurrence (f) and percent occurrence (p) for the parameters LAT for several latitude bands by month and year. Also given is the monthly F_{2800} value and the total number of study flare occurrences (N). F_{2800}/f values for a few selected LAT (bands) are:

TABLE 8. FREQUENCY (f) AND PERCENT (p) VALUES PER MONTH PER LATITUDE (LAT) GROUPING

		LATITUDE (LAT), degrees												
		0-9		10-19		20-29		≥30		NORTH		SOUTH		
	N	f	p	f	p	f	p	f	p	f	p	f	p	F_{2800}
JAN	69	14	20.3	50	72.5	2	2.9	3	4.3	28	40.6	41	59.4	199.6
FEB	73	18	24.7	48	65.8	7	9.6	0	0	31	42.5	42	57.5	195.1
MAR	96	12	12.5	36	37.5	48	50.0	0	0	50	52.1	46	47.9	166.5
APR	104	13	12.5	56	53.8	20	19.2	15	14.4	47	45.2	57	54.8	209.3
MAY	112	8	7.1	64	57.1	38	33.9	2	1.8	16	14.3	96	85.7	229.1
JUN	120	4	3.3	67	55.8	43	35.8	6	5.0	28	23.3	92	76.7	199.3
JUL	79	9	11.4	39	49.4	30	38.0	1	1.3	23	29.1	56	70.9	190.8
AUG	87	17	19.5	59	67.8	11	12.6	0	0	67	77.0	20	23.0	170.3
SEP	104	27	26.0	66	63.5	7	6.7	4	3.8	59	56.7	45	43.3	185.9
OCT	168	31	18.5	110	65.5	24	14.3	3	1.8	68	40.5	100	59.5	202.9
NOV	192	40	20.8	132	68.8	20	10.4	0	0	106	55.2	86	44.8	213.4
DEC	145	39	26.9	78	53.8	27	18.6	1	1.3	87	60.0	58	40.0	218.8
YEAR	1349	232	17.2	805	59.7	277	20.5	35	2.6	610	45.2	739	54.8	

$$\left.\begin{array}{ll} (\text{LAT} = 0\text{-}9^\circ) & F_{2800}/f = 15.761\,{}^{+34.064}_{-10.426} \\[2ex] (\text{LAT} = 10\text{-}19^\circ) & F_{2800}/f = 3.320\,{}^{+1.572}_{-1.703} \\[2ex] (\text{LAT} = 20\text{-}29^\circ) & F_{2800}/f = 18.991\,{}^{+80.809}_{-15.522} \\[2ex] (\text{NORTH LAT}) & F_{2800}/f = 5.345\,{}^{+8.974}_{-3.332} \\[2ex] \text{and} & \\ (\text{SOUTH LAT}) & F_{2800}/f = 3.808\,{}^{+4.707}_{-1.779} \end{array}\right\} , \qquad (24)$$

using all data points. Discarding the highest and lowest ratios yields:

$$
\left.
\begin{array}{ll}
(\mathrm{LAT} = 0\text{-}9^\circ) & F_{2800}/f = 13.397 \begin{smallmatrix} +15.241 \\ -\ 7.787 \end{smallmatrix} \\[2ex]
(\mathrm{LAT} = 10\text{-}19^\circ) & F_{2800}/f = 3.333 \begin{smallmatrix} +1.292 \\ -1.488 \end{smallmatrix} \\[2ex]
(\mathrm{LAT} = 20\text{-}29^\circ) & F_{2800}/f = 12.463 \begin{smallmatrix} +15.408 \\ -\ 7.828 \end{smallmatrix} \\[2ex]
(\mathrm{NORTH\ LAT}) & F_{2800}/f = 4.781 \begin{smallmatrix} +3.515 \\ -2.266 \end{smallmatrix} \\[2ex]
\text{and} & \\[1ex]
(\mathrm{SOUTH\ LAT}) & F_{2800}/f = 3.515 \begin{smallmatrix} +1.353 \\ -1.349 \end{smallmatrix}
\end{array}
\right\} \quad . \tag{25}
$$

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Figure 10 illustrates F_{2800} versus f for LAT = 10-19 degrees, using all data points. The month of year is identified beside each data point by a number, where 1 is January, 2 is February, etc. Please note that the solid line passing through the data points is not the best-fit line but, rather, the mean-slope line based on the ratio of F_{2800} to f for all data points. The dashed line is, perhaps, a better fit to the data points (assuming an F_{2800} variation of ±16 percent).

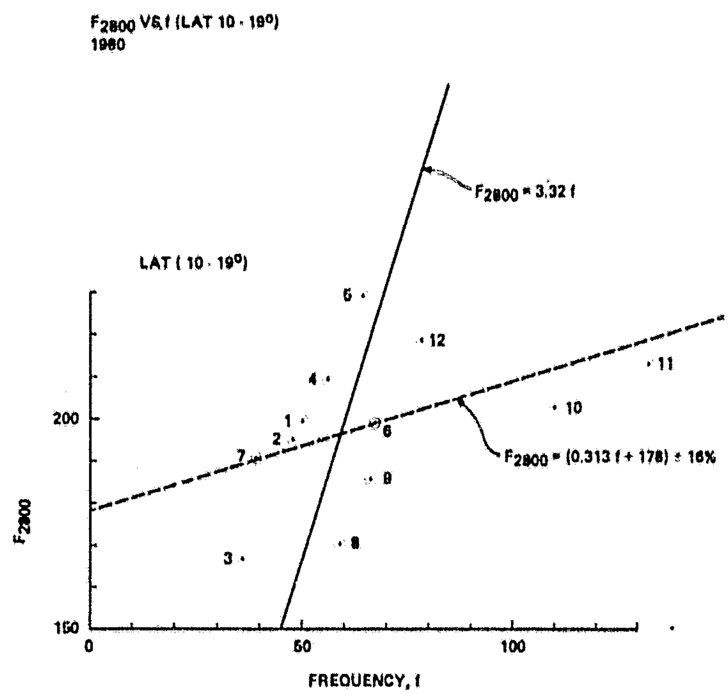

Figure 10. F_{2800} versus frequency (f) for latitudes 10-19 degrees. Solid line is mean-slope line and dashed line is visual approximation to data.

G. Importance

The ratio $F_{2800}/\overline{IMP}$ for all study flares equals $66.577 \begin{smallmatrix}+11.698 \\ -13.724\end{smallmatrix}$; therefore,

$$F_{2800} = 66.577\ \overline{IMP} \pm 13.7\ \overline{IMP} \quad , \tag{26}$$

based on Table 4, or

$$\overline{IMP} = 0.015\ F_{2800} \pm 0.004\ F_{2800} \quad , \tag{27}$$

since $\overline{IMP}/F_{2800} = 0.015 \begin{smallmatrix}+0.004 \\ -0.002\end{smallmatrix}$. Table 9 identifies the frequency of occurrence (f) and percent occurrence (p) for the parameter IMP for several selected Hα importance groups by month and year. (Table 9 is limited to subflares, class 1 and 2B events, due to sparseness of class 2, 3, and 4 events.) Also given in the monthly F_{2800} value and the total number of study flare occurrences (N). F_{2800}/f values for a few selected Hα importance classes are:

$$\left.\begin{array}{ll}
(SF) & F_{2800}/f = 13.210 \begin{smallmatrix}+10.640 \\ -7.264\end{smallmatrix} \\
(SN) & F_{2800}/f = 5.582 \begin{smallmatrix}+3.958 \\ -1.893\end{smallmatrix} \\
(SB) & F_{2800}/f = 9.986 \begin{smallmatrix}+7.750 \\ -5.845\end{smallmatrix} \\
(1N) & F_{2800}/f = 25.306 \begin{smallmatrix}+31.461 \\ -16.414\end{smallmatrix} \\
\text{and} & \\
(1B) & F_{2800}/f = 16.099 \begin{smallmatrix}+23.821 \\ -10.483\end{smallmatrix}
\end{array}\right\} \quad , \tag{28}$$

using all data points, and

$$\left.\begin{array}{ll}
(SF) & F_{2800}/f = 12.872 \begin{smallmatrix}+6.638 \\ -4.900\end{smallmatrix} \\
(SN) & F_{2800}/f = 5.376 \begin{smallmatrix}+1.496 \\ -1.398\end{smallmatrix} \\
(SB) & F_{2800}/f = 9.796 \begin{smallmatrix}+6.837 \\ -4.946\end{smallmatrix}
\end{array}\right. \tag{29}$$

TABLE 9. FREQUENCY (f) AND PERCENT (p) VALUES PER MONTH PER SELECTED Hα IMPORTANCE CLASSES

	IMPORTANCE(IMP), CLASS															
		SF		SN		SB		1F		1N		1B		2B		
	N	f	p	f	p	f	p	f	p	f	p	f	p	f	p	F_{2800}
JAN	69	13	18.8	32	46.4	12	17.4	0	0.0	6	8.7	5	7.2	1	1.4	199.6
FEB	73	10	13.7	30	41.1	11	15.1	0	0.0	5	6.8	12	16.4	2	2.7	195.1
MAR	96	28	29.2	36	37.5	13	13.5	1	1.0	9	9.4	8	8.3	0	0.0	166.5
APR	104	14	13.5	47	45.2	13	12.5	4	3.8	10	9.6	14	13.5	2	1.9	209.3
MAY	112	17	15.2	38	33.9	23	20.5	1	0.9	16	14.3	12	10.7	3	2.7	220.1
JUN	120	25	20.8	29	24.2	39	32.5	1	0.8	7	5.8	15	12.5	2	1.7	199.3
JUL	79	8	10.1	20	25.3	20	25.3	1	1.3	7	8.9	20	25.3	3	3.8	190.8
AUG	87	10	11.5	31	35.6	25	28.7	1	1.1	3	3.4	13	14.9	4	4.6	170.3
SEP	104	23	22.1	37	35.6	21	20.2	2	1.9	6	5.8	13	12.5	2	1.9	185.9
OCT	168	19	11.3	55	32.7	49	29.2	1	0.6	19	11.3	19	11.3	4	2.4	202.9
NOV	192	17	8.9	47	24.5	44	22.9	4	2.1	24	12.5	38	19.8	15	7.8	213.4
DEC	145	24	16.6	55	37.9	30	20.7	1	0.7	15	10.3	14	9.7	5	3.4	219.8
YEAR	1349	208	15.4	457	33.9	300	22.2	17	1.3	127	9.4	183	13.6	43	3.2	

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(1N) $$F_{2800}/f = 23.801 \begin{matrix} +15.219 \\ -13.122 \end{matrix}$$

and (29) (Conc.)

(1B) $$F_{2800}/f = 14.765 \begin{matrix} +6.048 \\ -5.225 \end{matrix}$$,

using all ratios, except the highest and lowest values. Figure 11 illustrates F_{2800} versus f for SN flares, using all data points. As before, the number beside each data point represents month. The solid line is the mean-slope line, and the dashed line is a visual approximation to the data points (assuming an F_{2800} variation of ±16 percent).

Table 10 identifies f and p values by month and year for a different subset of the parameter IMP; namely, by relative brightness grouping (F, N, B) and areal grouping (S,1). Also given is the monthly F_{2800} value and the total number of study flare occurrences (#). F_{2800}/f values for these groupings are:

(S) $$F_{2800}/f = 2.657 \begin{matrix} +1.318 \\ -1.007 \end{matrix}$$

(1) $$F_{2800}/f = 8.694 \begin{matrix} +9.451 \\ -5.610 \end{matrix}$$ (30)

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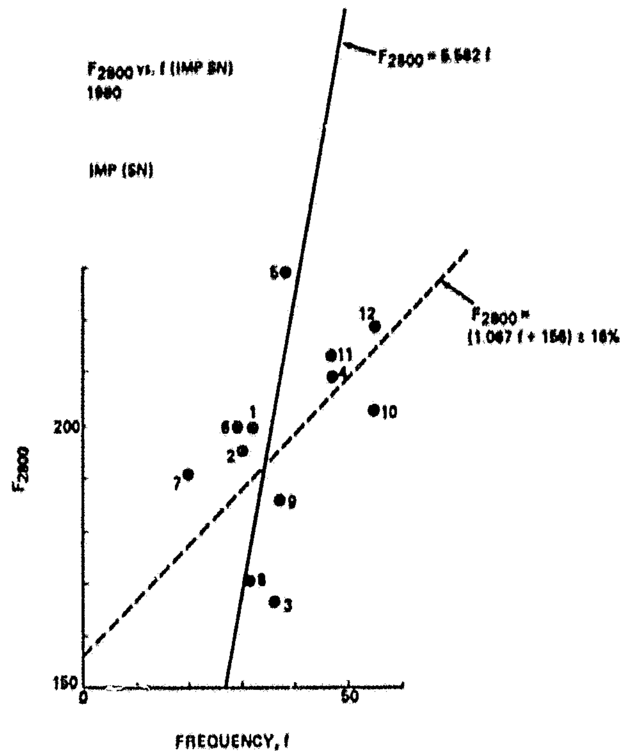

Figure 11. F_{2800} versus frequency (f) for importance class SN. Solid line is mean-slope line and dashed line is visual approximation to data.

TABLE 10. FREQUENCY (f) AND PERCENT (p) VALUES PER MONTH PER RELATIVE BRIGHTNESS AND AREA GROUPING

		IMPORTANCE(IMP), MAJOR CLASS												
		S		1		2		F		N		B		
	#	f	p	f	p	f	p	f	p	f	p	f	p	F_{2800}
JAN	69	57	82.6	11	15.9	1	1.4	13	18.8	38	55.1	18	26.1	199.6
FEB	73	51	69.9	17	23.3	5	6.8	11	15.1	37	50.7	25	34.2	195.1
MAR	96	77	80.2	18	18.8	1	1.0	29	30.2	46	47.9	21	21.9	166.5
APR	104	74	71.2	28	26.9	2	1.9	18	17.3	57	54.8	29	27.9	209.3
MAY	112	78	69.6	29	25.9	5	4.5	18	16.1	56	50.0	38	33.9	229.1
JUN	120	93	77.5	23	19.2	4	3.3	26	21.7	38	31.7	56	46.7	199.3
JUL	79	48	60.8	28	35.4	3	3.8	9	11.4	27	34.2	43	54.4	190.8
AUG	87	66	75.9	17	19.5	4	4.6	11	12.6	34	39.1	42	48.3	170.3
SEP	104	81	77.9	21	20.2	2	1.9	25	24.0	43	41.3	36	34.6	185.9
OCT	168	123	73.2	39	23.2	5	3.0	20	11.9	75	44.6	73	43.5	202.9
NOV	192	108	56.3	66	34.4	18	9.4	22	11.5	73	38.0	97	50.5	213.4
DEC	145	109	75.2	30	20.7	6	4.1	25	17.2	71	49.0	49	33.8	218.8
YEAR	1349	965	71.5	327	24.2	56	4.2	227	16.8	595	44.1	527	39.1	

$$\left.\begin{array}{ll}
\text{(F)} & F_{2800}/f = 11.964\,^{+9.236}_{-6.223} \\[2ex]
\text{(N)} & F_{2800}/f = 4.355\,^{+2.712}_{-1.650} \\[2ex]
\text{and} & \\
\text{(B)} & F_{2800}/f = 5.561\,^{+5.528}_{-3.361}
\end{array}\right\} , \qquad \begin{array}{c}(30)\\ \text{(Conc.)}\end{array}$$

using all data points, and

$$\left.\begin{array}{ll}
\text{(S)} & F_{2800}/f = 2.626\,^{+1.199}_{-0.650} \\[2ex]
\text{(1)} & F_{2800}/f = 8.295\,^{+3.181}_{-3.092} \\[2ex]
\text{(F)} & F_{2800}/f = 11.663\,^{+6.073}_{-4.227} \\[2ex]
\text{(N)} & F_{2800}/f = 4.249\,^{+1.024}_{-1.326} \\[2ex]
\text{and} & \\
\text{(B)} & F_{2800}/f = 5.344\,^{+2.585}_{-2.565}
\end{array}\right\} , \qquad (31)$$

using all data points, except the highest and lowest values.

Figure 12 depicts F_{2800} versus f for class 1 flares ($\odot$) and S flares ($\triangle$). Again, the solid lines represent the mean-slope lines, based on the ratio of F_{2800} to f, except that in these instances they exclude the highest and lowest ratio values. One observes that number of class 1 Hα importance flares is better correlated with F_{2800} than is number of subflares. Excluding the November data point, which is substantially high, the dashed line represents a visual approximation of F_{2800} versus f for class 1 flares.

Figures 13 and 14 are histograms of areal importance, showing the variation of f and p (respectively) with month of year for 1980, based on Table 10. Also shown is the F_{2800} variation. Notice that, while the trend of number of S flares increased during the year, the trend of p for S flares was downward. On the other hand, the trend of f and p for class 1 and class 2 flares was upward. Thus, larger areal flares were more frequent during periods of high F_{2800} and during the latter part of 1980, rather than earlier in the year.

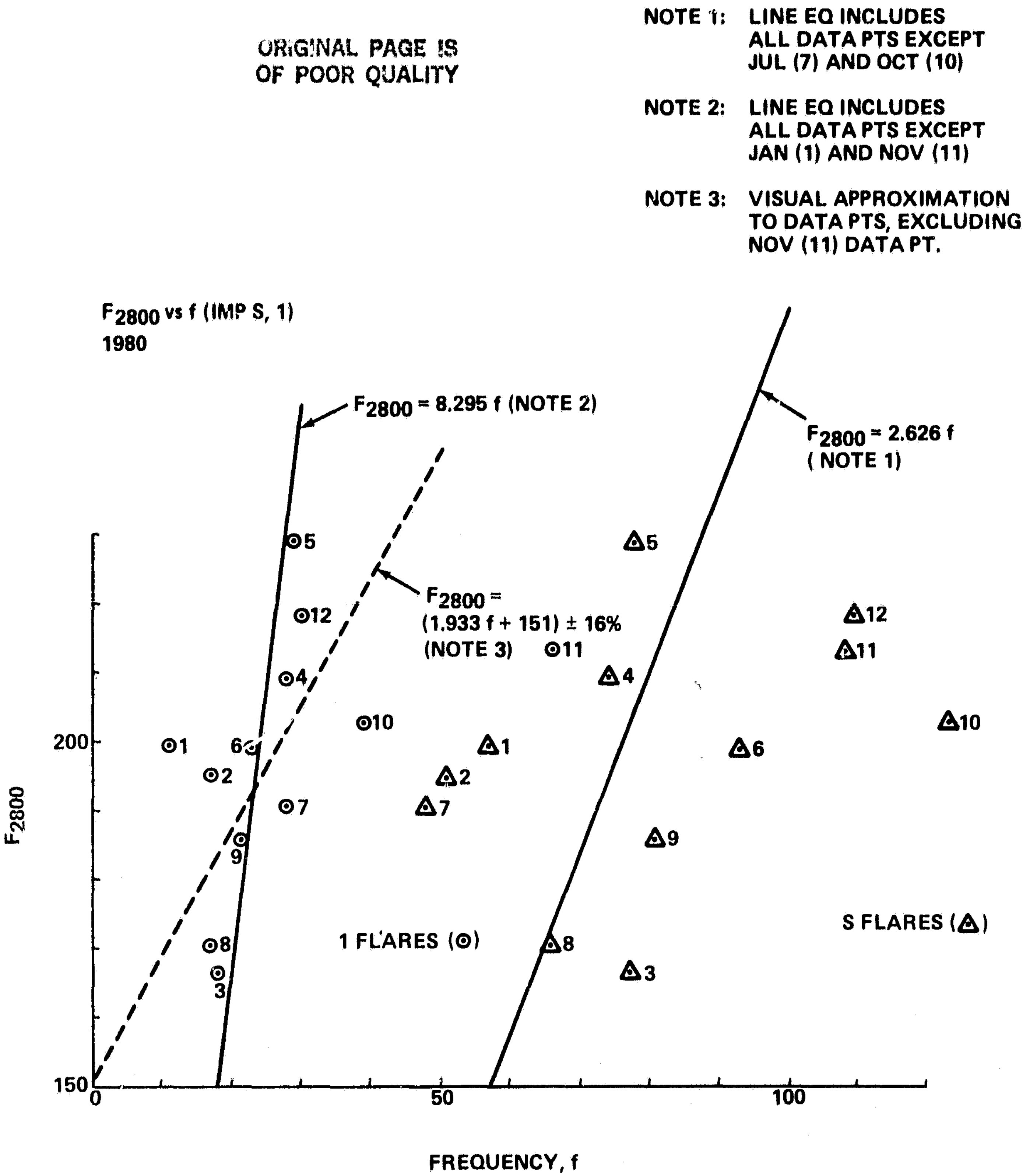

Figure 12. F_{2800} versus frequency (f) for importance classes S and 1. Solid line is mean-slope line and dashed line is visual approximation to data.

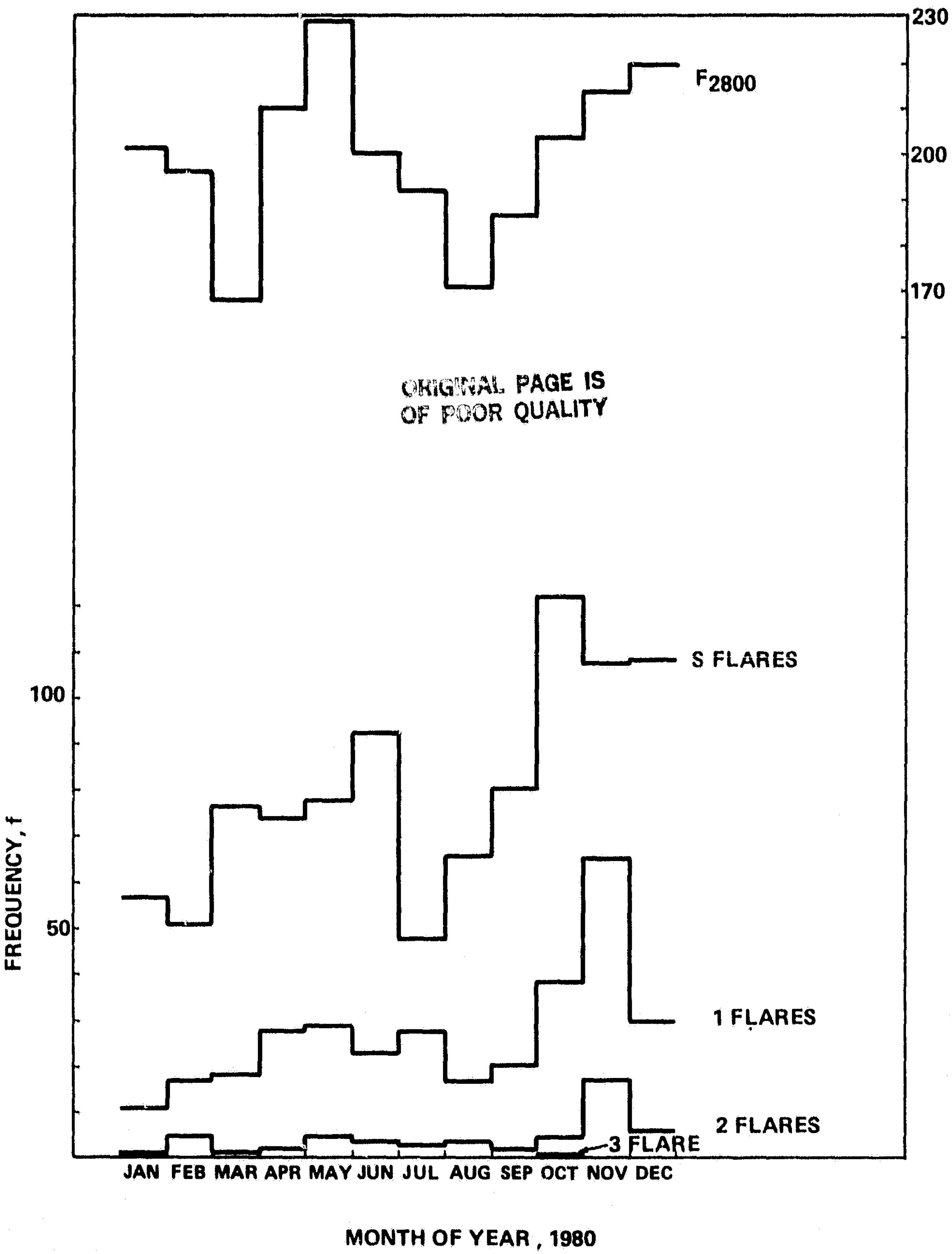

Figure 13. Variation of frequency (f) for importance classes S, 1, 2, and 3 versus month of year. Also, F_{2800} versus month of year.

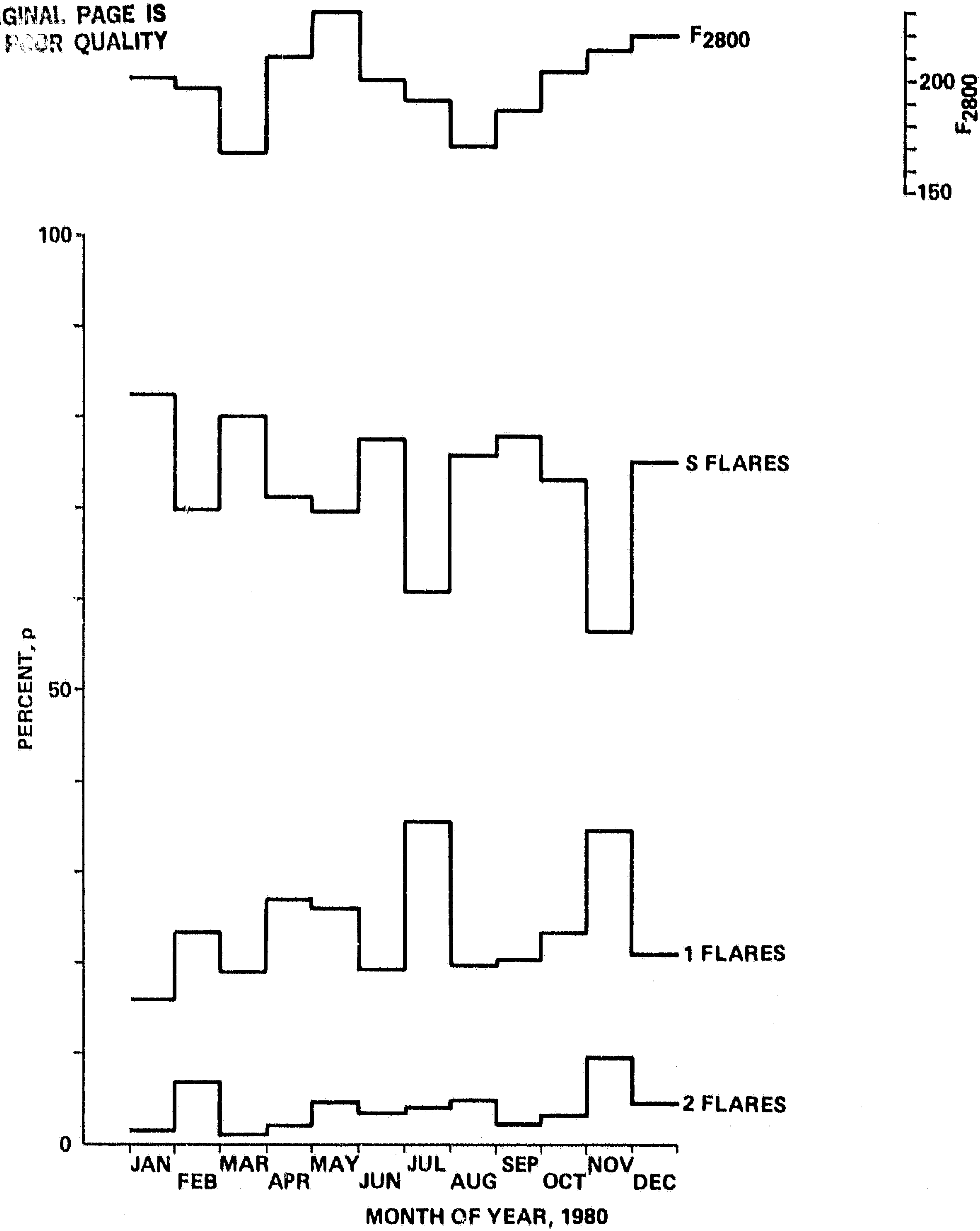

Figure 14. Variation of monthly percent (p) for importance classes S, 1, and 2 versus month of year. Also, F_{2800} versus month of year.

Figures 15 and 16 are histograms of relative brightness, showing the variation of f and p (respectively) with month of year for 1980, based on Table 10. Also shown is the F_{2800} variation. The trend of both f and p for B flares was upward during 1980. Hence, the brighter Hα flares occurred during periods of high F_{2800}, particularly late 1980. It is apparent, then, that number, size, and brightness of Hα flares were greater late in 1980 than in early 1980, implying that peak flare activity occurred subsequent to solar maximum, as adjudged by sunspot number.

II. X-Ray

The ratio $F_{2800}/\overline{XR}$ for all study flares equals $2.694 \times 10^4 \begin{smallmatrix} +3.480 \times 10^4 \\ -1.658 \times 10^4 \end{smallmatrix}$; therefore,

$$F_{2800} = 2.694 \times 10^4 \, \overline{XR} \pm 3.5 \times 10^4 \, \overline{XR} \quad , \tag{32}$$

based on Table 4 and using all data points. If the highest and lowest ratio values are removed, then

$$F_{2800} = 2.512 \times 10^4 \, \overline{XR} \pm 1.6 \times 10^4 \, \overline{XR} \quad , \tag{33}$$

since $F_{2800}/\overline{XR} = 2.512 \times 10^4 \begin{smallmatrix} +1.559 \times 10^4 \\ -1.196 \times 10^4 \end{smallmatrix}$. Thus

$$\overline{XR} = 4.48 \times 10^{-5} \, F_{2800} \pm 3.12 \times 10^{-5} \, F_{2800} \quad , \tag{34}$$

since $\overline{XR}/F_{2800} = 4.48 \times 10^{-5} \begin{smallmatrix} +3.12 \times 10^{-5} \\ -2.02 \times 10^{-5} \end{smallmatrix}$. Table 11 identifies the frequency of occurrence (f) and percent occurrence (p) for the parameter XR for several selected X-ray class groupings by month and year. Also given is the monthly F_{2800} value and the total number of study flare occurrences (N). F_{2800}/f values for several selected X-ray class groupings are:

$$\left.\begin{array}{ll} (C0\text{-}C5) & F_{2300}/f = 3.158 \begin{smallmatrix} +2.237 \\ -1.279 \end{smallmatrix} \\[2ex] (C6\text{-}C9) & F_{2800}/f = 13.454 \begin{smallmatrix} +17.529 \\ -\ 7.526 \end{smallmatrix} \\[2ex] (M1\text{-}M5) & F_{2800}/f = 12.658 \begin{smallmatrix} +15.092 \\ -\ 9.652 \end{smallmatrix} \end{array}\right\} \tag{35}$$

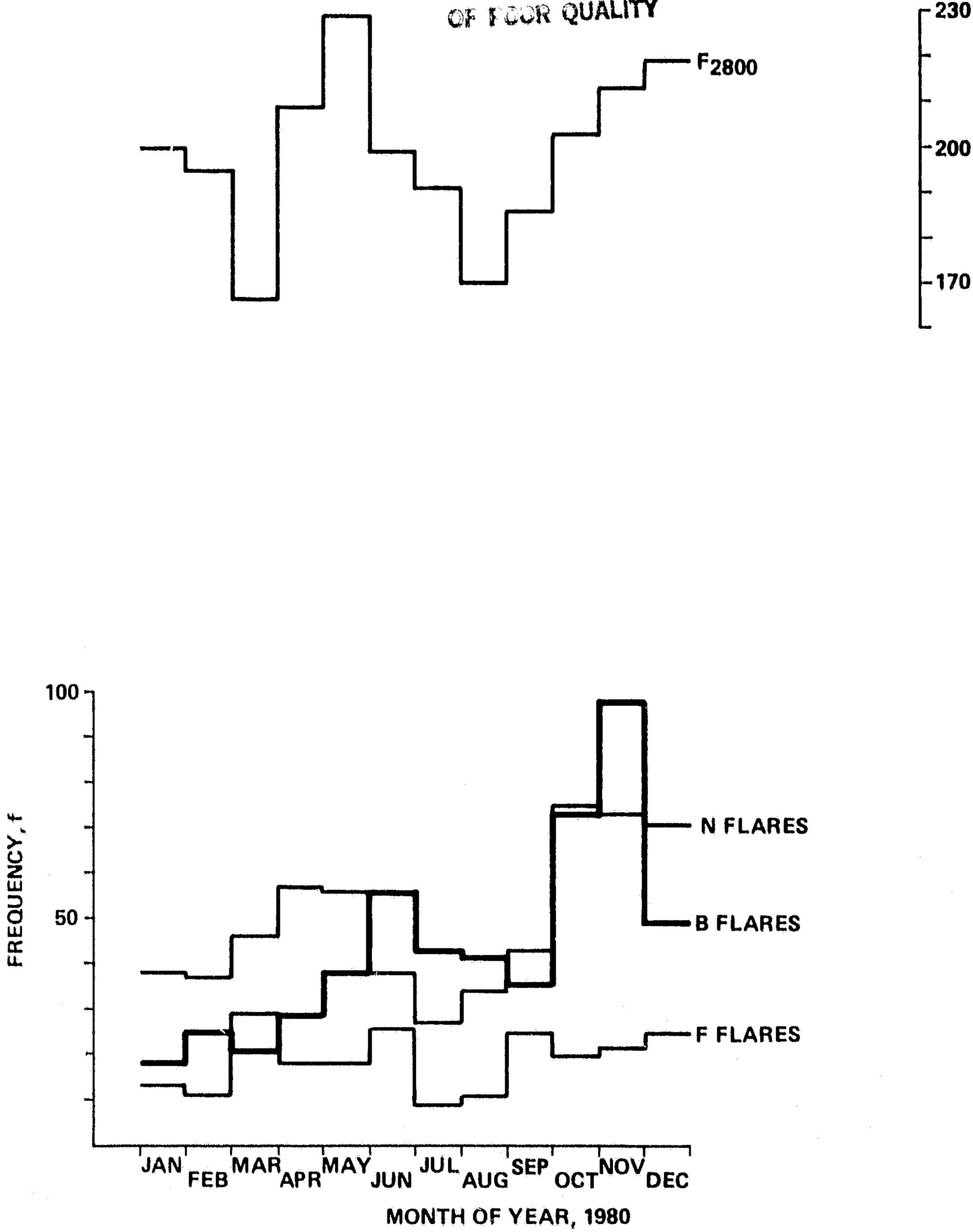

Figure 15. Variation of frequency (f) for relative brightness groups faint (F), normal (N), and bright (B) versus month of year. Also, F_{2800} versus month of year.

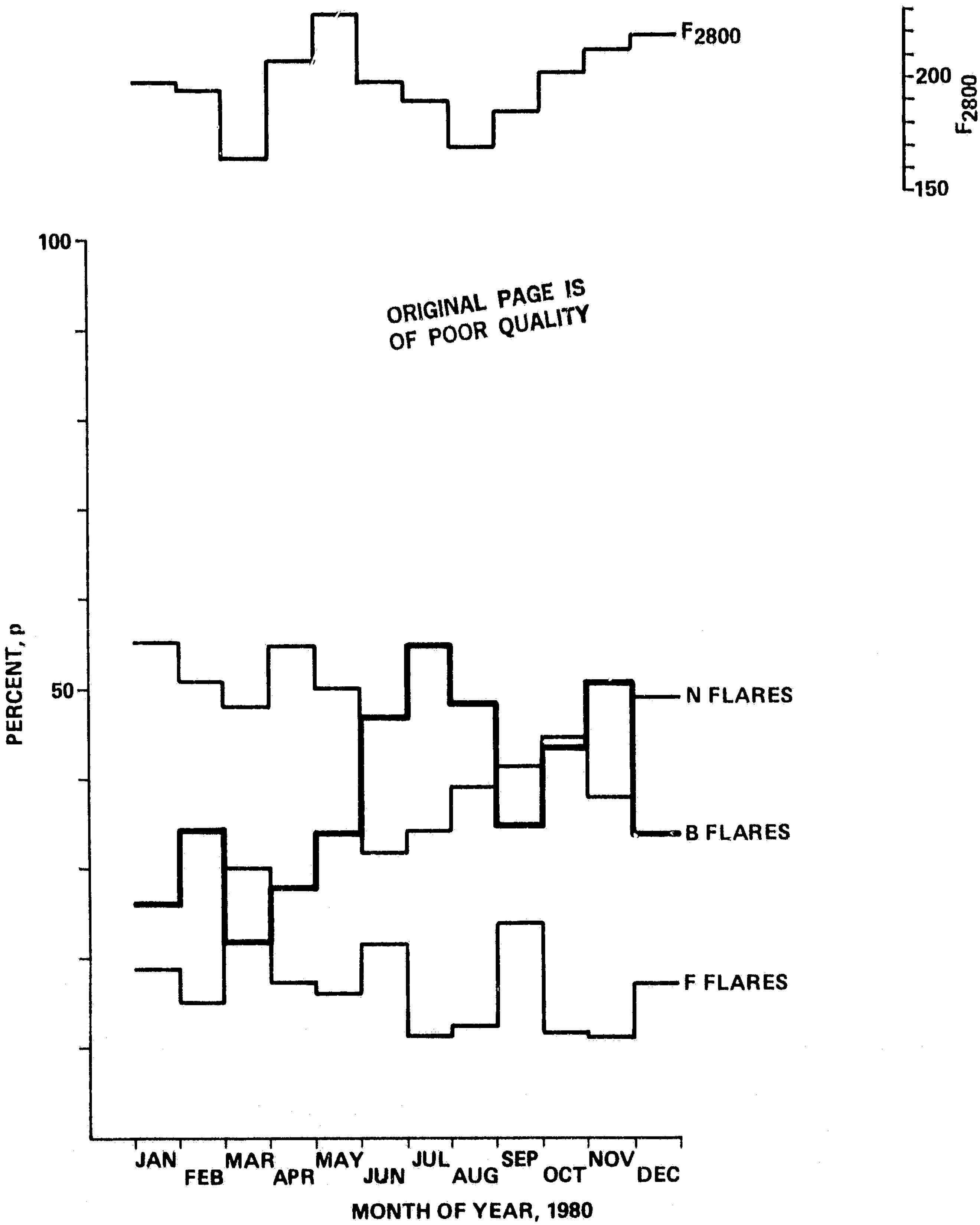

Figure 16. Variation of monthly percent (p) for relative brightness groups F, N, and B versus month of year. Also, F_{2800} versus month of year.

TABLE 11. FREQUENCY (f) AND PERCENT (p) VALUES PER MONTH PER X-RAY CLASS AND SELECTED X-RAY CLASS GROUPINGS

		X-RAY (XR), CLASS GROUPINGS																					
		C0-C5		C6-C9		M1-M5		M6-M9		≥X1		>M5		≥M1		>C5		C		M		X	
	N	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	f	p	F_{2800}
JAN	69	37	53.6	16	23.2	12	17.4	4	5.8	0	0.0	4	5.8	16	23.2	32	46.4	53	76.8	16	23.2	0	0.0	199.6
FEB	73	47	64.4	13	17.8	13	17.8	0	0.0	0	0.0	0	0.0	13	17.8	26	35.2	60	82.2	13	17.8	0	0.0	195.1
MAR	96	80	83.3	10	10.4	6	6.3	0	0.0	0	0.0	0	0.0	6	6.3	16	16.7	90	93.8	6	6.3	0	0.0	166.5
APR	104	61	58.7	21	20.2	20	19.2	2	1.9	0	0.0	2	1.9	22	21.2	43	41.3	82	78.8	22	21.2	0	0.0	209.3
MAY	112	71	63.4	12	10.7	24	21.4	2	1.8	3	2.7	5	4.5	29	25.9	41	36.6	83	74.1	26	23.2	3	2.7	229.1
JUN	120	63	52.5	26	21.7	25	20.8	4	3.3	2	1.7	6	5.0	31	25.8	57	47.5	89	74.2	29	24.2	2	1.7	199.3
JUL	79	42	53.2	15	19.0	17	21.5	2	2.5	3	3.8	5	6.3	22	27.8	37	46.8	57	72.2	19	24.1	3	3.8	190.8
AUG	87	62	71.3	13	14.9	11	12.6	1	1.1	0	0.0	1	1.1	12	13.8	25	28.7	75	86.2	12	13.8	0	0.0	170.3
SEP	104	86	82.7	6	5.8	10	9.6	2	1.9	0	0.0	2	1.9	12	11.5	18	17.3	92	88.5	12	11.5	0	0.0	185.9
OCT	168	108	64.3	32	19.0	25	14.9	1	0.6	2	1.2	3	1.8	28	16.7	60	35.7	140	83.3	26	15.5	2	1.2	202.9
NOV	192	74	38.5	36	18.8	71	37.0	6	2.6	5	2.6	11	5.7	82	42.7	118	61.5	110	57.3	77	40.1	5	2.6	213.4
DEC	145	98	67.6	19	13.1	27	18.6	1	0.7	0	0.0	1	0.7	28	19.3	47	32.4	117	80.7	28	19.3	0	0.0	218.8
YEAR	1349	829	61.5	219	16.2	261	19.3	25	1.9	15	1.1	40	3.0	301	22.3	520	38.5	1048	77.7	286	21.2	15	1.1	

$$
\left.
\begin{aligned}
&(XR \geq M1) && F_{2800}/f = 11.258 \begin{smallmatrix} +16.492 \\ -\ 8.656 \end{smallmatrix} \\
&(XR > C5) && F_{2800}/f = 5.853 \begin{smallmatrix} +4.553 \\ -4.045 \end{smallmatrix} \\
&(C) && F_{2800}/f = 2.443 \begin{smallmatrix} +1.323 \\ -0.994 \end{smallmatrix} \\
\text{and} & \\
&(M) && F_{2800}/f = 11.545 \begin{smallmatrix} +16.205 \\ -\ 8.774 \end{smallmatrix}
\end{aligned}
\right\} , \qquad \begin{matrix} (35) \\ (\text{Conc.}) \end{matrix}
$$

using all data points. Removing the highest and lowest ratio values yields:

$$
\left.
\begin{aligned}
&(C0\text{-}C5) && F_{2800}/f = 3.062 \begin{smallmatrix} +1.481 \\ -0.981 \end{smallmatrix} \\
&(C6\text{-}C9) && F_{2800}/f = 12.453 \begin{smallmatrix} +6.639 \\ -6.112 \end{smallmatrix} \\
&(M1\text{-}M5) && F_{2800}/f = 12.114 \begin{smallmatrix} +6.476 \\ -4.142 \end{smallmatrix} \\
&(XR \geq M1) && F_{2800}/f = 10.474 \begin{smallmatrix} +5.018 \\ -3.228 \end{smallmatrix} \\
&(XR > C5) && F_{2800}/f = 5.803 \begin{smallmatrix} +4.525 \\ -4.421 \end{smallmatrix} \\
&(C) && F_{2800}/f = 2.410 \begin{smallmatrix} +0.937 \\ -0.560 \end{smallmatrix} \\
\text{and} & \\
&(M) && F_{2800}/f = 10.802 \begin{smallmatrix} +4.690 \\ -3.930 \end{smallmatrix}
\end{aligned}
\right\} . \qquad (36)
$$

Figures 17 through 19 depict F_{2800} versus f for M and C X-ray flares, flares of X-ray class $>$C5, and flares of X-ray class $\geq$M1, respectively. In these figures, the number beside each data point refers to the month of year, as before. Also, the solid lines represent the mean-slope lines based on the ratio of F_{2800} to f, excluding the highest and lowest ratio values. The dashed lines are visual approximations to the data, excluding the NOV data point. The figures suggest a fairly good correlation between F_{2800} and number of flares of specific X-ray class grouping, particularly for M X-ray flares and flares of X-ray class $\geq$M1.

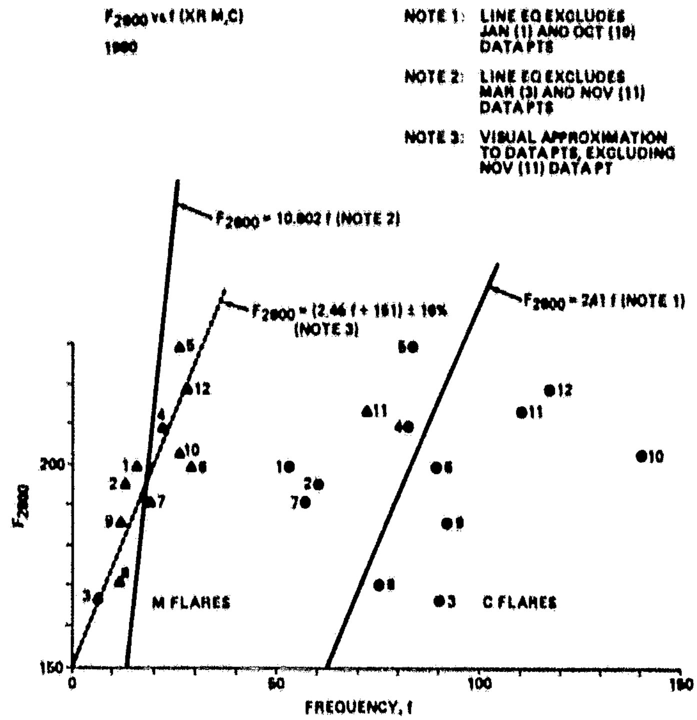

Figure 17. F_{2800} versus frequency (f) for X-ray classes M and C. Solid lines are mean-slope lines and dashed line is visual approximation to data.

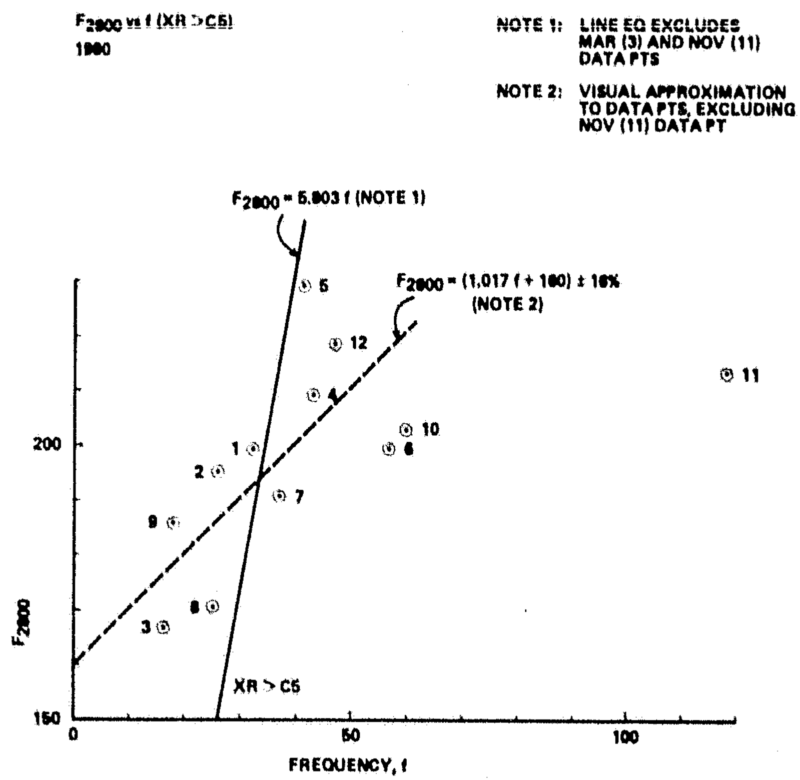

Figure 18. F_{2800} versus frequency (f) for X-ray grouping (XR > C5). Solid line is mean-slope line and dashed line is visual approximation to data.

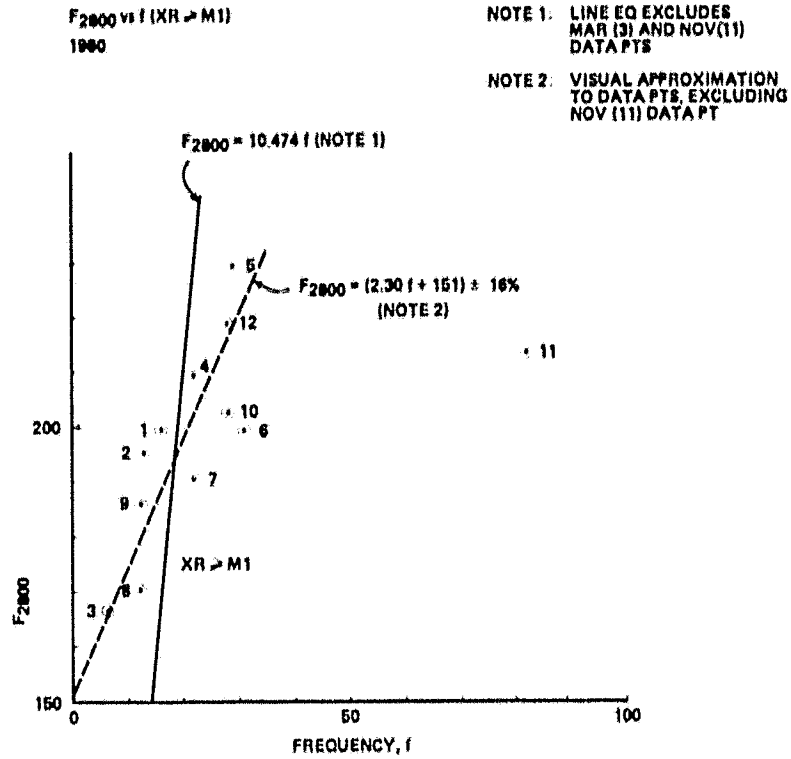

Figure 19. F_{2800} versus frequency (f) for X-ray grouping (XR ≥ M1). Solid line is mean-slope line and dashed line is visual approximation to data.

Figures 20 and 21 are histograms showing the variation of f and p (respectively) with month of year 1980, based on Table 11. Also shown is the F_{2800} variation. While M and C flares increased in number during the year, the monthly percent occurrence for C flares decreased and was markedly depressed in November. (This may be due to the rather high threshold (about M1) which was employed during part of November when numerous flares were occurring from a particular active region; thus, many C flares may not have been counted.) The monthly percent occurrence for M flares may have slightly increased during the year, being significantly enhanced in November. Thus, X-ray flares were more numerous late in 1980 than in early 1980, and they appeared to be much more energetic.

IV. CONCLUSIONS

This study, the second of a three-part investigation, has reviewed additional aspects of the 1980 solar flares, particularly looking at solar cycle activity effects. It has been noted that during 1980: (1) 1349 study flares were a subset of 5053 reported flares with known positions; (2) R_z and F_{2800} were rather strictly related; (3) daily flare rate appeared to be associated with F_{2800}; (4) mean relative brightness of flares was associated with mean areal extent; (5) R_z varied by 18 percent and F_{2800} by 16 percent; (6) mean rise times, decay times, and durations all increased with month of year; (7) mean latitude decreased with month of year; (8) larger,

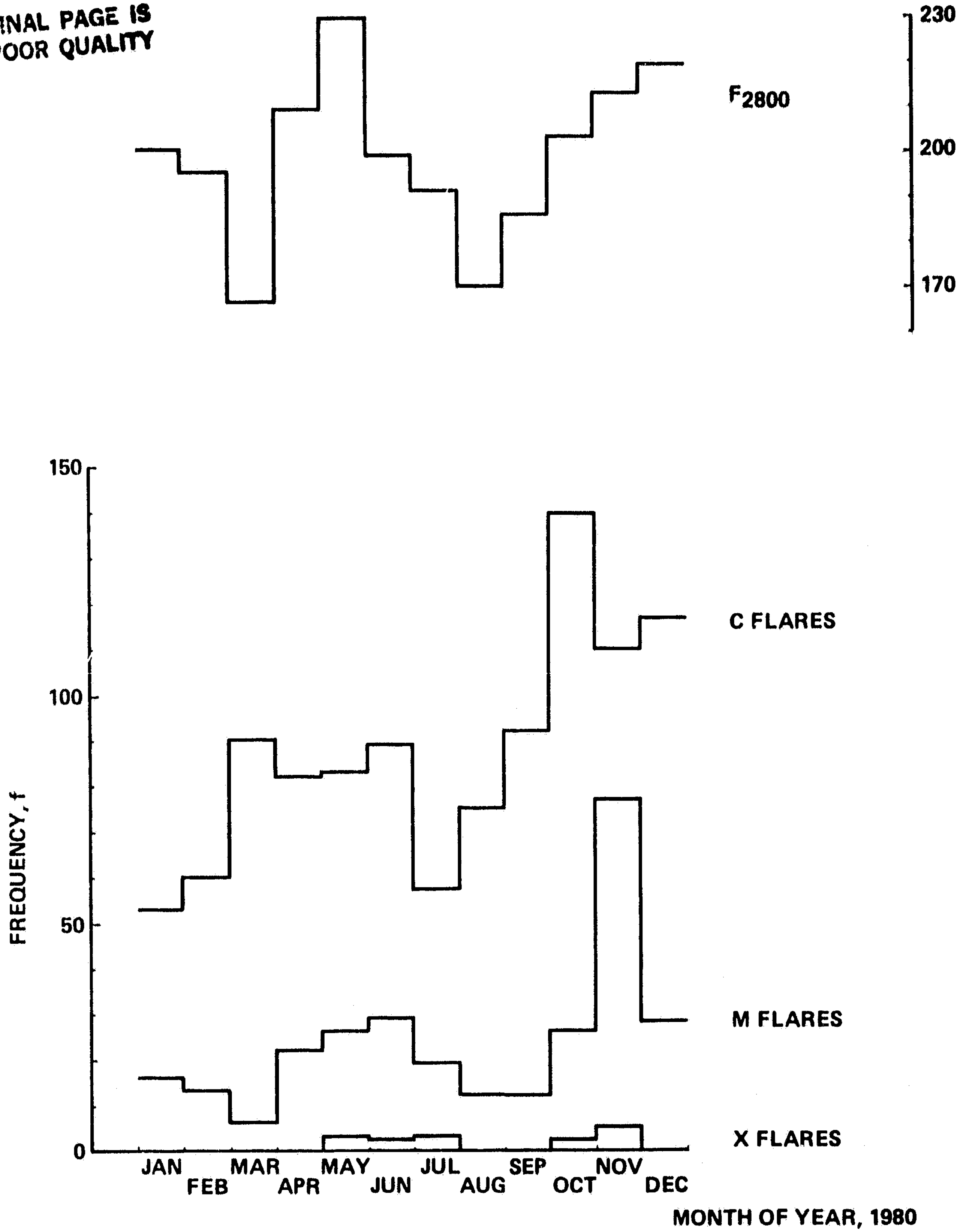

Figure 20. Variation of frequency (f) for X-ray classes C, M, and X versus month of year. Also, F_{2800} versus month of year.

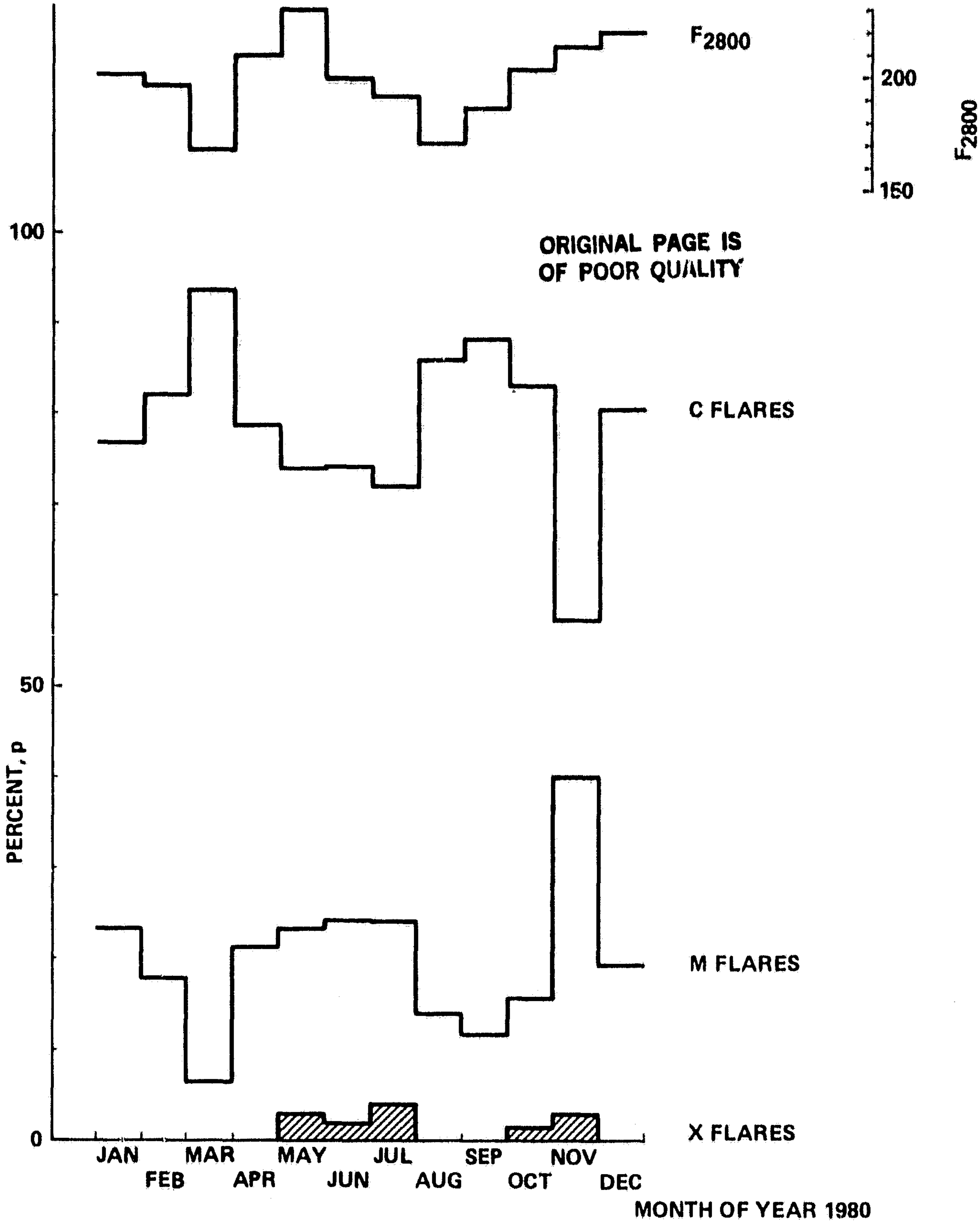

Figure 21. Variation of monthly percent (p) for X-ray classes C, M, and X versus month of year. Also, F_{2800} versus month of year.

brighter, and more energetic flares were more numerous late in the year, subsequent to solar maximum; (9) mean rise time, decay time, and duration appeared to be related to F_{2800}; and (10) number of Hα importance class 1 flares and number of X-ray class M (and M + X) flares were both correlated with F_{2800}.

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APPROVAL

STATISTICAL ASPECTS OF THE 1980 SOLAR FLARES: II. SOLAR CYCLE ACTIVITY RELATIONSHIPS AND ADDITIONAL REMARKS

By Robert M. Wilson

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

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