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PRIME MINITRACK AND BAKER-NUNN ORBITS OF SATELLITE 1959α_1 (VANGUARD II)

by Hans G. Hertz

Goddard Space Flight Center

Greenbelt, Md.

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ABSTRACT 21100

Concurrent data necessary for making a comparison study of the accuracies of Prime Minitrack and Baker-Nunn observations of Satellite 1959α_1 (Vanguard II) are presented in this report. In all, 244 Prime Minitrack and 187 Baker-Nunn observations are available which were made over a 26-day period while the satellite's transmitter was operating. Prime Minitrack observations were possible only during transmitter operation. Data included here are comprised of Prime Minitrack and Baker-Nunn observations made concurrently.

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CONTENTS

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INTRODUCTION

Satellite 1959α_1 (Vanguard II) was launched 17 February 1959. The transmitter was operating for 26 days through 15 March 1959. Therefore Prime Minitrack observations could be obtained during this period. It was suggested to the author that a comparison of the accuracies of Prime Minitrack and Baker-Nunn observations of a satellite would be interesting. In the present report the data necessary for such a study are presented. The observations used are those made in the period where both types of observations were possible. There were 244 Prime Minitrack and 187 Baker-Nunn observations available which were made during this 26-day period.

DISCUSSION OF DATA

For each of the two types, twelve orbits were determined. Their epochs were at 2-day intervals from 19 February 1959 through 13 March 1959 inclusive. For each orbit, the values of the parameters $S_1, S_2, \ldots S_6, S_{18}$ were determined by differential corrections. Here $S_1, S_2, \ldots S_6$ are the values of the constant terms in the expressions for the osculating elements $a, e, I, \Omega, \omega, M$ as given by Brouwer (Reference 1). The quantity S_{18} is the coefficient of the term $S_{18}\tau^2$, τ in units of 100 hours from the epoch, added to Brouwer's expression for the mean anomaly. In each differential correction all observations within 72 hours of the epoch have been used provided they generated residuals, $\cos\delta\,\Delta\alpha$ and $\Delta\delta$, not larger than 0°10.

The earth parameters used in these solutions are shown in Table 1. The parameters are the equatorial radius R of the earth and the constants k, k_2, A_{30}, k_4, A_{50}. The last four constants occur in the expression,

$$U = \frac{\mu}{r}\left[1 + \frac{k_2}{r^2}\left(1 - 3\sin^2\beta\right) + \frac{A_{30}}{r^3}\left(-\frac{3}{2}\sin\beta + \frac{5}{2}\sin^3\beta\right)\right.$$
$$\left. + \frac{k_4}{r^4}\left(1 - 10\sin^2\beta + \frac{35}{3}\sin^4\beta\right) + \frac{A_{50}}{r^5}\left(\frac{15}{8}\sin\beta - \frac{35}{4}\sin^3\beta + \frac{63}{8}\sin^5\beta\right)\right]$$

used by Brouwer. The constant k is given by $\mu = k^2$.

Several iterations were made. The orbits finally adopted as those based on the Prime Minitrack observations are called briefly Prime Minitrack orbits (PM orbits) and received the numbers 603 through 614. The numbers for the Baker-Nunn orbits (BN orbits) are 631, 616 through 625, and 632. The relationship between these numbers and the epochs is shown in Table 2.

The resulting values for the parameters s_1, s_2, ... s_6, s_{18} are shown in Table 3. There are twelve pairs of lines, one pair each belonging to one of the twelve epochs. The first line in each pair gives the results for the PM orbit, the second for the BN orbit. The orbit numbers given serve to identify the epochs.

Table 4 gives the probable errors for the s_i obtained. They are arranged in eight pairs of columns. The first column of each pair belongs to PM orbits, the second to BN orbits. One line corresponds to a PM and the corresponding BN orbit for the same epoch. The numbers of this PM and BN orbit are given in the first two columns of the table.

The residuals for the PM observations are shown in Table 5 and those for the BN observations in Table 6. Except for the observations near the beginning and end of the 26-day period every PM or every BN observation appears in three orbits. The PM observations have received serial numbers starting with 1. The numbers of the BN observations are those assigned by the Smithsonian Astrophysical Observatory, without the designation of the year. The observations being precision-reduced observations, all numbers begin with a '7'.

Table 7 gives information as to the accuracy of the representation of the observations by the adopted parameters. The weights given are those found in an iterative process in such a way that they are consistent with the probable errors computed from the residuals. This table shows that the rejection limit of $0^\circ\!.10$ referred to on page 1 was too large. Better results would be achieved if it were lowered or if the rejection limit were made dependent on the distribution of errors.

By making additional runs the condition that no observations with residuals of more than 3 times the probable error be included was approximately met.

Table 8 shows the differences Δs_i of the values of the s_i obtained for a PM orbit and the corresponding BN orbit belonging to the same epoch. The differences are given in the sense PM-BN.

The s_i are plotted versus the time in Figures 1a-g for the Prime Minitrack orbits and in Figures 2a-g for the Baker-Nunn orbits. If no drag or other non-gravitational forces were present s_1, s_2, s_3 would be constant, s_4, s_5, s_6 would be linear functions of the time, and s_{18} would be zero. The probable errors in Table 4 and Figures 1a-f, 2a-f, and the non-vanishing of s_{18} indicate that there are deviations from gravitational behavior.

CONCLUSION

Additional aspects of this problem are of interest and will be investigated if sufficient time and resources are available. For instance, the dependence of the s_i on the time could be investigated.

An examination of the Δs_i as to significance could be made. It would also be interesting to examine the residuals of the Prime Minitrack observations with respect to the Baker-Nunn orbits and the residuals of the Baker-Nunn observations with respect to the Prime Minitrack orbits. Finally, the data provide information on the relative accuracy of the two types of observations.

ACKNOWLEDGMENTS

The computations on which the results of this report are based were carried out with a Differential Correction Program System and some additional programs. The original package was based on the satellite theory by H.G.L. Krause (Reference 2) and was programmed by Miss Elise R. Fisher of the Theoretical Division. Gratitude is also expressed to Mr. Cahill of the same division. The IBM Corporation under Dr. K. Deahl was utilized to substitute Brouwer's theory. Additional work was carried out under the supervision of Mr. A. Shapiro of GSFC. I thank Messrs. H. Bremer and R. Bryant of the Theoretical Division, Messers. R. Danek and J. Weld of the Data Systems Division, and others for help and advice received. Acknowledgement is also due the Smithsonian Astrophysical Observatory for providing the observations prior to publication.

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2. Krause, H. G. L., "Die säkularen und periodischen Störungen der Bahn eines künstlichen Erdsatelliten," *Proceedings of the 7th International Astronautical Congress*, (1956) p. 523.

Table 1

Earth Parameters Used in Solutions.

R	6.378165	megameters
k	4118.0870	degrees megameters $^{3/2}$ hour $^{-1}$
k_2	0.02201451	megameters^2
A_{30}	0.00059678	megameters^3
k_4	0.00111709	megameters^4
A_{50}	0.00000000	megameters^5

Table 2

Prime Minitrack and Baker-Nunn Orbits.

Epoch 0^h AT	J.D.	PM Orbit	BN Orbit
1959 February 19	2436618.5	603	631
21	6620.5	604	616
23	6622.5	605	617
25	6624.5	606	618
27	6626.5	607	619
March 1	6628.5	608	620
3	6630.5	609	621
5	6632.5	610	622
7	6634.5	611	623
9	6636.5	612	624
11	6638.5	613	625
13	6640.5	614	632

Table 3. Parameters of the Prime Minitrack and Baker-Nunn Orbits.

Orbit		S_1 Megameters	S_2	S_3	S_4	S_5	S_6	S_{18}
PM	603	8.3221388	0.16576178	32°.872299	177°.88713	142°.47921	76°.79972	+0°.300991
BN	631	8.3221335	0.16584522	32.874176	177.89304	142.48830	76.79066	+0.300444
PM	604	8.3220465	0.16577543	32.873182	170.89423	153.01337	34.92399	+0.291683
BN	616	8.3220482	0.16577952	32.873129	170.89609	153.00516	34.93060	+0.308462
PM	605	8.3219558	0.16576787	32.874733	163.89978	163.53023	353.19875	+0.291654
BN	617	8.3219551	0.16577466	32.872571	163.90085	163.52863	353.19961	+0.300984
PM	606	8.3218575	0.16574035	32.874485	156.90739	174.06878	311.58485	+0.342934
BN	618	8.3218515	0.16576406	32.874596	156.90589	174.04075	311.61272	+0.356665
PM	607	8.3217416	0.16572010	32.873771	149.91296	184.57046	270.16722	+0.392135
BN	619	8.3217394	0.16573206	32.874683	149.91135	184.56912	270.17781	+0.356052
PM	608	8.3216274	0.16569527	32.873218	142.92069	195.08509	228.91773	+0.346715
BN	620	8.3216305	0.16573413	32.874890	142.91888	195.08849	228.92077	+0.338364
PM	609	8.3215251	0.16570116	32.872239	135.92960	205.59692	187.83316	+0.313567
BN	621	8.3215263	0.16572163	32.875379	135.92625	205.60918	187.82031	+0.329167
PM	610	8.3214260	0.16568639	32.872083	128.93408	216.11123	146.89236	+0.329278
BN	622	8.3214295	0.16571999	32.876015	128.93162	216.13230	146.86993	+0.302446
PM	611	8.3213280	0.16566514	32.873338	121.93588	226.64131	106.08772	+0.311599
BN	623	8.3213248	0.16575409	32.876659	121.93894	226.63302	106.08707	+0.381831
PM	612	8.3212291	0.16565315	32.875728	114.92644	237.17748	65.42991	+0.318442
BN	624	8.3212210	0.16572557	32.877521	114.93593	237.13776	65.47480	+0.270705
PM	613	8.3211282	0.16567097	32.875879	107.92496	247.70289	24.92186	+0.347865
BN	625	8.3211260	0.16575377	32.879222	107.93073	247.69734	24.93162	+0.333624
PM	614	8.3210186	0.16567475	32.876008	100.92886	258.22770	344.56841	+0.366178
BN	632	8.3210180	0.16576193	32.879606	100.93520	258.21165	344.58977	+0.356728

Table 4

Probable Errors of the Parameters of the Prime Minitrack and Baker-Nunn Orbits.

PM	BN	Probable Error of													
Orbit		$S_1 \cdot 10^7$		$S_2 \cdot 10^8$		$S_3 \cdot 10^6$		$S_4 \cdot 10^5$		$S_5 \cdot 10^5$		$S_6 \cdot 10^5$		$S_{18} \cdot 10^6$	
603	631	19	83	839	3900	1911	33	322	25	779	576	669	714	10939	27677
604	616	5	1	564	167	787	152	195	70	367	123	282	108	3820	1156
605	617	4	1	551	130	625	194	152	81	344	113	276	97	2622	456
606	618	5	1	717	382	467	219	123	88	326	234	260	315	4632	1962
607	619	5	5	601	312	886	142	192	64	311	200	227	251	3538	3220
608	620	4	3	785	354	758	127	172	70	312	230	293	276	3272	1940
609	621	5	2	542	441	788	163	197	99	294	322	203	396	3796	2052
610	622	5	7	634	1210	757	191	180	170	314	619	240	711	4338	5687
611	623	4	11	567	1531	1094	131	270	161	408	561	334	522	3116	9095
612	624	5	4	614	711	713	309	233	202	332	707	190	707	1945	4643
613	625	4	3	756	217	545	124	237	49	341	226	189	245	2285	2321
614	632	3	2	589	309	583	207	209	59	291	270	139	313	2190	2313

Table 5

Residuals of Prime Minitrack Observations.

cos δ Δα (unit 0°0001)

Obs. \ Orbit	603	604	605	606	607	608	609	610	611	612	613	614
1	+ 446											
2	+ 323											
3	+ 249											
4	+ 78											
5	- 69											
6	- 53	- 207										
7	+ 79	+ 91										
8	+ 264	+ 131										
9	- 400	- 341										
10	+ 305	+ 125										
11	- 1878	- 1653										
12	+ 629	+ 526										
13	+ 1050	+ 1496										
14	- 141	- 314										
15	- 1485	- 1596										
16	+ 616	+ 427										
17	- 310	- 509										
18	- 82	- 205										
19	+ 631	+ 486										
20	+ 73	+ 21										
21	+ 221	+ 14										
22	+ 78	+ 132										
23	+ 213	+ 437										
24	- 1623	- 1718										
25	+ 188	+ 6										
26	+ 456	+ 264										
27	+ 603	+ 384	+ 409									
28	+ 15	- 135	- 122									
29	+ 441	+ 240	+ 293									
30	- 266	- 281	- 277									
31	+ 681	+ 519	+ 589									
32	+ 412	+ 210	+ 242									
33	- 7	+ 45	+ 178									
34	+ 316	+ 117	+ 132									
35	- 1215	- 1352	- 1279									
36	+ 197	+ 134	+ 152									
37	+ 311	+ 169	+ 241									
38	- 22	- 51	- 38									
39	+ 289	+ 97	+ 131									
40	- 49	+ 80	+ 58									
41	+ 273	+ 101	+ 117									
42	+ 211	+ 58	+ 104									
43	- 2084	- 2106	- 2007									
44	+ 32	- 104	- 48									
45		+ 701	+ 726	+ 456								
46		+ 405	+ 430	+ 167								
47		- 418	- 395	- 684								
48		0	+ 23	- 296								
49		+ 270	+ 362	+ 334								
50		- 89	- 91	- 357								

$\Delta\delta$ (unit 0°0001)

Obs. \ Orbit	603	604	605	606	607	608	609	610	611	612	613	614
1	+ 225											
2	+ 105											
3	− 23											
4	+ 695											
5	− 22											
6	+ 311	+ 272										
7	− 72	− 89										
8	− 532	− 468										
9	− 314	− 320										
10	− 592	− 580										
11	− 268	− 301										
12	+ 110	+ 198										
13	+ 16	− 143										
14	0	+ 56										
15	+ 497	+ 603										
16	+ 1064	+ 1110										
17	+ 1227	+ 1194										
18	− 1512	− 1600										
19	− 745	− 684										
20	− 237	− 310										
21	− 125	− 87										
22	− 48	− 102										
23	− 126	− 208										
24	+ 382	+ 442										
25	− 42	− 123										
26	+ 987	+ 1050										
27	+ 940	+ 931	+ 976									
28	− 228	− 328	− 335									
29	− 611	− 546	− 484									
30	− 114	− 186	− 257									
31	+ 224	+ 336	+ 403									
32	+ 148	+ 178	+ 232									
33	− 231	− 202	− 142									
34	+ 248	+ 182	+ 205									
35	+ 456	+ 579	+ 646									
36	+ 147	+ 87	+ 21									
37	− 652	− 579	− 513									
38	− 290	− 335	− 414									
39	− 545	− 534	− 482									
40	+ 240	+ 160	+ 93									
41	− 738	− 806	− 792									
42	− 118	− 53	+ 9									
43	+ 504	+ 608	+ 682									
44	+ 901	+ 944	+ 1006									
45		+ 1490	+ 1525	+ 1436								
46		− 1729	− 1686	− 1736								
47		− 1386	− 1414	− 1593								
48		+ 364	+ 320	+ 147								
49		− 724	− 659	− 701								
50		+ 40	− 42	− 101								

cos δ Δα (unit 0°0001)

Obs. \ Orbit	603	604	605	606	607	608	609	610	611	612	613	614
51		+ 512	+ 628	+ 831								
52		+ 194	+ 157	+ 70								
53		- 160	- 188	+ 105								
54		+ 385	+ 510	+ 899								
55		- 5	+ 69	+ 224								
56		+ 73	+ 110	+ 108								
57		+ 687	+ 712	+ 576								
58		- 267	- 258	- 337								
59		- 80	- 77	- 129								
60		- 54	- 20	+ 16								
61		+ 102	+ 113	+ 31								
62		+ 62	+ 35	+ 213								
63		- 6	- 28	+ 101								
64		- 756	- 603	+ 466								
65		- 57	- 30	- 51								
66		+ 154	+ 248	+ 707								
67		+ 191	+ 243	+ 428								
68			- 172	- 171	- 81							
69			- 898	- 982	- 875							
70			- 2699	- 2808	- 2812							
71			+ 131	+ 267	+ 413							
72			+ 180	+ 147	+ 313							
73			+ 72	+ 56	- 22							
74			+ 674	+ 675	+ 898							
75			- 148	+ 349	+ 485							
76			+ 216	+ 200	+ 456							
77			- 401	- 593	- 404							
78			- 40	- 286	- 130							
79			- 1294	- 1603	1479							
80			+ 312	+ 553	+ 824							
81			+ 168	+ 57	+ 84							
82			+ 72	- 82	+ 218							
83			- 200	- 165	+ 106							
84			+ 170	+ 24	+ 341							
85			- 85	- 338	- 32							
86				- 186	+ 69	+ 311						
87				- 267	- 59	+ 85						
88				- 120	+ 80	+ 216						
89				+ 219	+ 481	+ 942						
90				- 2053	- 1793	- 1513						
91				- 106	- 6	+ 50						
92				+ 10	+ 11	+ 65						
93				+ 19	- 182	+ 39						
94				+ 147	+ 344	+ 487						
95				- 394	- 265	- 216						
96				+ 249	+ 278	+ 238						
97				+ 752	+ 568	+ 707						
98				- 134	- 158	- 225						
99				+ 305	+ 76	- 63						
100				+ 1155	+ 623	+ 676						

$\Delta\delta$ (unit 0°0001)

Obs. \ Orbit	603	604	605	606	607	608	609	610	611	612	613	614
51		+ 276	+ 343	+ 190								
52		+ 180	+ 93	+ 117								
53		+ 197	+ 159	+ 88								
54		− 288	− 214	− 448								
55		+ 202	+ 269	+ 214								
56		+ 100	+ 148	+ 132								
57		− 1555	− 1560	− 1631								
58		− 435	− 514	− 491								
59		+ 258	+ 204	+ 152								
60		− 575	− 530	− 531								
61		− 26	− 90	− 130								
62		+ 117	+ 63	− 35								
63		− 14	− 101	− 79								
64		+ 543	+ 630	+ 17								
65		+ 18	+ 43	+ 25								
66		+ 1011	+ 1079	+ 886								
67		+ 1006	+ 1067	+ 1065								
68			− 48	− 87	− 82							
69			+ 215	+ 168	+ 201							
70			− 1395	− 1419	− 1431							
71			− 480	− 459	− 476							
72			− 480	− 531	− 493							
73			− 3	+ 7	+ 27							
74			+ 285	+ 295	+ 329							
75			− 909	− 1020	− 1116							
76			+ 450	+ 413	+ 451							
77			− 1523	− 1647	− 1556							
78			− 405	− 520	− 440							
79			− 94	− 154	− 102							
80			− 342	− 493	− 584							
81			− 108	− 40	+ 47							
82			+ 411	+ 404	+ 427							
83			− 28	− 73	− 181							
84			+ 66	+ 60	− 6							
85			+ 612	+ 546	+ 566							
86				− 467	− 382	− 268						
87				− 1187	− 1082	− 965						
88				+ 4	+ 88	+ 175						
89				− 206	− 265	− 324						
90				− 523	− 497	− 441						
91				− 53	+ 4	+ 56						
92				− 15	+ 16	+ 38						
93				+ 146	+ 369	+ 234						
94				− 40	+ 3	+ 58						
95				+ 249	+ 286	+ 327						
96				+ 186	+ 179	+ 177						
97				− 532	− 532	− 600						
98				− 124	− 148	− 154						
99				− 19	− 17	− 4						
100				+ 114	+ 202	+ 123						

$\cos\delta\ \Delta\alpha$ (unit 0°0001)

Obs. \ Orbit	603	604	605	606	607	608	609	610	611	612	613	614
101				+ 662	+ 130	− 86						
102				+ 348	+ 267	+ 332						
103				+ 186	− 302	− 232						
104					− 352	− 290	− 144					
105					+ 59	+ 119	+ 262					
106					− 244	− 211	− 125					
107					− 415	− 428	− 371					
108					+ 345	+ 303	+ 368					
109					+ 344	+ 434	+ 496					
110					+ 24	− 100	− 11					
111					+ 245	+ 320	+ 357					
112					+ 24	− 80	− 13					
113					+ 141	− 12	+ 48					
114					+ 107	− 110	− 97					
115					+ 29	+ 152	+ 126					
116					− 2241	− 2055	− 2145					
117					− 213	− 93	− 141					
118					+ 127	+ 202	+ 162					
119					+ 17	+ 56	+ 20					
120					+ 88	+ 470	+ 205					
121					− 225	+ 67	− 76					
122					− 93	− 45	− 94					
123					− 22	+ 63	− 22					
124					− 99	+ 48	− 133					
125						+ 227	+ 90	+ 64				
126						− 160	− 246	− 234				
127						+ 230	+ 169	+ 149				
128						+ 356	− 101	− 301				
129						+ 199	− 43	− 84				
130						+ 62	+ 5	− 14				
131						− 15	− 88	− 164				
132						+ 291	+ 171	+ 32				
133						+ 80	− 62	− 19				
134						+ 109	− 9	+ 54				
135						+ 7	− 111	− 48				
136						− 411	− 471	− 394				
137						− 1214	− 1244	− 1180				
138						+ 36	+ 14	+ 62				
139						+ 102	− 202	− 221				
140						− 208	− 218	− 178				
141						− 294	− 268	− 257				
142						+ 134	− 76	− 99				
143						− 380	− 328	− 354				
144						− 168	− 138	− 209				
145						+ 172	+ 189	+ 298				
146						+ 174	+ 174	+ 175				
147						− 218	− 128	− 37				
148						+ 169	+ 282	+ 405				
149							+ 399	+ 512	+ 608			
150							+ 222	+ 318	+ 358			

Δδ (unit 0°.0001)

Obs. \ Orbit	603	604	605	606	607	608	609	610	611	612	613	614
101				- 188	+ 27	+ 103						
102				+ 258	+ 180	+ 196						
103				+ 438	+ 417	+ 384						
104					+ 903	+ 905	+ 936					
105					- 502	- 487	- 445					
106					+ 385	+ 416	+ 487					
107					- 1893	- 1891	- 1801					
108					+ 311	+ 314	+ 413					
109					- 653	- 672	- 709					
110					+ 318	+ 345	+ 405					
111					- 605	- 594	- 581					
112					- 72	- 64	+ 1					
113					- 2	+ 41	+ 65					
114					- 65	+ 41	+ 14					
115					+ 193	+ 213	+ 190					
116					- 627	- 613	- 652					
117					- 924	- 873	- 878					
118					+ 15	+ 82	+ 100					
119					- 327	- 273	- 236					
120					- 448	- 498	- 552					
121					- 519	- 462	- 514					
122					- 358	- 315	- 274					
123					+ 90	+ 109	+ 147					
124					- 258	- 292	- 259					
125						- 649	- 704	- 742				
126						+ 493	+ 474	+ 451				
127						- 43	- 23	- 56				
128						- 675	- 699	- 671				
129						- 521	- 595	- 622				
130						- 180	- 148	- 153				
131						+ 96	+ 130	+ 126				
132						+ 125	+ 188	+ 258				
133						+ 220	+ 162	+ 149				
134						+ 963	+ 919	+ 917				
135						- 671	- 722	- 729				
136						+ 569	+ 554	+ 566				
137						- 803	- 778	- 771				
138						+ 86	+ 125	+ 131				
139						- 886	- 937	- 904				
140						- 136	- 90	- 87				
141						+ 154	+ 202	+ 202				
142						- 366	- 453	- 397				
143						+ 101	+ 123	+ 143				
144						- 364	- 379	- 286				
145						+ 187	+ 172	+ 172				
146						- 62	- 211	- 170				
147						+ 122	+ 18	+ 12				
148						+ 743	+ 731	+ 735				
149							- 946	- 925	- 939			
150							+ 713	+ 742	+ 699			

Orbit / Obs.	603	604	605	606	607	608	609	610	611	612	613	614
						cos δ $\Delta\alpha$ (unit 0°0001)						
151							+ 86	+ 153	+ 141			
152							− 63	+ 44	+ 376			
153							− 86	− 48	− 122			
154							+ 175	+ 178	+ 58			
155							+ 54	+ 20	− 71			
156							+ 125	+ 70	+ 67			
157							+ 232	+ 345	+ 425			
158							− 244	− 154	+ 40			
159							− 207	− 103	− 20			
160							+ 128	+ 172	+ 121			
161							− 127	− 157	+ 141			
162							+ 85	+ 115	+ 41			
163							− 574	− 546	− 613			
164							− 1090	− 1107	− 1234			
165							− 800	− 907	− 1004			
166							− 664	− 736	− 876			
167							+ 910	+ 939	+ 1051			
168								− 286	− 212	− 78		
169								+ 282	+ 270	+ 353		
170								− 121	+ 334	+ 730		
171								− 722	− 814	− 868		
172								+ 138	+ 59	+ 23		
173								+ 107	+ 8	− 55		
174								− 138	− 178	− 109		
175								− 705	− 455	+ 20		
176								− 760	− 128	+ 455		
177								+ 104	+ 151	+ 247		
178								− 225	− 242	− 272		
179								− 193	+ 228	+ 411		
180								+ 65	+ 51	− 2		
181								+ 194	+ 244	+ 254		
182								− 145	+ 23	+ 179		
183								+ 2	+ 357	+ 536		
184								− 492	− 15	+ 172		
185									+ 491	+ 552	+ 429	
186									− 164	− 139	− 256	
187									+ 285	+ 472	− 200	
188									+ 141	+ 81	− 36	
189									− 134	− 176	− 265	
190									− 33	+ 106	− 118	
191									− 178	− 131	− 136	
192									+ 652	+ 742	+ 559	
193									− 205	− 214	− 75	
194									+ 41	+ 42	+ 143	
195										+ 86	+ 134	+ 14
196										+ 207	+ 382	− 64
197										+ 26	+ 67	− 44
198										+ 29	+ 96	− 14
199										− 387	− 234	− 338
200										− 129	+ 195	+ 37

$\Delta\delta$ (unit 0°0001)

Obs. \ Orbit	603	604	605	606	607	608	609	610	611	612	613	614
151							− 324	− 301	− 378			
152							− 812	− 830	− 725			
153							+ 226	+ 235	+ 150			
154							+ 214	+ 221	+ 187			
155							− 201	− 165	− 105			
156							+ 251	+ 360	+ 447			
157							+ 82	+ 96	+ 84			
158							+ 291	+ 282	+ 352			
159							− 662	− 655	− 644			
160							+ 76	+ 70	− 40			
161							− 833	− 832	− 714			
162							− 278	− 288	− 392			
163							+ 146	+ 152	+ 65			
164							+ 64	+ 64	+ 8			
165							− 41	+ 37	+ 147			
166							+ 154	+ 207	+ 235			
167							+ 152	+ 124	+ 157			
168								− 8	− 4	− 168		
169								+ 217	+ 124	− 110		
170								− 1169	− 1065	− 596		
171								+ 482	+ 433	+ 329		
172								+ 178	+ 109	− 36		
173								+ 160	+ 153	+ 157		
174								+ 84	+ 147	+ 376		
175								− 366	− 319	+ 213		
176								+ 148	+ 168	+ 751		
177								− 92	− 139	− 347		
178								+ 505	+ 457	+ 330		
179								− 686	− 581	− 645		
180								+ 426	+ 404	+ 399		
181								+ 60	+ 68	+ 217		
182								− 206	− 228	+ 64		
183								− 89	− 4	− 164		
184								− 879	− 709	− 853		
185									− 2	− 216	− 355	
186									− 280	− 475	− 582	
187									− 657	− 637	− 846	
188									+ 359	+ 308	+ 317	
189									− 327	− 250	− 174	
190									− 64	− 147	− 318	
191									− 179	− 403	− 496	
192									− 746	− 632	− 661	
193									− 453	− 207	− 135	
194									− 334	+ 22	+ 65	
195										− 167	− 254	− 335
196										− 540	− 461	− 423
197										− 184	− 226	− 265
198										− 124	− 119	− 113
199										− 214	− 178	− 122
200										− 135	− 112	− 84

$\cos\delta\,\Delta\alpha$ (unit 0°0001)

Obs. \ Orbit	603	604	605	606	607	608	609	610	611	612	613	614
201										+ 3	+ 133	+ 5
202										− 132	− 70	− 125
203										− 67	+ 117	+ 153
204										+ 50	+ 72	+ 19
205										+ 451	+ 482	+ 490
206										+ 1390	+ 1417	+ 1370
207										+ 174	+ 191	+ 144
208										− 95	− 25	− 53
209										+ 600	+ 540	+ 582
210										+ 137	− 43	+ 137
211										− 96	− 250	− 173
212										− 114	− 199	− 172
213											+ 395	+ 376
214											+ 93	+ 394
215											− 127	+ 80
216											+ 186	+ 156
217											+ 121	+ 398
218											− 66	− 47
219											− 328	− 73
220											+ 150	+ 144
221											+ 200	+ 169
222											+ 210	+ 353
223											+ 47	− 5
224											+ 252	+ 361
225											+ 690	+ 634
226											+ 295	+ 288
227											+ 269	+ 275
228											− 439	− 407
229											− 77	− 104
230											+ 261	+ 159
231											+ 103	− 5
232												+ 499
233												+ 69
234												− 47
235												+ 436
236												− 176
237												+ 160
238												+ 740
239												− 140
240												+ 193
241												+ 710
242												+ 417
243												+ 441
244												− 86

Δδ (unit 0°0001)

Obs. \ Orbit	603	604	605	606	607	608	609	610	611	612	613	614
201										− 243	− 323	− 364
202										+ 117	− 42	− 120
203										− 582	− 452	− 394
204										− 377	− 438	− 474
205										− 2364	− 2469	− 2481
206										+ 960	+ 958	+ 957
207										− 87	− 97	− 104
208										− 253	− 210	− 194
209										+ 43	− 168	− 185
210										− 124	− 159	− 148
211										+ 337	+ 158	+ 198
212										+ 445	+ 196	+ 191
213											− 31	− 69
214											− 233	− 249
215											− 632	− 581
216											+ 194	+ 189
217											+ 640	+ 642
218											− 138	− 124
219											− 69	− 65
220											− 338	− 388
221											− 62	− 102
222											− 275	− 222
223											− 95	− 121
224											− 126	− 114
225											− 222	− 217
226											+ 298	+ 339
227											− 990	− 941
228											+ 404	+ 462
229											− 339	− 318
230											+ 259	+ 200
231											− 1085	− 1203
232												− 210
233												− 220
234												− 306
235												− 603
236												− 405
237												+ 283
238												− 277
239												− 165
240												+ 228
241												− 23
242												− 407
243												− 558
244												− 282

Table 6. Residuals of Baker-Nunn Observations.

cos δ Δα (unit 0°0001)

Obs. \ Orbit	631	616	617	618	619	620	621	622	623	624	625	632
71338	+ 23	+ 29										
71414	+ 11	+ 12										
71132	+ 19	+ 18										
70993	+ 7	+ 3										
70992	− 4	− 19										
70991	+ 6	− 15										
70896	− 2	− 26										
70100	+ 13	− 1	− 10									
70101	+ 25	+ 10	+ 1									
70102	+ 20	+ 8	+ 5									
70103	+ 16	+ 6	+ 4									
70104	− 3	− 5	− 4									
70329	− 9	− 8	− 5									
70340	+ 4	+ 7	+ 11									
70961	− 29	− 16	− 8									
70962	− 25	− 9	0									
70015	− 615	− 522	− 527									
70813	+ 31	+ 144	+ 123									
70757	− 67	+ 42	+ 32									
70756	− 86	+ 34	+ 23									
70791		− 7	− 2	+ 35								
70792		+ 5	+ 10	+ 46								
70793		− 11	− 8	+ 27								
70394		+ 18	+ 16	+ 22								
70022		− 9	− 10	− 9								
70023		+ 9	+ 8	+ 7								
70024		− 20	− 19	− 28								
71599		− 6	− 5	− 16								
70493			− 21	+ 308	+ 380							
70494			− 55	+ 286	+ 376							
70495			− 32	+ 310	+ 404							
70492			− 26	+ 316	+ 413							
70064			+ 5	+ 57	+ 62							
70065			− 1	+ 38	+ 47							
71006			− 125	− 83	− 87							
70072			− 137	− 102	− 104							
71342			− 244	− 356	− 109							
70576				− 22	+ 102	+ 183						
70360				− 58	+ 61	+ 140						
71362				− 40	+ 74	+ 150						
70480				− 55	+ 56	+ 131						
70484				− 50	+ 56	+ 129						
71363				− 927	− 828	− 758						
70748				+ 39	+ 13	+ 65						
70750				+ 14	− 13	+ 41						
70751				+ 21	− 7	+ 51						
70083				− 141	− 181	− 122						
70084				− 144	− 183	− 123						
71519				+ 39	− 4	− 7						
71405				+ 22	− 26	− 29						

Orbit / Obs.	631	616	617	618	619	620	621	622	623	624	625	632
						Δδ (unit 0°0001)						
71338	+ 6	− 27										
71414	+ 1	− 34										
71132	− 4	− 40										
70993	− 2	− 40										
70992	+ 1	− 44										
70991	+ 4	− 46										
70896	− 7	− 59										
70100	+ 1	− 16	− 27									
70101	+ 3	− 13	− 22									
70102	− 1	− 6	− 6									
70103	+ 6	+ 3	+ 3									
70104	− 7	− 5	− 2									
70329	− 9	− 6	− 2									
70340	+ 1	+ 5	+ 9									
70961	+ 2	+ 9	+ 15									
70962	+ 5	+ 13	+ 19									
70015	+ 218	+ 211	+ 208									
70813	+ 136	+ 118	+ 90									
70757	+ 5	+ 90	+ 82									
70756	+ 4	+ 78	+ 73									
70791		+ 42	0	+ 49								
70792		+ 47	+ 5	+ 54								
70793		+ 40	− 3	+ 45								
70394		− 1	− 16	− 61								
70022		+ 16	+ 2	− 46								
70023		0	− 14	− 62								
70024		− 25	− 38	− 88								
71599		+ 5	− 7	− 58								
70493			+ 221	+ 252	+ 256							
70494			+ 242	+ 245	+ 248							
70495			+ 252	+ 248	+ 250							
70492			+ 265	+ 253	+ 254							
70064			+ 81	+ 35	+ 13							
70065			+ 87	+ 36	+ 15							
71006			+ 32	− 54	− 66							
70072			+ 54	− 37	− 47							
71342			− 10	+ 26	+ 60							
70576				− 20	− 27	+ 4						
70360				− 3	− 11	+ 20						
71362				− 3135	− 3144	− 3113						
70480				− 2	− 12	+ 19						
70484				− 1	− 13	+ 18						
71363				− 381	− 395	− 365						
70748				+ 2	− 29	0						
70750				+ 8	− 24	+ 5						
70751				+ 6	− 25	+ 4						
70083				+ 29	+ 4	+ 19						
70084				+ 9	− 12	− 1						
71519				+ 51	+ 12	+ 6						
71405				+ 46	+ 17	+ 11						

Obs. \ Orbit	631	616	617	618	619	620	621	622	623	624	625	632
						$\cos\delta\,\Delta\alpha$ (unit 0°0001)						
71272				+ 35	− 36	− 49						
70466				+ 34	− 37	− 50						
70467				+ 28	− 43	− 56						
70086				+ 24	− 46	− 59						
70087				+ 80	+ 27	+ 24						
71189				+ 75	+ 20	+ 17						
71596				+ 24	− 24	− 29						
71597				− 10	− 41	− 47						
71155				− 78	− 141	− 156						
70037				− 96	− 161	− 176						
71156				− 99	− 163	− 179						
70038				− 92	− 156	− 172						
72030					+ 26	− 8	+ 40					
72031					+ 30	− 4	+ 43					
70482					+ 44	+ 7	+ 48					
70438					+ 36	− 2	+ 36					
70396					+ 80	+ 36	+ 37					
70397					+ 85	+ 41	+ 42					
70398					+ 52	+ 8	+ 9					
70868					+ 64	+ 20	+ 21					
71247					+ 54	+ 9	+ 11					
71246					+ 49	+ 4	+ 6					
71642					+ 41	− 4	− 1					
71986					+ 29	− 17	− 42					
70970					− 7	− 44	− 64					
71205					+ 41	+ 11	− 3					
71331					+ 41	+ 8	− 7					
71206					+ 32	0	− 16					
70092					+ 27	− 14	− 36					
70975					+ 31	− 17	− 42					
70091					− 92	− 134	− 163					
71195					− 90	− 133	− 162					
70485					− 26	− 64	− 42					
70787					− 75	− 114	− 97					
71364					− 521	− 560	− 545					
70341					− 26	− 66	− 55					
70651					+ 10	− 11	− 82					
70039					+ 83	+ 62	− 14					
71313					− 67	− 60	− 36					
71152					− 34	− 41	− 33					
71314					− 88	− 108	− 122					
70344					− 26	− 28	− 33					
70111						+ 93	+ 7	+ 1				
70112						+ 94	+ 6	+ 1				
71473						+ 95	+ 8	+ 3				
71520						+ 131	+ 53	+ 60				
70095						+ 103	+ 21	+ 28				
71516						+ 147	+ 57	+ 64				
70113						+ 234	+ 128	+ 130				
70964						+ 205	+ 99	+ 101				

Δδ (unit 0°0001)

Obs. \ Orbit	631	616	617	618	619	620	621	622	623	624	625	632
71272				+28	−6	−7						
70466				+28	−5	−7						
70467				+30	0	−2						
70086				+25	−5	−6						
70087				+51	+18	+13						
71189				+57	+25	+19						
71596				+57	+57	+47						
71597				+67	+73	+63						
71155				−6	−38	−50						
70037				−41	−66	−78						
71156				−1	−21	−33						
70038				+6	−9	−19						
72030					+15	−6	+9					
72031					+47	+26	+41					
70482					+43	+21	+34					
70438					+24	+2	+13					
70396					−60	−66	−84					
70397					−58	−64	−82					
70398					−57	−62	−81					
70868					−58	−63	−82					
71247					−54	−58	−78					
71246					−59	−62	−82					
71642					−68	−71	−92					
71986					+12	+7	+1					
70970					−5	−5	−10					
71205					+36	+20	+3					
71331					+30	+14	−4					
71206					+35	+18	+1					
70092					+38	+23	+3					
70975					+38	+28	+10					
70091					+21	+2	−18					
71195					+27	+9	−11					
70485					+50	+29	+34					
70787					+27	+5	+9					
71364					−140	−162	−160					
70341					+40	+17	+18					
70651					+48	+39	+13					
70039					+49	+42	+20					
71313					−76	−68	−42					
71152					−76	−72	−48					
71314					−99	−102	−90					
70344					−26	−37	−48					
70111						+44	+26	+2				
70112						+44	+29	+5				
71473						+45	+32	+8				
71520						+67	+25	+5				
70095						+63	+24	+4				
71516						+41	+11	−10				
70113						+37	+29	+6				
70964						+26	+22	−1				

cos δ Δα (unit 0°0001)

Obs. \ Orbit	631	616	617	618	619	620	621	622	623	624	625	632
76905						+ 180	+ 88	+ 52				
70779						+ 327	+ 244	+ 170				
71085						+ 345	+ 259	+ 183				
70115						+ 377	+ 290	+ 214				
71521						+ 357	+ 269	+ 194				
70117						+ 348	+ 260	+ 185				
70957						+ 54	+ 94	+ 53				
70815						− 349	− 408	− 483				
71008						− 332	− 392	− 467				
70120						− 287	− 347	− 420				
70816						− 237	− 294	− 362				
70121						− 184	− 239	− 304				
71655						− 284	− 325	− 383				
70044						− 342	− 388	− 450				
71653						− 382	− 436	− 506				
72123						− 396	− 457	− 534				
70045						− 137	− 180	− 229				
70123							+ 5	− 50	− 328			
74186							+ 74	+ 18	− 268			
71028							+ 75	+ 19	− 272			
70837							+ 73	+ 16	− 281			
76907							+ 172	+ 144	− 52			
70125							− 438	− 447	− 568			
70126							− 294	− 299	− 484			
71647							− 219	− 220	− 406			
70127							− 149	− 147	− 328			
71593							+ 142	+ 206	+ 201			
71474							+ 151	+ 216	+ 204			
71318							+ 152	+ 217	+ 198			
71218							+ 153	+ 221	+ 184			
71022							+ 168	+ 235	+ 196			
71021							+ 157	+ 224	+ 183			
76908							+ 98	+ 180	+ 224			
76909							+ 131	+ 214	+ 255			
76910							− 1022	− 940	− 902			
70128							− 362	− 183	− 269			
71643								− 101	− 116	+ 54		
70131								+ 1101	+ 1077	+ 1236		
71648								− 120	− 174	− 46		
71649								− 50	− 151	− 96		
70051									+ 116	+ 73	− 7	
70744									+ 132	+ 86	+ 9	
70555									+ 129	+ 64	+ 6	
71594									+ 126	+ 59	+ 4	
70052									+ 123	+ 28	+ 11	
70132									+ 128	0	+ 115	
71027									+ 70	− 111	+ 125	
70134									− 116	+ 64	+ 82	
70141										− 80	− 35	− 52
70144										− 56	+ 9	− 10

$\Delta\delta$ (unit 0°0001)

Obs. \ Orbit	631	616	617	618	619	620	621	622	623	624	625	632
76905						− 55	− 70	− 96				
70779						+ 32	+ 15	+ 1				
71085						+ 2	− 8	− 14				
70115						− 13	− 20	− 23				
71521						− 50	− 51	− 47				
70117						− 46	− 43	− 37				
70957						+ 4	+ 22	− 9				
70815						+ 151	+ 135	+ 107				
71008						+ 173	+ 159	+ 135				
70120						+ 189	+ 180	+ 162				
70916						+ 215	+ 212	+ 203				
70121						+ 211	+ 210	+ 205				
71655						− 52	− 82	− 119				
70044						− 46	− 75	− 109				
71653						− 2	− 26	− 52				
72123						+ 128	+ 121	+ 118				
70045						+ 120	+ 125	+ 142				
70123							+ 73	+ 41	− 5			
74186							+ 78	+ 49	+ 12			
71028							+ 70	+ 42	+ 11			
70837							+ 83	+ 58	+ 37			
76907							− 58	− 79	− 80			
70125							+ 145	+ 123	+ 82			
70126							+ 216	+ 200	+ 240			
71647							+ 208	+ 193	+ 252			
70127							+ 166	+ 151	+ 224			
71593							+ 69	+ 46	+ 19			
71474							+ 60	+ 35	+ 8			
71318							+ 55	+ 27	+ 1			
71218							+ 39	+ 6	− 16			
71022							+ 33	− 1	− 22			
71021							+ 35	0	− 20			
76908							+ 16	− 2	− 9			
76909							− 35	− 55	− 63			
76910							− 41	− 63	− 73			
70128							+ 117	+ 2	+ 6			
71643								− 5	− 39	− 51		
70131								+ 30	− 5	− 26		
71648								+ 19	− 11	− 45		
71649								+ 22	+ 24	+ 6		
70051									+ 35	+ 20	− 13	
70744									+ 22	+ 8	− 23	
70555									+ 12	+ 9	− 13	
71594									+ 1	0	− 21	
70052									− 3	+ 20	+ 7	
70132									− 21	+ 135	+ 104	
71027									− 64	+ 159	+ 86	
70134									+ 4	− 1	− 30	
70141										+ 30	+ 27	+ 14
70144										+ 9	0	− 10

cos δ Δα (unit 0°0001)

Obs. \ Orbit	631	616	617	618	619	620	621	622	623	624	625	632
70146										− 70	− 2	− 21
70147										− 81	− 3	− 24
70349										− 228	+ 20	− 5
71675										− 637	− 465	− 461
70151										+ 95	+ 89	+ 117
70976										+ 48	+ 70	+ 95
70977										+ 12	+ 63	+ 84
72025											− 9	− 16
71639											− 14	− 22
71616											− 47	− 52
72024											− 4	− 8
71400											− 62	− 40
71040											− 40	− 20
71384											− 41	− 24
71037											− 42	− 26
71038											− 42	− 28
70817											+ 59	+ 76
71674											+ 38	+ 52
71266											+ 49	+ 59
72469											− 20	− 12
72466											− 19	− 11
72039											− 26	− 19
72625											− 39	− 32
72040											− 32	− 26
70332											+ 65	+ 32
71262												+ 67
70056												+ 106
70158												+ 99
70843												− 214
70162												− 169
70164												− 163
70844												+ 687
70745												+51020
70468												+50191
70165												+49156
70166												+ 121
70167												+ 127

Obs. \ Orbit	631	616	617	618	619	620	621	622	623	624	625	632
						$\Delta\delta$ (unit 0°0001)						
70146										+ 30	+ 20	+ 10
70147										− 4	− 18	− 26
70349										+ 109	+ 109	+ 101
71675										+ 79	+ 67	+ 65
70151										− 19	+ 15	+ 13
70976										− 2	+ 27	+ 27
70977										+ 9	+ 30	+ 33
72025											+ 16	− 10
71639											+ 12	− 14
71616											− 118	− 137
72024											+ 20	− 4
71400											− 18	− 30
71040											− 16	− 29
71384											0	− 14
71037											− 10	− 24
71038											− 8	− 22
70817											− 15	− 20
71674											− 19	− 23
71266											− 14	− 16
72469											+ 4	− 12
72466											+ 17	0
72039											+ 15	− 2
72625											+ 15	− 2
72040											+ 15	− 1
70332											− 170	− 158
71262												− 172
70056												+ 59
70158												+ 39
70843												+ 33
70162												+ 44
70164												+ 39
70844												+ 574
70745												+35403
70468												+34673
70165												+33529
70166												+ 22
70167												+ 17

Table 7. Accuracy of Representation of Observations

	Orbit											
PM	603	604	605	606	607	608	609	610	611	612	613	614
BN	631	616	617	618	619	620	621	622	623	624	625	632
	Probable Error of Observation of Weight 1											
PM	0.0100	0.0103	0.0104	0.0099	0.0108	0.0124	0.0115	0.0116	0.0111	0.0110	0.0128	0.0104
BN	0.0004	0.0013	0.0009	0.0031	0.0033	0.0035	0.0045	0.0041	0.0022	0.0021	0.0016	0.0022
	Weight in R.A.											
PM	1.45	1.44	1.18	0.57	1.51	1.29	1.50	1.33	1.64	1.59	1.38	1.63
BN	0.06	1.65	1.80	0.86	0.55	0.23	0.32	0.12	0.03	0.20	0.31	0.19
	Weight in Decl.											
PM	0.55	0.56	0.82	1.43	0.49	0.71	0.50	0.67	0.36	0.41	0.62	0.37
BN	1.94	0.35	0.20	1.14	1.45	1.77	1.68	1.88	1.97	1.80	1.69	1.81
	Probable Error of Observation in R.A.											
PM	0.0083	0.0086	0.0095	0.0130	0.0088	0.0109	0.0094	0.0101	0.0087	0.0087	0.0109	0.0081
BN	0.0018	0.0010	0.0007	0.0033	0.0044	0.0073	0.0080	0.0118	0.0140	0.0047	0.0028	0.0051
	Probable Error of Observation in Decl.											
PM	0.0135	0.0137	0.0115	0.0083	0.0154	0.0147	0.0163	0.0142	0.0185	0.0172	0.0163	0.0170
BN	0.0003	0.0022	0.0021	0.0029	0.0027	0.0026	0.0035	0.0030	0.0016	0.0016	0.0012	0.0017

Table 8. Differences of Parameters

PM-BN

PM Orbit	ΔS_1 Megameters	ΔS_2	ΔS_3	ΔS_4	ΔS_5	ΔS_6	ΔS_{18}
603	+0.0000053	−0.00008344	− 0°.001877	− 0°.00591	− 0°.00909	+ 0°.00906	+0°.000547
604	−0.0000017	−0.00000409	+ 0.000053	− 0.00186	+ 0.00821	− 0.00661	−0.016779
605	+0.0000007	−0.00000679	+ 0.002162	− 0.00107	+ 0.00160	− 0.00086	−0.009330
606	+0.0000060	−0.00002371	− 0.000111	+ 0.00150	+ 0.02803	− 0.02787	−0.013731
607	+0.0000022	−0.00001196	− 0.000912	+ 0.00161	+ 0.00134	− 0.01059	+0.036083
608	−0.0000031	−0.00003886	− 0.001672	+ 0.00181	− 0.00340	− 0.00304	+0.008351
609	−0.0000012	−0.00002047	− 0.003140	+ 0.00334	− 0.01226	+ 0.01285	−0.015600
610	−0.0000035	−0.00003360	− 0.003932	+ 0.00246	− 0.02107	+ 0.02243	+0.026832
611	+0.0000032	−0.00008895	− 0.003321	− 0.00306	+ 0.00829	+ 0.00065	−0.070232
612	+0.0000081	−0.00007242	− 0.001793	− 0.00949	+ 0.03972	− 0.04489	+0.047737
613	+0.0000022	−0.00008280	− 0.003343	− 0.00577	+ 0.00555	− 0.00976	+0.014241
614	+0.0000006	−0.00008718	− 0.003598	− 0.00634	+ 0.01605	− 0.02136	+0.009450

Figure 1a through 1g—S_i versus time for Prime Minitrack Orbits.

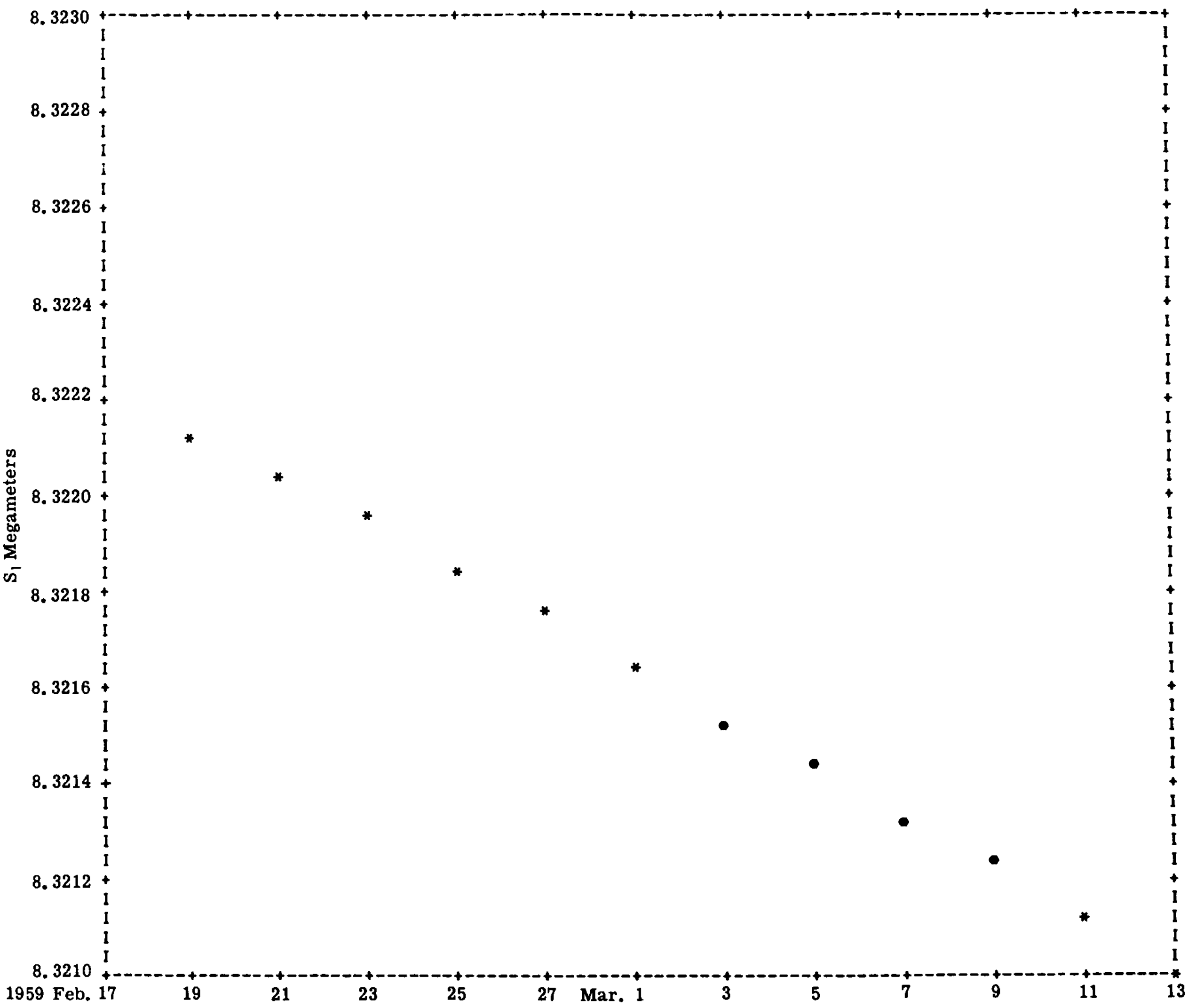

Figure 1a—Values of S_1 (megameters)

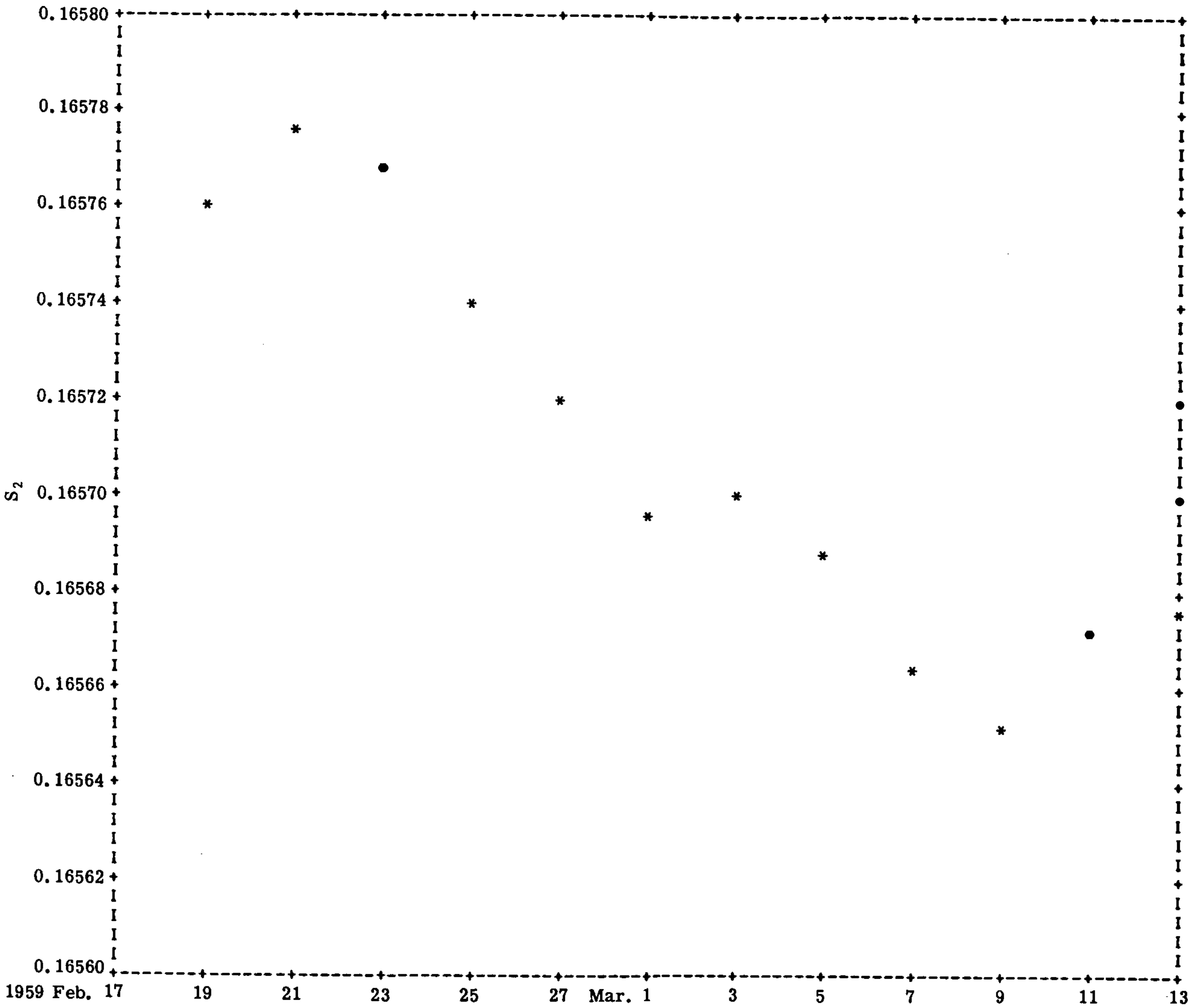

Figure 1b—Values of S_2

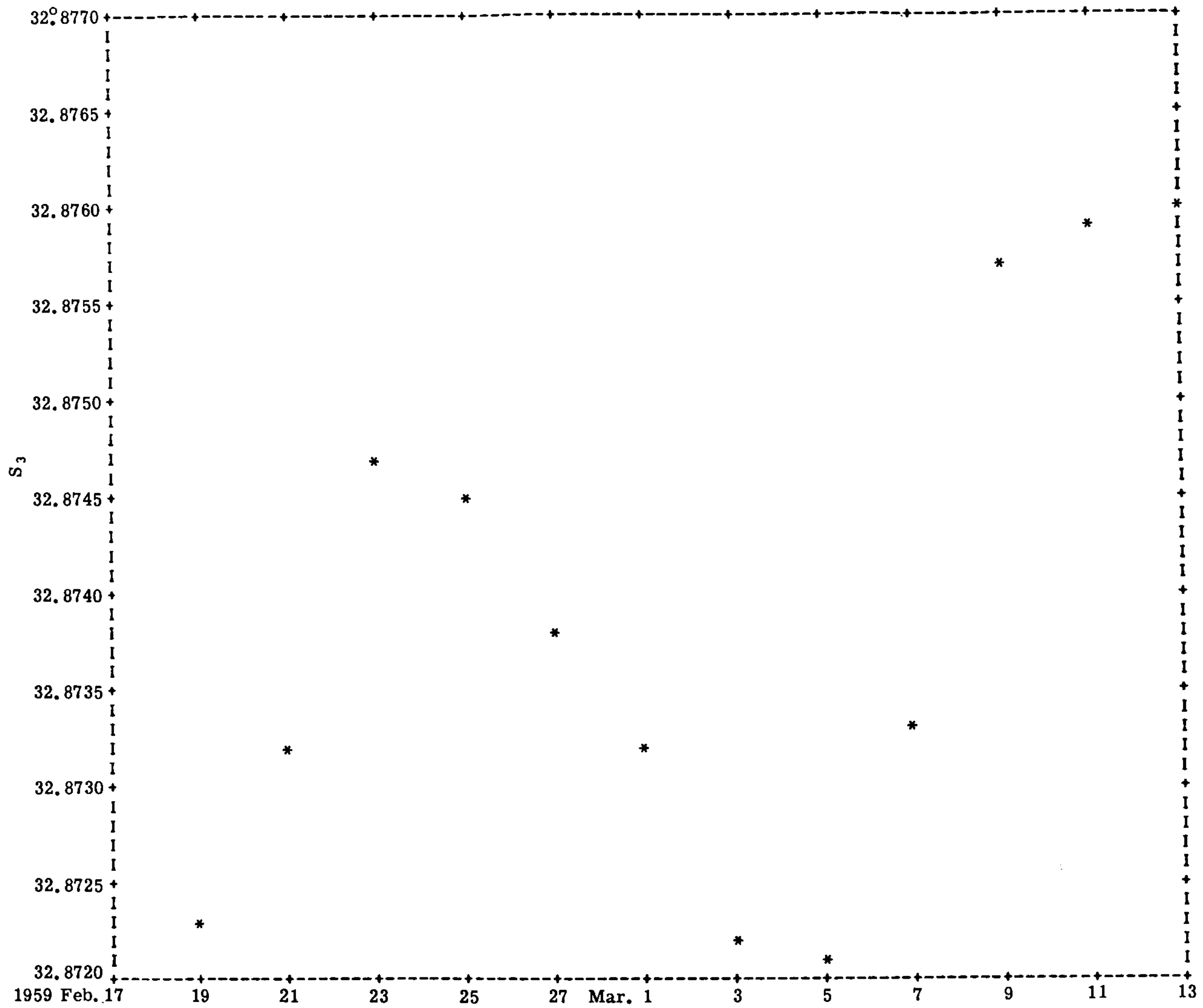

Figure 1c—Values of S_3 (degrees)

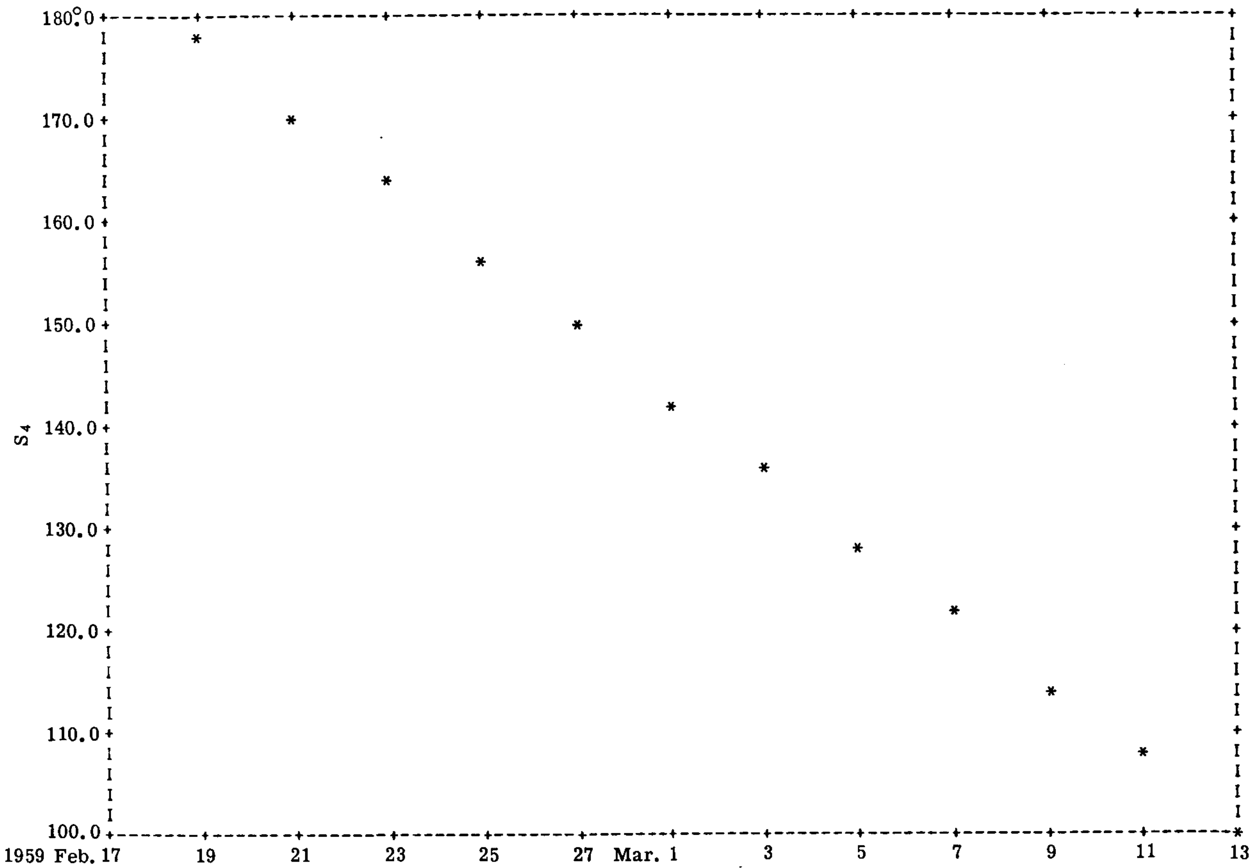

Figure 1d—Values of S_4 (degrees)

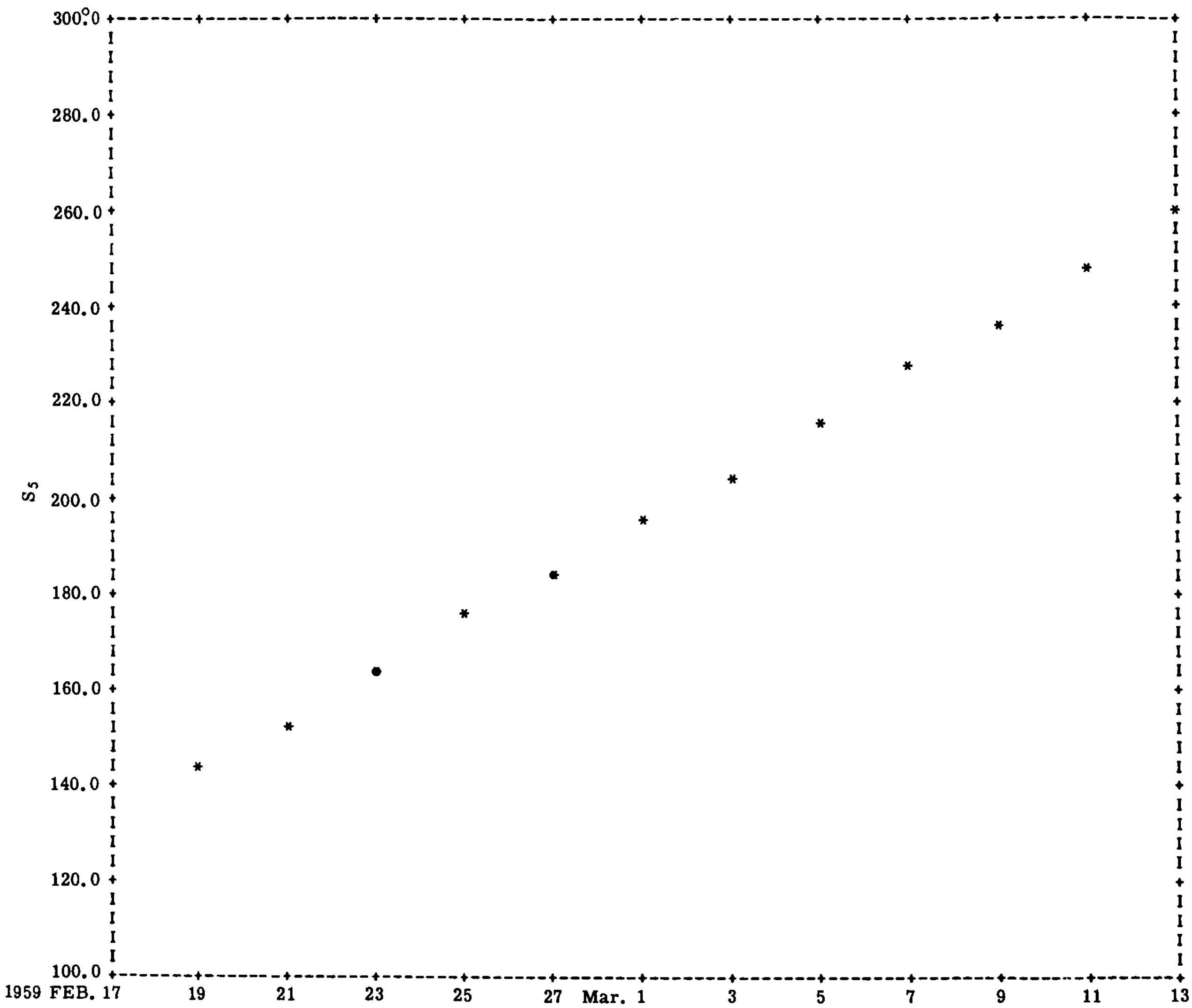

Figure 1e—Values of S_5 (degrees)

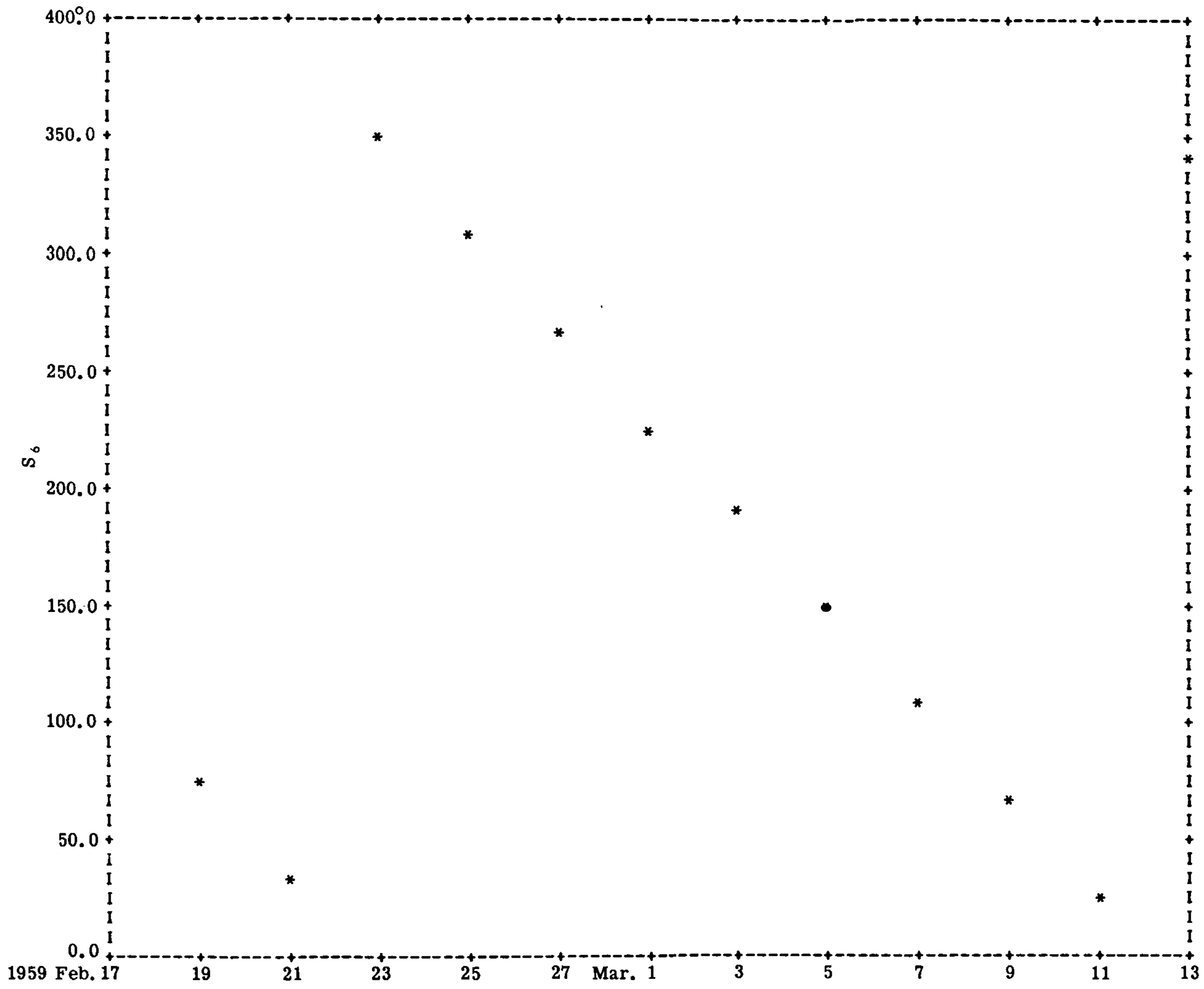

Figure 1f—Values of S_6 (degrees)

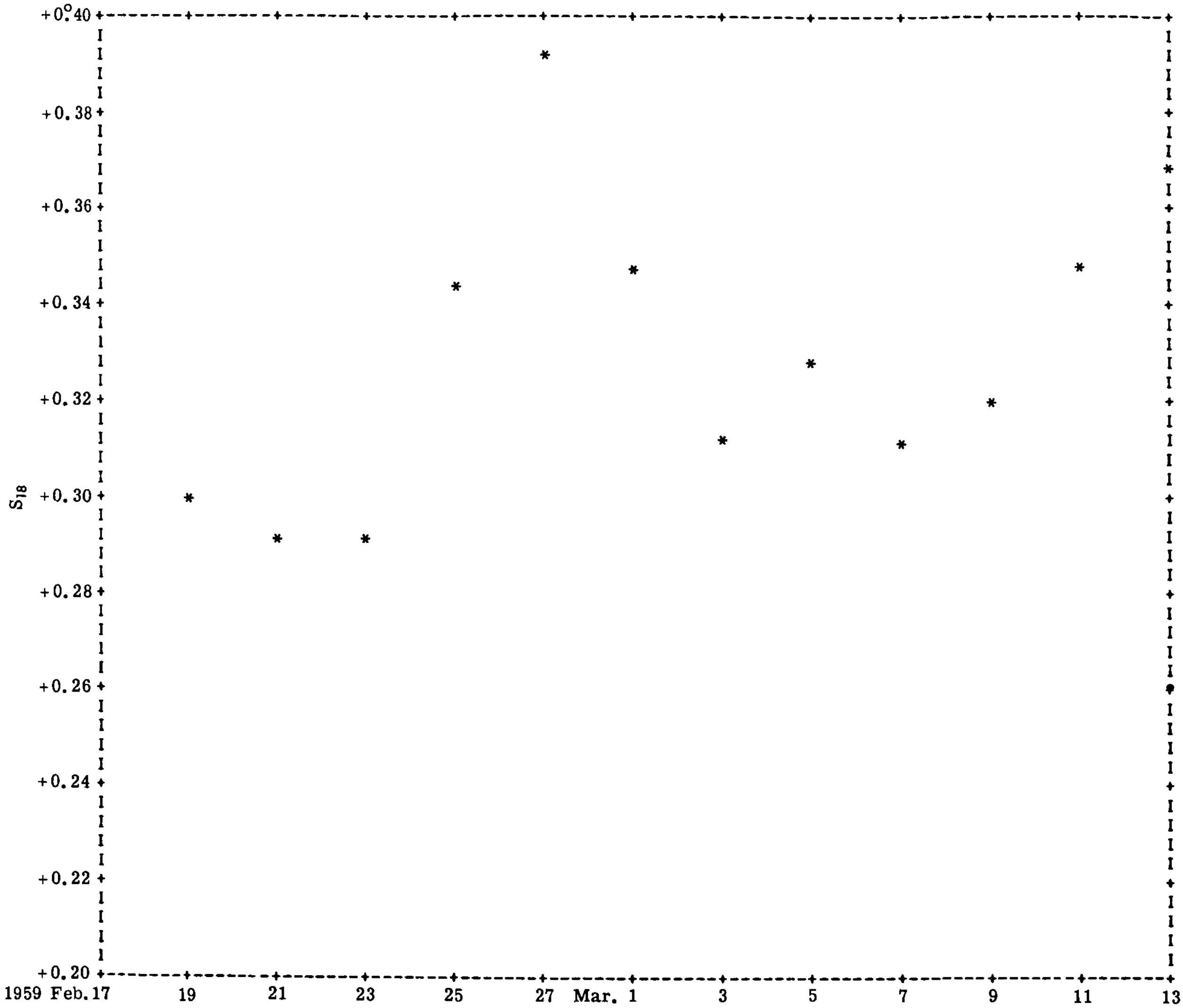

Figure 1g—Values of S_{18} (degrees)

Figure 2a through 2g—S_i versus time for Baker-Nunn Orbits.

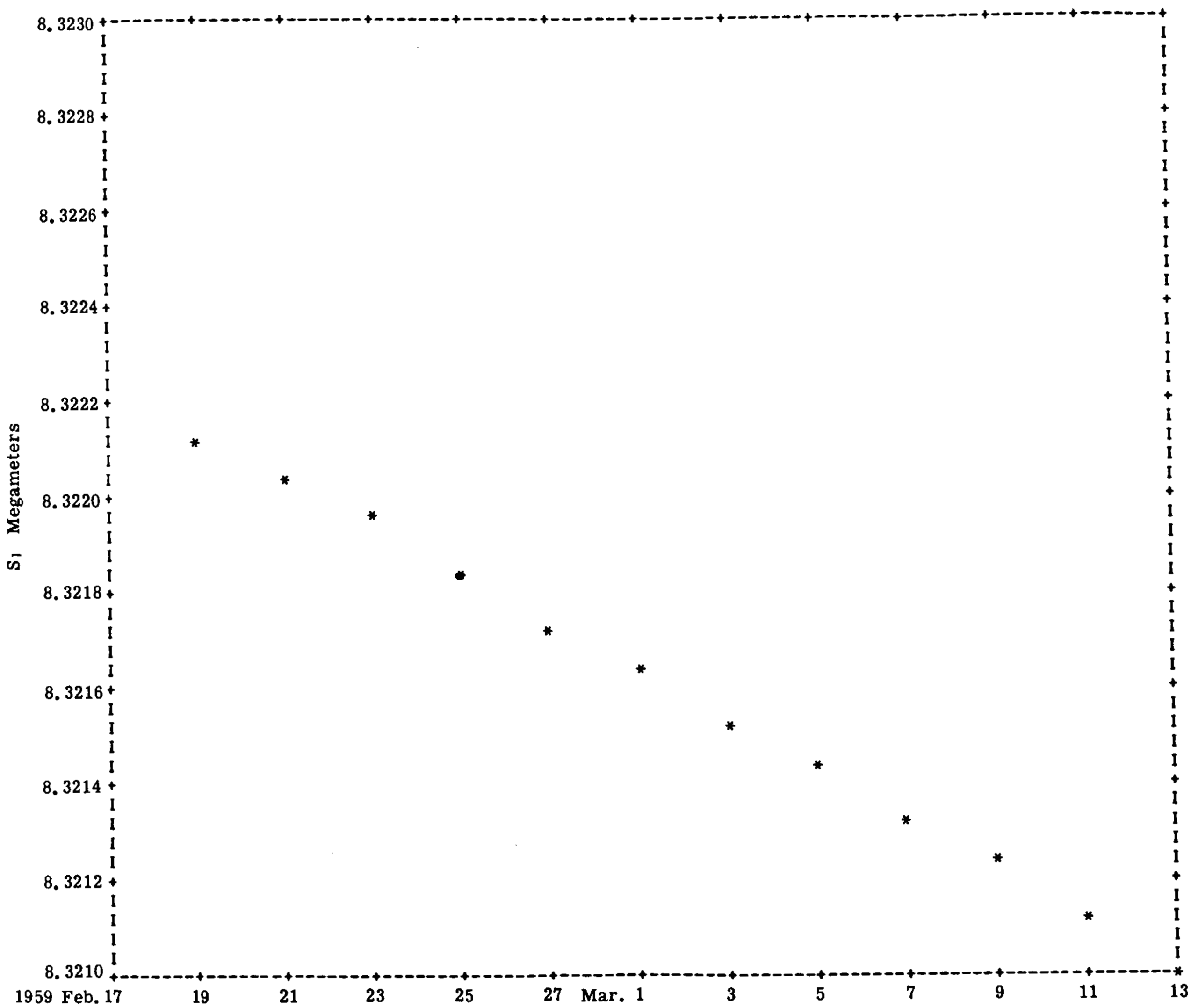

Figure 2a—Values of S_1 (megameters)

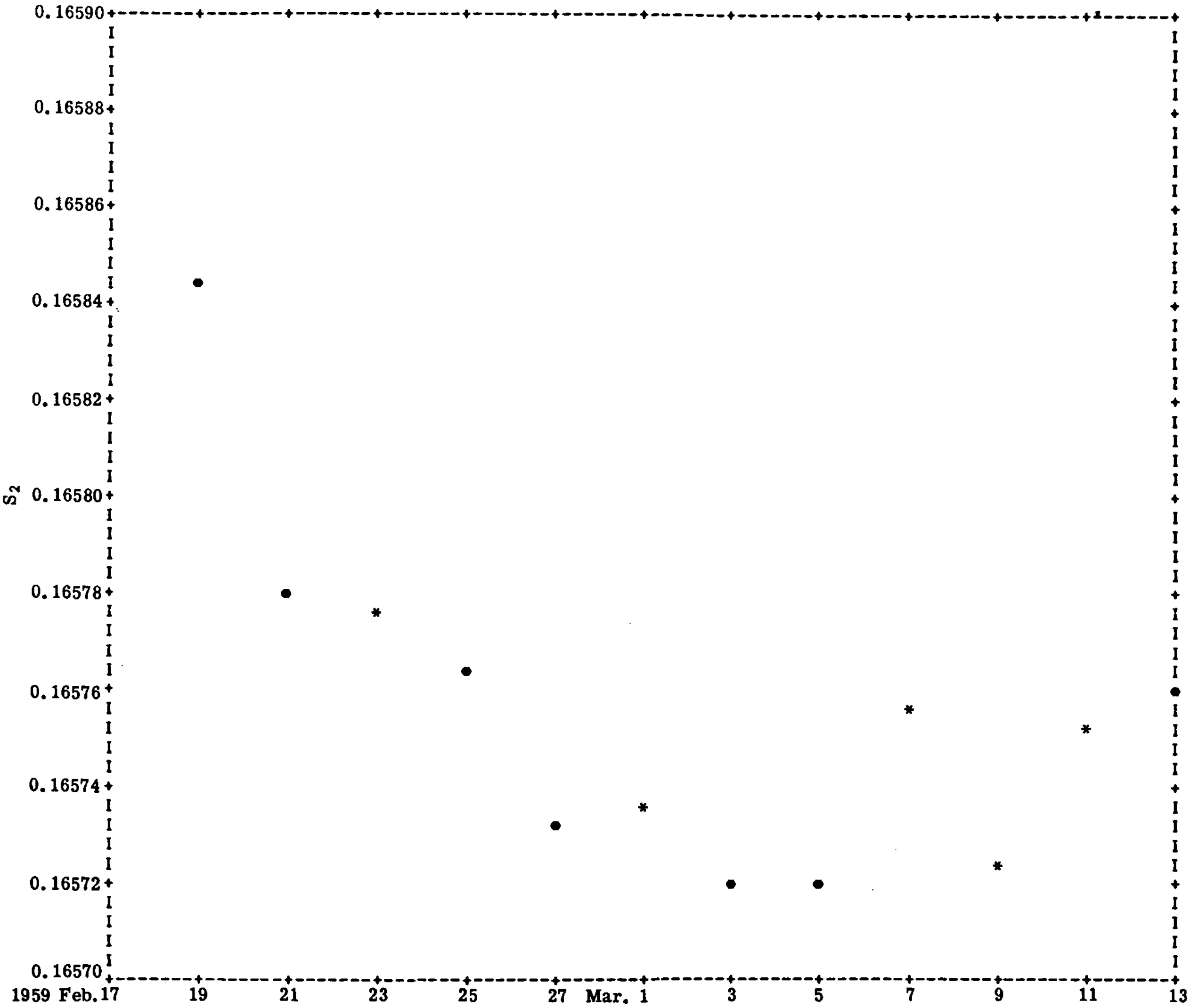

Figure 2b—Values of S_2

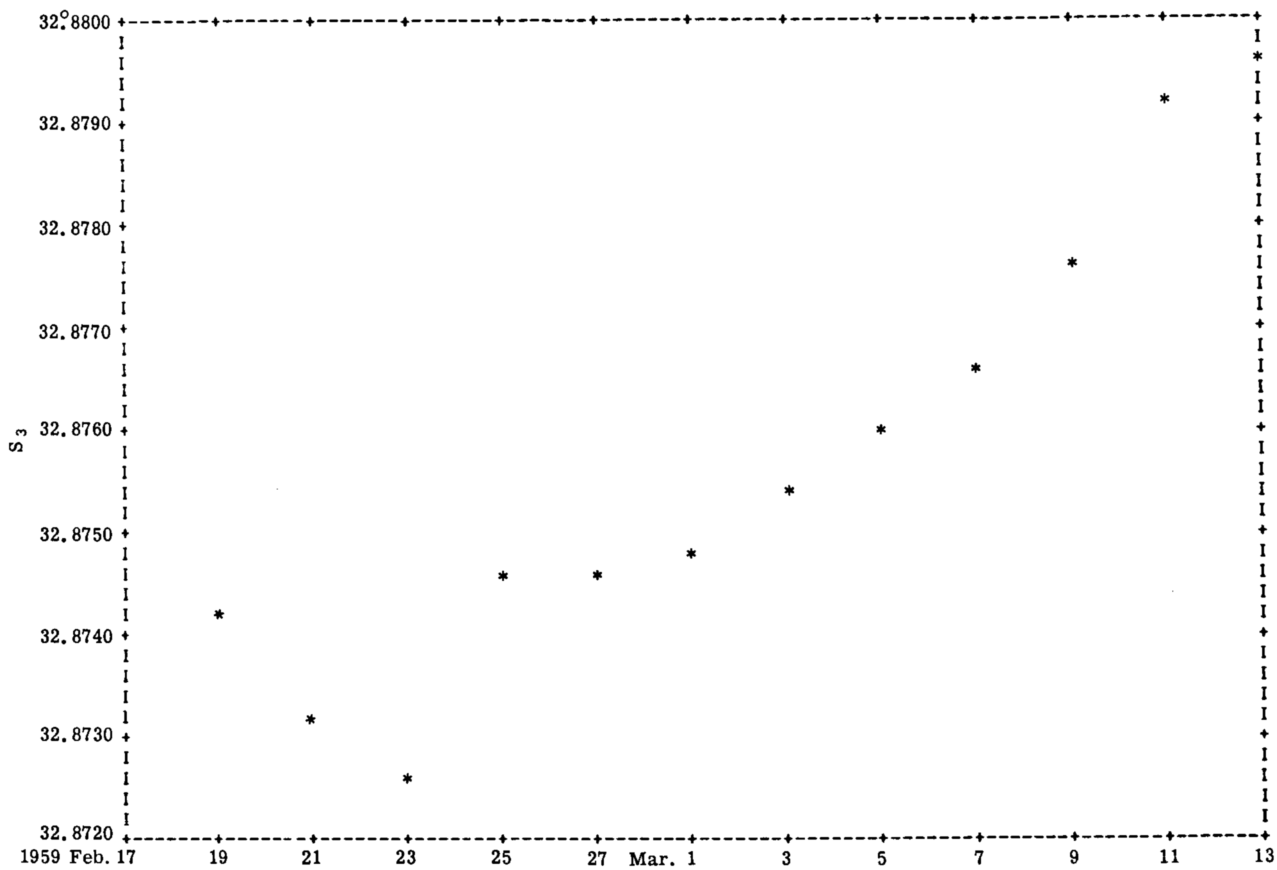

Figure 2c—Values of S_3 (degrees)

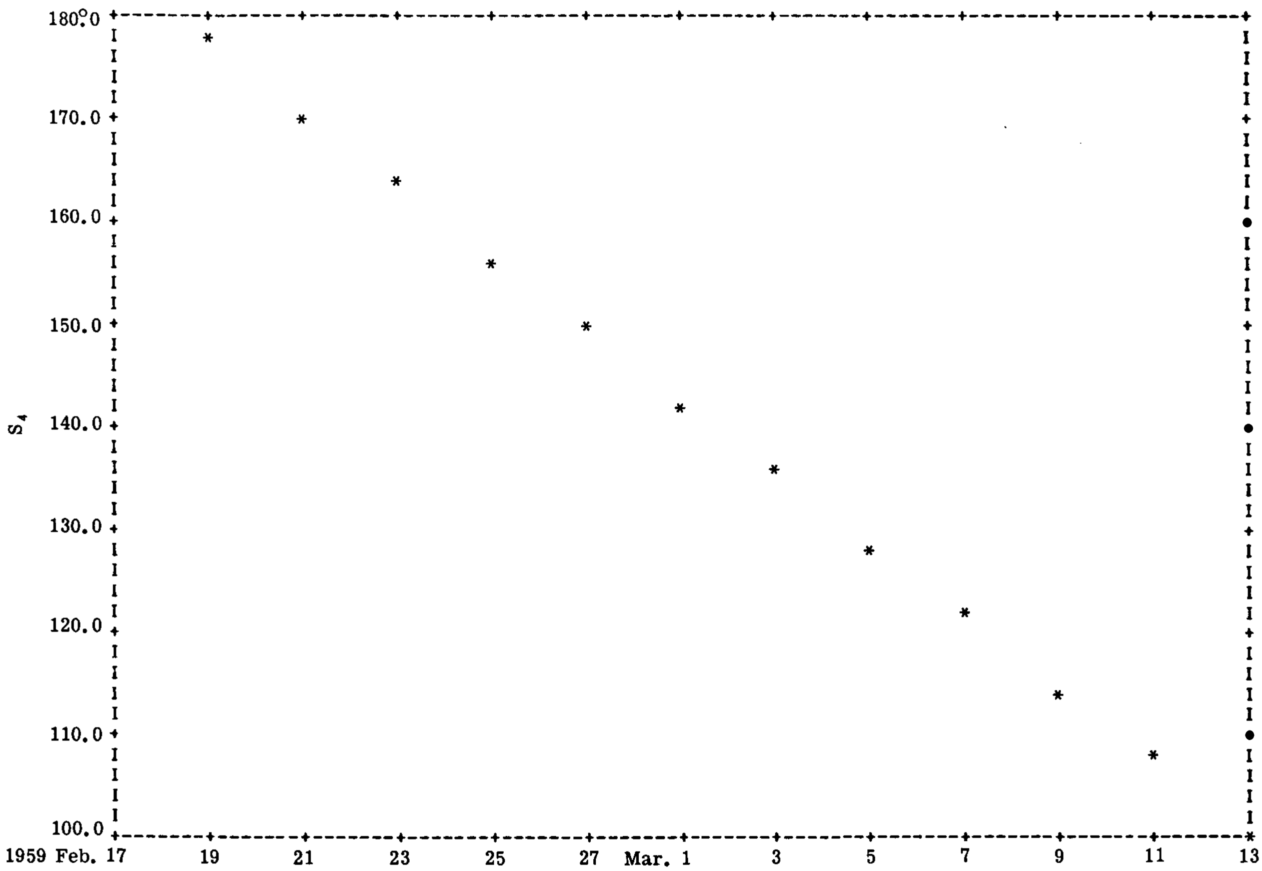

Figure 2d—Values of S_4 (degrees)

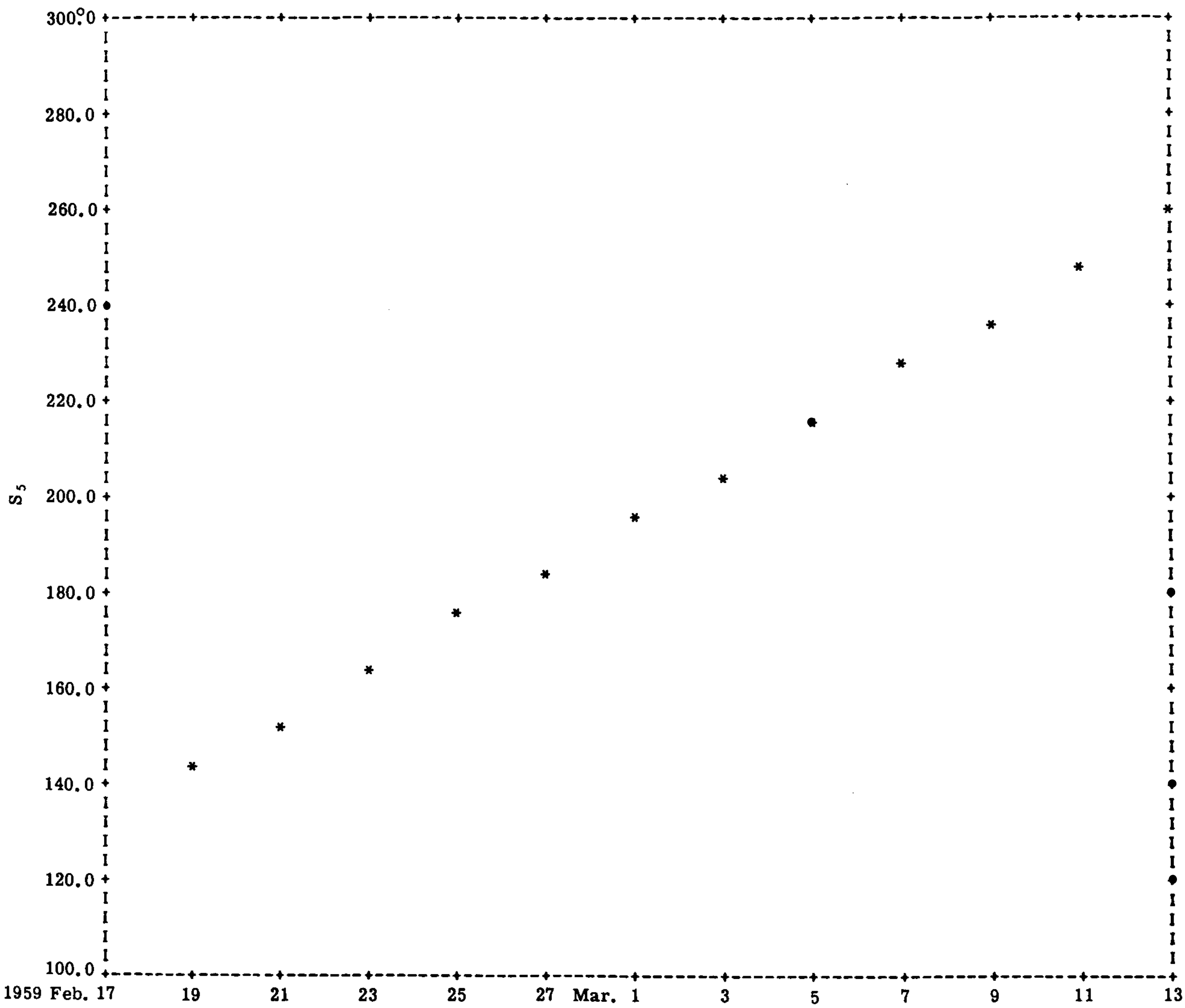

Figure 2e—Values of S_5 (degrees)

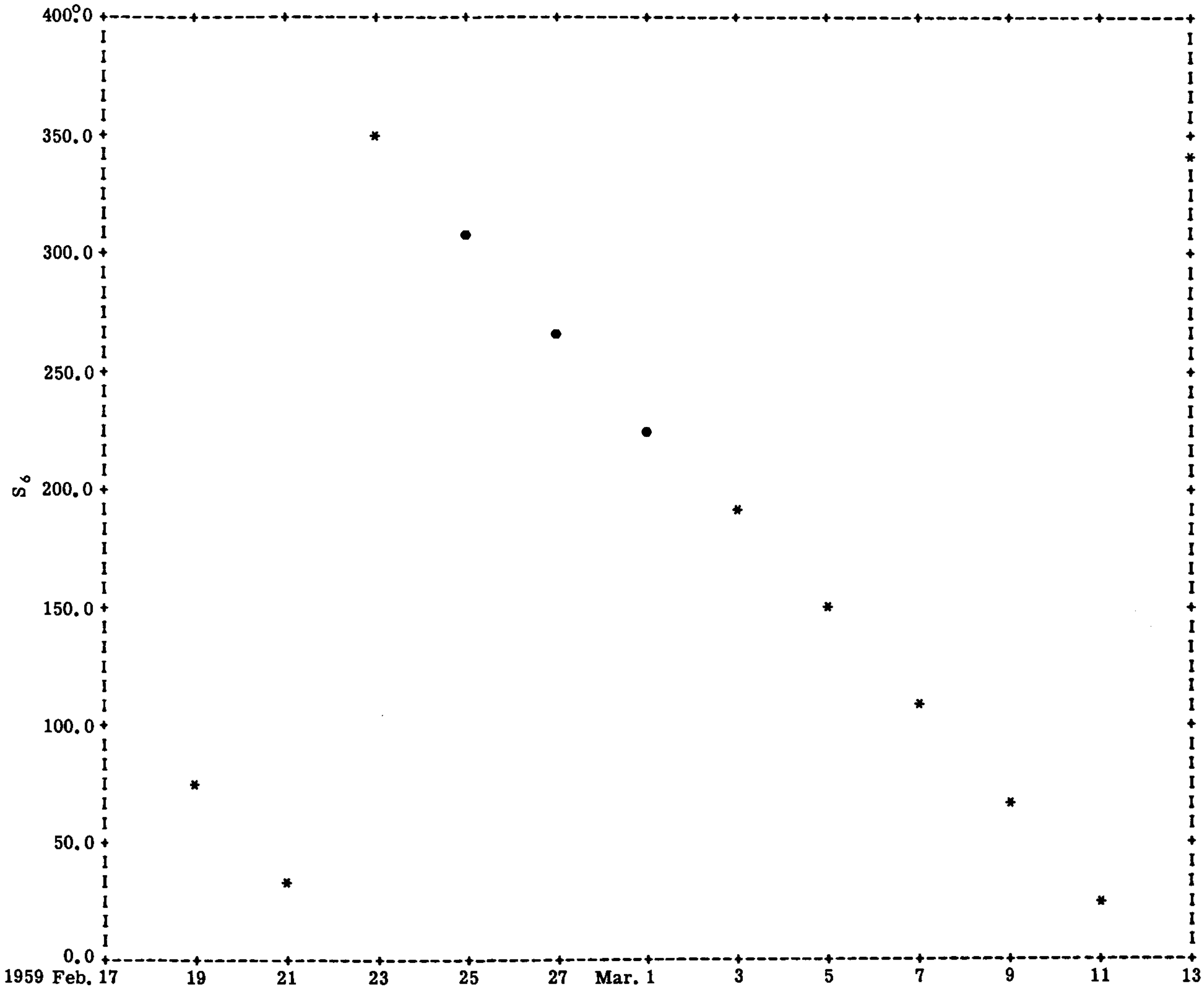

Figure 2f—Values of S_6 (degrees)

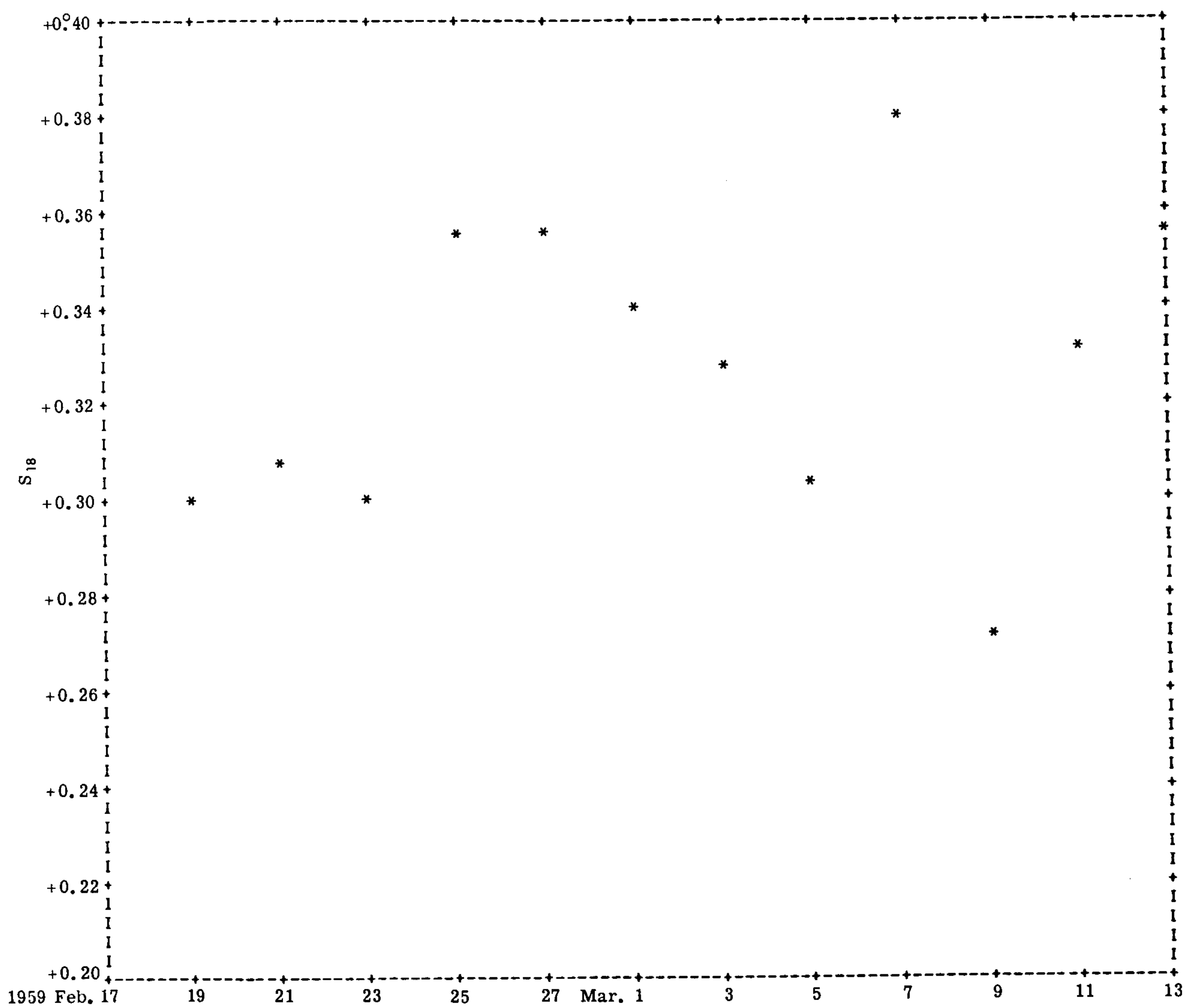

Figure 2g—Values of S_{18} (degrees)

Appendix A

List of Symbols

Symbol	Meaning
A_{30}	Constant for earth's potential (megameters^3)
A_{50}	Constant for earth's potential (megameters^5)
I	Inclination of orbital plane to equator (degrees)
M	Mean anomaly
R	Earth equatorial radius (megameters)
a	Semimajor axis (megameters)
e	Eccentricity (non-dimensional)
k	Gravitational constant (degrees megameters$^{3/2}$ hour^{-1})
k_2	Constant for earth's potential (megameters^2)
k_4	Constant for earth's potential (megameters^4)
$\Delta\delta$	Residual in declination
Ω	Longitude of ascending node
α	Right ascension
β	Declination of point for which potential is considered
δ	Declination
μ	k^2 (degrees^2 megameters^3 hours^{-2})
τ	Time in units of one-hundred hours
ω	Argument of perigee
$\cos\delta\,\Delta\alpha$	Residual in right ascension