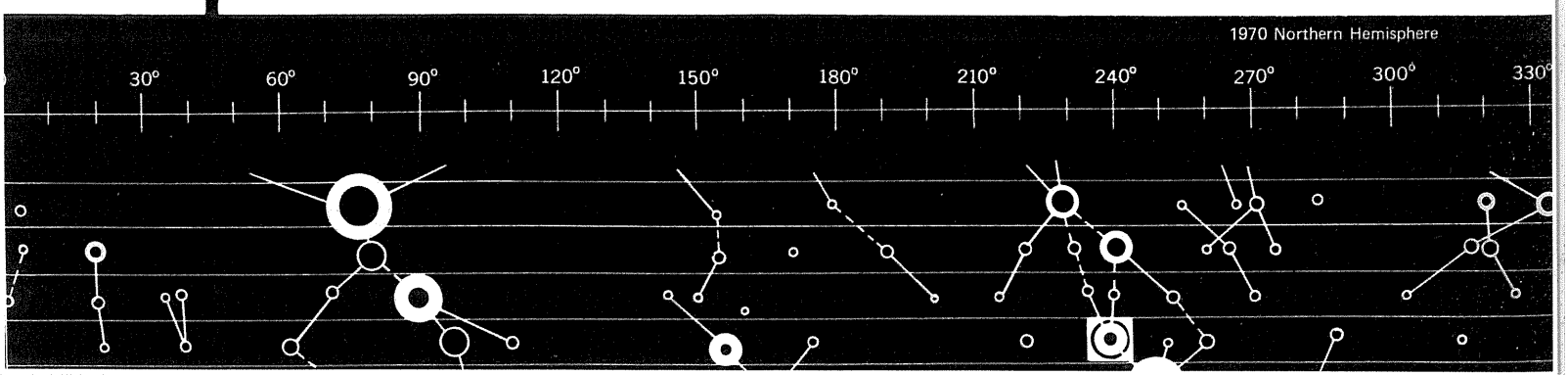
REPORT UAG-81

WORLD DATA CENTER A
for
Solar-Terrestrial Physics

EVOLUTIONARY CHARTS OF SOLAR ACTIVITY (CALCIUM PLAGES) AS FUNCTIONS OF HELIOGRAPHIC LONGITUDE AND TIME 1964-1979

August 1981



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Solar-Terrestrial Physics

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EVOLUTIONARY CHARTS OF SOLAR ACTIVITY (CALCIUM PLAGES) AS FUNCTIONS OF HELIOGRAPHIC LONGITUDE AND TIME 1964-1979

by

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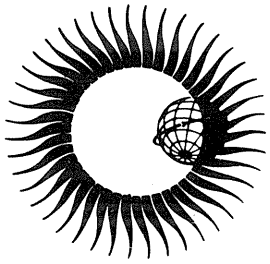

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I. INTRODUCTION

The richness and diversity of data relating to solar activity present a challenge from the point of view of organization and evaluation. For phenomena such as plages and centers of activity that tend to last for more than one solar rotation, we have found useful a sequence of "evolutionary charts" based on heliographic longitude for successive solar rotations. Such a diagrammatic representation of calcium plages as a function of longitude and time, coupled with considerations of heliographic latitude, permits relatively easy and confident recognition of successively returning centers of activity.

In past years, certain studies of solar activity prepared at the former McMath-Hulbert Observatory of the University of Michigan have used the format of such evolutionary charts to organize the chromospheric aspects of long enduring solar activity for time intervals of several years. For examples, see "Some Patterns in the Development of Centers of Solar Activity, 1962-1966", H. W. Dodson and E. R. Hedeman, IAU Symposium No. 35, Structures and Development of Solar Active Regions, page 56, 1968; also, "The History and Morphology of Solar Activity, 1964-1965", H. W. Dodson and E. R. Hedeman, Annals of the IQSY, Vol. 4, Page 3, 1969. These charts proved useful in recognizing patterns of large scale organization on the sun. It is possible that solar activity organized in this manner for 16 years, somewhat more than an entire solar cycle, can provide guidance for the interpretation of other aspects of solar activity and of phenomena of the interplanetary medium including sector boundaries, geomagnetic activity, energetic particle events and solar wind streams. To this end, evolutionary charts have been prepared at the Applied Physics Laboratory of the Johns Hopkins University on the basis of McMath-Hulbert Observatory data and diagrams, (with the exception of the last three months of 1979, for which plage data from the Hale Observatories and reported in the Solar-Geophysical Data Bulletins have been used). These charts organize data relating to practically all calcium plages reported by the McMath-Hulbert Observatory to World Data Center A for Solar-Terrestrial Physics (Boulder) in the years 1964-1979. The survey covers centers of activity for all of Cycle 20 and the rise to maximum of Cycle 21. More than 200 solar rotations are represented in the charts.

In order to characterize more fully the characteristics of the active centers depicted in the evolutionary charts, we present in Section II (Table 1) an extensive compilation of data on the principal centers of activity, 1964-1979. For each "family" of active regions, the remarks in Table 1 summarize significant solar characteristics as well as terrestrial effects such as geomagnetic storms and energetic particle events. In addition, a quantitative Active Region Index (ARI) and a more detailed Active Region Profile is computed from five solar indicators of the regions' disc transit activity (flares of $H\alpha$ importance ≥ 1, sudden ionospheric disturbances, sunspot area and magnetic complexity, and decimeter and meter radio emission). The Active Region Indices and Profiles are included in Section II, not only because they provide useful solar diagnostics, but also because of their possible relationship to the severity of solar-terrestrial disturbances during the disc transit of the principal active centers.

Each circle on the charts themselves represents a calcium plage reported by the McMath-Hulbert Observatory. The size and form of the circles vary according to the area, intensity, and flare activity of the center of activity defined by the plage. The size is related quantitatively to representative disc-transit CaK plage area-intensity measure (k) based on the daily values of corrected plage areas A (in millionths of a solar hemisphere) and intensities I (1 = faint, 5 = very bright) reported by the McMath-Hulbert Observatory and published in Solar Geophysical Data. The area-intensity measure is

$$k = \frac{A}{500} + 2\,(I - 3)$$

The thickness of the circles representing the active centers increases with increasing flare activity. Surrounding squares indicate the regions that produced flares associated with the most highly energetic particle emission. When the charts for 1979 were prepared, complete energetic particle data were not available; consequently no squares appear even though there were some PCA events, e.g., June 5, August 18 and 20, and November 15. The circles are plotted at the heliographic longitudes of the centers of the respective plages for the rotation in question (within $\pm$ 5°). Plages for which both latitudes and longitudes are relatively similar on successive rotations are considered to be returns of the same center of activity, and are connected by straight lines. Dashed lines sometimes connect old and dying plages with the resurgence of new and more active centers of activity in the same location. Dashed lines also join transient plages (duration < 14 days) with other more permanent features. On the charts, time runs from right to left (according to change in heliographic longitude on the sun) and from top to bottom (according to advancing Carrington rotations). The beginning time (month and day, to a decimal fraction) is indicated to the right of the Carrington rotation number on the right margin of the charts.

Latitudes are not specifically indicated for the individual plages on the charts because of the clutter which would result during years of high activity. To aid in the identification of specific centers of activity and to permit a clearer evaluation of the development of activity on the sun, separate evolutionary charts for the northern and southern hemispheres are presented in Section III. The section opens with an extensive graphical legend illustrating the description of symbols given above, and the pair of charts for each year (1964-1979) is preceded by a brief summary of the most notable patterns in the evolution of that year's activity. In order to provide a view of activity on the whole solar disc, combined evolutionary charts for the years 1964-1979 are presented in Section IV, with the symbols for northern regions in black and southern regions over-printed in blue. Again, the section is preceded by a graphical legend, in which the symbol sizes are graded by the values of the CaK area-intensity measure (k) precisely to the same scale as the following charts. Finally, a summary chart appears at the end of Section IV which combines the northern and southern charts of Section III into a single 16-year, 214-rotation (Carrington 1474-1689) evolutionary history of Solar Cycle 20 and the rise of Solar Cycle 21.

The effects of differential rotation are clearly evident in the evolutionary charts. In general, centers of activity with latitudes in the teens have rotation rates of approximately 27.3 days and present nearly vertical flow lines in the diagrams. New cycle regions with considerably higher latitudes tend to rotate more slowly and describe flow lines sloping downward to the left (e.g., chart for 1966N). Later in the cycle, regions with lower latitudes have faster rotation rates and generally develop flow lines sloping downward to the right (e.g., charts for 1970N and 1970S). Proper motions of the regions or asymmetric growth and decay frequently modify the above general patterns. It may be of some interest to compare the patterns in these evolutionary charts to the trends which appear in the charts of large-scale solar magnetic fields inferred from Hα absorption features published in the "Annotated Atlas of Hα Synoptic Charts" by P. S. McIntosh (UAG Special Report No. 70) which covers Solar Cycle 20 (1964-1974) in a corresponding format of 140 Carrington rotations (1487-1616).

II. DATA RELATING TO THE PRINCIPAL CENTERS OF ACTIVITY, 1964-1979

To aid in correlating the information contained in the evolutionary charts with other aspects of solar-terrestrial interactions, descriptive notes on individual centers of activity that were significantly above average, on the basis of flares, spots, or associated aspects of geophysical or particle phenomena, have been compiled in Table 1 for the principal centers of activity for the 16 years covered by the charts. Table 1 is arranged so that successive rotations of the same center of activity are grouped together. For each of the important centers, the level of activity has been quantified by computing an Active Region Index (ARI) which has been derived on the basis of the following solar indicators:

a. Number of flares of Hα importance 1 or greater (scale of 0-5)

No.	Scale
0-2	0
3-9	1
10-19	2
20-29	3
30-35	4
> 36	5

b. Number of Sudden Ionospheric Disturbances (scale of 0-5)

No.	Scale
0-1	0
2-5	1
6-15	2
16-25	3
26-49	4
> 50	5

c. Spots - area and magnetic complexity (scale of 0-5)

Sunspot Area*		Spot Type and Scale		
Max	Mean	α_p	β	βγ,γ
<500	<500	0	0	1
500-1000	<1000	0	1	2
>1000	400-1000	1	2	3
1000-3000	1000-2000	2	3	4
>3000	>2000	-	4	5

*Spot areas in millionths of the hemisphere.

d. Intensity of ~ 10 centimeter radio emission/maximum radio temperature (scale of 0-5). When data were available, this component of the region profile was based on the maximum radio temperature of the plage as it traversed the solar disk, as observed on the whole disk scans made by the radio telescope of Stanford University at a wavelength of ~ 10 centimeters.

Max. Radio Temp. (x 10^4 °K)	Scale
0-25	1
26-50	2
51-75	3
76-100	4
>100	5

After 1973, the Stanford temperature data were no longer available. For subsequent years, evaluations have been based on the daily east-west scans at a wavelength of ~ 10 centimeters, made with the radio telescope at Ottawa. The scale used (0-5) was then dependent on the maximum height reached on the daily scans for the appropriate region. This was a subjective evaluation, but was made after intercomparing many of the earlier regions, for which radio temperatures were known from the Stanford data, with the concurrent Ottawa scans.

e. Intensity of meter wavelength radio emission (scale of 0-4). For this component of the region profile, the Nancay charts presenting the solar interferometric observations at 169 MHz were examined. The Nancay records also were compared with plots of the daily 200 MHz solar flux, and when Nancay observations were not available, the latter data were used.

When an active region could be identified on the Nancay charts with a reasonable degree of certainty, the maximum intensity of the region as it crossed the disk between east limb and west limb (as recorded on the charts) was then converted to a scale of 0-4. Although these were subjective evaluations, an effort was made to keep the numbers within the following bounds:

Evaluation	Nancay Max. Intensity	Scale
"Radio noisy" region for only a few days.	< ~ 30	0
"Radio noisy" region for 1-7 days.	< 100	1
Radio noise present during almost entire disk transit.	100-200	2
Strong radio noisy region.	~ 200	3
Very strong radio noise during disk transit.	> 200	4

The Active Region Index is the sum of the five evaluations:

$$ARI = a + b + c + d + e$$

More detailed information pertaining to causal effects of solar-terrestrial disturbances is contained in the Active Region Profile, which is represented by the five numbers (a,b,c,d,e) that appear to the left of the ARI in Table 1.

The list of principal centers of activity in Table 1 has been supplemented by the addition of data relating to certain regions of apparently lesser levels of activity but known to have been of some specific interest. For these regions, the Active Region Index is not reported.

In addition, extensive remarks have been prepared for the plages and "families" of plages of Table 1. These comments include frequent references to "CFI flares", i.e., "major" flares for which Comprehensive Flare Indices have been derived and published in UAG Special Reports Nos. 14, 52, and 80. The energetic particle events referred to for 1964-1969 are based on data in the "Catalogue of Solar Particle Events, 1955-1969" edited by Z. Svestka and P. Simon (D. Reidel, Dordrecht, 1975). For subsequent years, flare-associations with particle events are based on data (1) for 1970-1972 in Technical Reports by Dodson and Hedeman to Air Force Geophysics Laboratory, (2) for 1973-1974 in reports to The Johns Hopkins University/Applied Physics Laboratory, and (3) for 1975-1979 on unreported studies by the authors. PCA events for 1979 are included in these remarks, even though we were not able to indicate them on the evolutionary charts. It is hoped that the detailed information contained in these extensive comments can provide useful information and guidance in the interpretation of possible relationships between features of the evolutionary charts and time-related interplanetary or geophysical phenomena.

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TABLE 1

INFORMATION ABOUT REGIONS OF SPECIAL INTEREST, 1964-1979

YEAR	ROT. NO.	L_o (Deg)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1964	1478	200	7182	Mar 11	N04	11000	2
An active region of old cycle 19. PCA flare on March 16.							
1965	1490	160	7661	Feb 04	N09	10000	1
Last significant active center of old cycle 19. Continuation of activity in same zone of active longitude, after lull during months of solar minimum (April-December, 1964). Major PCA flare on February 5.							
	1494	195	7809	May 21	N23	11100	3
	1494	175	7812	May 23	N24	10000	1
Development of first significant activity of new cycle 20, in same active longitude zone of earlier old cycle activity. Two large, bright and flaring plages at high latitude. Low energy proton flare on May 25, in region 7809.							
	1499	230	8012	Oct 02	S19	10000	1
	1499	217	8005	Oct 03	N21	22210	7
Continued new cycle activity in same longitude zone (with slight shift westward on sun). Weak PCA flare on October 4 in southern region 8012.							
	1502	203	8105	Dec 25	N10	10200	3
Major new cycle activity has rapidly reached low latitude of N10°. Weak proton flare on December 30 in region 8105.							
1966	1503	235	8130	Jan 19	N29		
	1503	227	8131	Jan 19	N18	01300	4
	1503	207	8132	Jan 21	N11		
	1503	195	8133	Jan 22	N31		
A "cluster" of bright and active new cycle plages at both high and low latitudes in same active longitude zone as previous active regions. Proton flares in region 8131 on January 17 and January 19.							
	1505	137	8207	Mar 22	N20	54313	16
A great flaring region during entire transit across disk. Twelve major CFI flares between March 15-25. Energetic proton flares on March 17, 18, 19, 20, 21, 22, 24, 25 and 27. PCA flare on March 24. Region contains first large, complex γ spot of new cycle.							
	1506	335	8223	Apr 03	N27	34421	14
First major region to appear in hitherto inactive longitude zone, on opposite hemisphere of sun. Six major CFI flares between March 28-31. Weak							

low energy proton flares on March 31 and April 1. Region contains large, complex βγ spot.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1966	1509	213	8362	Jul 03	N33	23310	9

A flare-rich region at high latitude, in active longitude zone, with rapidly growing large, complex βγ spot. Energetic flare with ground-level cosmic ray event on July 7 (first GLE of new cycle). Also proton flare on July 9 (near west limb) and proton events on July 14 and 16, attributed to region 8362 on invisible hemisphere.

	1510	198	8413	Jul 31	N35		

Return of region 8362, still active. Energetic proton flare of importance 3b on July 28.

	1511	248	8454	Aug 24	N08		

A low latitude new cycle region. A βρ spot appears on disk on August 23, grows rapidly, and becomes a very "stable" feature since it persists for 6 solar rotations (until January 1967).

	1511	180	8461	Aug 29	N22	22312	10

A major active region, with large and complex βγ spot, and growth of added new plage since previous rotation. Nine major CFI flares between August 24 and September 4.

Strong PCA-proton flares on August 28 and September 2. Proton flare at west limb on September 4.

1967	1517	127	8687	Feb 13	N24		

A major GLE on January 28, 1967 is spatially located about 60° beyond west limb of sun, on invisible hemisphere. This coincides with the location of new region 8687, which formed on the invisible hemisphere. A major flare of importance 3b occurs in this region on February 13 (as small spots are dying), producing PCA and protons.

	1518	295	8704	Feb 27	N23	54442	19
	1519	295	8740	Mar 27	N21	54330	15

Successive returns of a great flare-rich region in its second and third rotations. Proton flares on February 27 and March 24 and March 27. Both regions contain very large and complex spots, and each region produced 8 major CFI flares, between February 22-March 4, and March 22-April 1.

	1521	232	8818	May 25	N26	34451	17

A great, active and flare-rich region with very large and complex βγ-δ spot. Major flares on May 23 and May 28 produce strong PCA and

very energetic proton events, and subsequent strong geomagnetic activity at earth.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1967	1523	100	8905	Jul 28	N27	45444	21
	1524	90	8942	Aug 26	N22	34330	13

Successive returns of very large and flare-rich regions that contain both old and new plage which can be traced back to its original appearance in rotation 1517. Both regions contain large and complex $\beta\gamma$ spots. Although the regions each produce many flares, relatively few of them are major CFI flares.

Proton flares occur in region 8905 on July 30, August 1, 2, 3 and 4, and numerous electron events occur on July 28, 29, 30, 31 and August 2.

Low energy proton flares occur in region 8942 on August 18 and August 24.

	1526	27	9034	Oct 24	N13	21300	6
	1527	32	9073	Nov 19	N16	11300	5
	1528	30	9115	Dec 17	N14	23322	12
1968	1529	30	9153	Jan 13	N20	11200	4

The second, third, fourth and fifth members of a long-lived family of active plages, with successive returns at same location for about 8 solar rotations. Represents a new outbreak at this longitude after a long interval of quiescence (at corresponding longitudes) in the northern hemisphere. Proton flares occur on October 26, 27, 29 and 30 in region 9034. No major proton flares during disk passage of regions 9073 and 9115 in subsequent rotations. Proton flare on January 14, 1968 in region 9153.

Low energy proton flux, however, is greatly enhanced during entire disk passage of region 9073. The spot in region 9073 is large and complex ($\beta\gamma$-δ).

1967	1527	245	9047	Nov 03	S22	22100	5

Increased activity in southern hemisphere, in longitude zone favored during early onset of new cycle activity in northern hemisphere. Four major CFI flares. PCA flares on November 2 and November 7. Other flares with energetic protons on November 4, 10, and 11.

	1529	245	9128	Dec 28	S21	11302	7

A resurgence of activity in southern hemisphere in midst of old plage from active region 9047 (see preceding event). Flares with electron bursts on December 28 and 29.

1968	1529	87	9145	Jan 09	S22	21300	6

Increased activity in southern hemisphere, on opposite side of sun from location of previous active region 9128. Four major CFI flares occur in region 9145. PCA flare on January 11 and other proton flares on January 11 and 12. Spot is large and complex ($\beta\gamma$).

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1968	1529	60	9146	Jan 11	N13	33410	11

Flare-rich region with complex βγ spot. Six major CFI flares. PCA flare on January 12, and other proton flares on January 9, 15 and 17.

Low energy proton flux is enhanced during C. M. passage of regions 9145 and 9146.

	1530	160	9184	Jan 31	N15	33543	18

Flare-rich region with very large βγ spot. Strong radiator at CM and M wavelengths, and in X-rays. Four major CFI flares. PCA flare on February 8. Other proton flares on February 1, 2, 5 and 6. This major flaring region does not produce any major geomagnetic activity at earth.

During the early part of 1968, increased solar activity has spread to all longitude zones on the sun, in both the northern and the southern hemispheres. Much of the increased flare activity was accompanied by proton emission (mostly at low energies). The most significant events were associated with the following regions.

	1535	245	9429	Jun 09	S12	12200	5

A major flare of importance 3b (CFI = 14) occurs in this region on June 9. The flare was accompanied by PCA (6.5 db), electrons (> 40 keV), and strong proton emission (> 94 MeV), and was followed by a major geomagnetic storm on June 10. Although plage and spot are not especially large, they lie in a favored longitude zone (245°). New cycle solar activity in the southern hemisphere has now reached low latitudes.

	1536	155	9503	Jul 13	N11	23430	12

A resurgence of solar activity in the northern hemisphere, at longitude ~ 160°. (See region 9184, above). Region 9503 is a very large and very bright plage. The accompanying large and complex sunspot diminishes rapidly in area after east limb passage. Four major CFI flares occur while region is far to east (between E40 and E90°). A flare at the east limb on July 6 was accompanied by PCA and very strong proton emission. Another major flare, of importance 3b, CFI = 17, followed on July 8, also with PCA and protons. Very strong proton emission was recorded with each of these flares by the satellite Pioneer VII, for which the Earth-Sun angle was -77°. After July 12 (near C. M. passage), major flaring in the region ceased.

	1537	157	9567	Aug 09	N12	22320	9

Return of active region 9503. Very large and very bright plage. Large and magnetically complex spot with δ configuration. Flares on August 3, 6 and 14 accompanied by proton emission.

	1537	32	9593	Aug 18	S14	23301	9

An important southern region, in a longitude zone previously dominated (for almost a year) by active regions in the northern hemisphere. Four major

CFI flares on August 13, 18, 20 and 21. Flare with low energy proton emission on August 21.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1968	1540	240	9735	Oct 23	N17	34311	12

A major northern region in a favored longitude zone for previous southern hemisphere activity (see active regions 9429, 9128 and 9047). A very large and very bright plage, with large and magnetically complex spot. Four major CFI flares on October 20, 21, 28 and 29. No "proton flares", but probably a low energy "particle stream" (sequential), related to the disk transit and C.M.P. of the region.

	1540	175	9740	Oct 28	S15	44414	17

One of the few truly great regions of solar cycle 20, and the most important region of 1968. Very large and complex spot, with δ configuration. Strong emitter of x-rays, and of radio emission at meter wave-lengths. Fourteen CFI flares occur in the region between October 23 and November 4. Six of these flares are importance 2, with CFI's of 10, 11, 12 and 14. A major flare of importance 3b (CFI = 13) occurs on October 30, with PCA and strong proton emission. Other PCA flares occur on November 1 and November 4. This great region 9740 is the first active region in the southern hemisphere to appear in the active longitude zone between 150°-180°, which heretofore has been dominated by activity from regions in the northern hemisphere. Major geomagnetic activity at earth between October 31 and November 4 can be associated with the major flaring activity in region 9740.

	1541	350	9760	Nov 11	N18	12301	7

A flare at the west limb in region 9760 (CFI = 10) on November 18 produced a significant ground level cosmic ray enhancement, PCA, and energetic electron and proton emission. Although flaring regions have appeared off and on between longitudes 330°-360° since the onset of solar cycle 20, this has not been an especially active longitude zone (see other active region at this longitude in April 1966).

	1542	354	9802	Dec 08	N21		

Region 9802 is a return of the "cosmic ray flare" region 9760 of the previous rotation. It is not a major active region, and contains only rather small α spots. A major CFI flare of importance 3n ($I > 9$) occurs on December 2 when the region is near the east limb. The flare was accompanied by PCA, and strong proton emission.

	1542	105	9842	Dec 27	N19	22401	9

Six major CFI flares occur in this region between December 23 and December 29, mostly of importance 1, and with type II bursts in the dynamic spectrum. A flare of importance 2b on December 27 (CFI = 10) was accompanied by moderate proton emission. Other low energy proton flares occurred on December 26, 28, 30, and January 3.

Although the longitude of ~ 100° has not been an especially active zone during previous months in 1968, it will prove to be extremely active throughout most of 1969.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1969	1543	108	9879	Jan 23	N22		

Region 9879 is a return of active region 9842 of the previous rotation (see above). A flare of importance 3n occurred in the region on January 24 (CFI ≥ 8). Although the plage continues to be large and bright, it contains only a rather small and inconspicuous single spot. The 3n flare was accompanied by PCA and energetic protons and electrons.

1544	60	9946	Feb 23	N16	24212	11
1545	75	9994	Mar 21	N18	35431	16
1546	75	10035	Apr 18	N17	34200	9
1548	85	10134	Jun 10	N17	23322	12

Region 9946 is an extremely large and very bright plage (some of which formed on the disk during the previous rotation), containing a large β-type spot. Activity in this region and in its many successive "descendents" make the longitude zone of 60°-110° a conspicuous feature throughout 1969.

Ten major CFI flares occur in region 9946 between February 20 and March 1, as the region transits the disk. Major flares on February 23, 24, 26 and 27 were accompanied by PCA and other energetic particle emission. A great flare on February 25 (CFI = 13) also produced a major ground level cosmic ray event.

Region 9946 returns in March as region 9994 - an extremely large and very bright plage, containing a very large and complex spot with a δ configuration. The region is rich in x-rays, and is a strong emitter of ten-cm. radio radiation. Eleven major CFI flares occur in 9994 as it transits the disk between C.M. and west limb passage. Major flares on March 21 (CFI = 12 and 14) contribute to the production of PCA and other very energetic particle emission. A great "beyond the west limb" event on March 30 (seen as a great eruptive prominence, and recorded on the Culgoora radioheliograph) produced another large ground level cosmic ray event.

When the region returned again in April (as region 10035), it continued to be active, although at a somewhat reduced level. While the plage remains very large and bright, the spots are considerably reduced in size, and are no longer complex. A major PCA event on April 11 (with very energetic protons and electrons) is attributed to region 10035 when just beyond the east limb. A great flare of importance 3b (CFI = 10) occurs in the region on April 21. No energetic particles are reported with this flare.

After an inactive transit in May, the region returns in June (as region 10134), having undergone a resurgence in spot development and major flare activity. The plage is larger and brighter, and a large, complex spot has developed in the region. Five major CFI flares occur between June 5 and June 11, while the region transits the eastern half of the disk. Two major flares on June 5 (importance 2b, CFI = 14, and importance 3b, CFI = 11) are accompanied only by low energy particle emission. A flare on June 7 produced moderate PCA.

Although there continue to be plage "descendents" in subsequent rotations, major activity in the region essentially ceases after the transit of region 10134.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1969	1545	275	9966	Mar 06	N13	23100	6
	1546	270	10014	Apr 03	N17	14440	13
	1547	275	10057	Apr 30	N13	12200	5
	1548	290	10109	May 26	N13	33101	8

On the opposite hemisphere of the sun, the solar longitude of ~ 270° (which was an active longitude throughout 1968) continues to be a part of an active zone (between 240°-280°) in which another "family" of active regions is comspicuous. Major activity in this family begins in region 9966, when it is in its third rotation. Five major CFI flares occur in the region between March 2 and March 13. A major flare on March 12 (CFI = 14), when the plage was near the west limb, was accompanied by PCA.

The region returns in April, rich in x-rays and strong in ten cm. radio radiation. The plage is very large and very bright and contains a very large and magnetically complex spot, with a δ configuration. No major flares or energetic particle events are reported during the disk transit of region 10014. (There is an unidentified strong PCA event on April 11, but it is attributed to an active region on the opposite hemisphere.)

The region returns again at the end of April (as region 10057), still large and bright, but with its complex spot now greatly reduced in area. Two major CFI flares occur on April 26 (CFI = 12) and May 2 (CFI = 10). Moderately energetic particle emission occurs with flares on May 2 and May 5, as the region moves toward the west limb.

In May, the region returns again, as region 10109. Eight major CFI flares occur, between May 17 and May 30, as the region transits the disk. Several flares on May 28 and May 29 produce moderate proton emission. The conspicuous activity of region 10109, however, is in the frequent electron bursts that accompany small flares in the region, especially between May 28 and May 31, as the plage approaches the west limb. Rotation 1548 is the last rotation in which any major activity occurs in any member of this "family" of plages, although the "line of descent" continues for 3 more rotations.

	1548	85	10135	Jun 10	S16	23422	13
	1549	90	10181	Jul 07	S16	22310	8

During the first half of 1969, major solar activity has been confined to longitude zones located on opposite hemispheres, and to active regions in the northern hemisphere. Region 10135 is the first <u>major</u> southern region to appear, and it has developed after the active "family" of northern plages (L_o = 60°-85°) has reached its maximum development. Region 10135 contains one of the largest spots of solar cycle 20; it is the first large spot (mean area > 1500 millionths of the hemisphere) to appear in the southern hemisphere. The spot is magnetically complex, with a δ configuration. Although region 10135 is a strong producer of x-rays and radio radiation, almost no particle emission is reported with any of its flares.

Region 10135 returns in the next rotation as active region 10181. The plage continues to be very large and bright, and the spot is still large and complex, though now diminished in area to half its previous size.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1969	1552	130	10326	Sep 24	N15		

During July, August and September, 1969, there is a marked diminution in major solar activity, interrupted by the occurrence of major flares on September 25 and September 27. A flare of importance 3n occurs in region 10326 on September 25 (CFI = 5). The region is in its third rotation, and is virtually "spotless". The flare produced moderate PCA, and other energetic particle emission.

	1552	86	10333	Sep 27	N09	10200	3

On September 27, a flare of importance 3b (CFI = 12) occurs in region 10333. This region, in its third rotation, is a part of the continuing activity in the northern hemisphere in the favored longitude zone 60°-85°. Moderate proton emission accompanied this major flare.

	1553	65	10385	Oct 26	N12	23421	12
	1554	75	10432	Nov 22	N11	54421	16
	1555	78	10477	Dec 19	N12	22000	4
1970	1557	90	10568	Feb 10	N16	34210	10

There is renewed major activity in the northern hemisphere in the active longitude zone (60-80°) favoring the production of major flares and energetic particle emission. Region 10385 is in its third rotation, and apparently developed rapidly while on the invisible hemisphere. The plage is very large and bright and contains a very large and complex spot, with a δ configuration. A major flare at the west limb on November 2 (CFI = 11) produced the strongest PCA event (14.5 db) since the onset of solar cycle 20.

Region 10432 is a return of region 10385, which must have continued its development while on the invisible hemisphere. The plage continues to be extremely large and bright, and the spot continues to be large and complex, with a δ configuration. Region 10432 was a strong producer of flares of importance $\geq$ 1, and was also rich in x-rays. Nine major CFI flares occurred in the region between November 18 and November 27, as it transited the disk. Many of these flares also were accompanied by energetic particle emission. A flare of importance 2b on November 24 (CFI $\geq$ 12) produced a moderate PCA event.

The very active region 10432 returns as region 10477 - still a very large plage, but lessened in intensity, and with spots now fragmented, much smaller in area, and no longer complex.

Region 10568 exhibits the characteristic development of new plage that frequently occurs in the midst of persistent old plage. There has been a resurgence of activity at the favored active longitude of 60°-90°. Although region 10568 is large and bright, contains a large spot, and is rich in x-rays, it does not produce any major CFI flares, or any particle emission.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1970	1557	290	10542	Jan 27	S20	22310	8
	1558	295	10584	Feb 23	S15	22000	4

A resurgence of activity in the other active longitude zone of 1969 (L_o = ~ 270°), this time in the southern hemisphere. Region 10542, in its third rotation, has developed a large β_p -type spot which becomes magnetically complex, with δ configuration, between January 28 and January 30. Major CFI flares on January 28 and January 31 are accompanied by strong proton emission, and some PCA.

Region 10584 is a return of active region 10542. It is very large and very bright, but spots are greatly reduced in area and no major solar activity occurs in the region.

1558	237	10595	Feb 27	N16	22300	7
1559	247	10641	Mar 25	N16	33110	8
1561	260	10743	May 18	N16	13420	10
1562	265	10781	Jun 14	N18	22301	8

Activity in region 10595 represents a major increase in activity in what had been a persistently inactive zone on the sun for most of 1969. Six major CFI flares occur in the region between February 21 and March 4, as the plage transits the disk. Strong flares on March 1 and 4 (CFI's = 10 and 11) are accompanied by low energy particle emission. PCA on March 6 is attributed to a "behind the west limb" event, when bright surges, a spray, and loops are observed at the location of region 10595 at the northwest limb. The region returns as 10641 - a large and very bright plage, containing a scattering of β-type spots. Six major CFI flares occur in 10641 between March 21 and March 29, as the region traverses the disk. Flares with energetic particle emission occur on March 21 (CFI = 5), March 25 (CFI = 11) and March 29 (CFI = 14). A small PCA event also is reported on March 29.

There is a resurgence of activity within this "family" of active regions in rotations 1561 and 1562 when very large and magnetically complex spots appear in the large and bright plages 10743 and 10781. No major flares occur in these regions, however.

1558	155	10607	Mar 05	N08	24202	10
1559	160	10652	Apr 01	N07	11100	3

Region 10607 is a major region which has developed in a previously inactive longitude zone. Seven major CFI flares occur between February 27 and March 2, as the region transits the disk. Four of these flares have CFI's = 11, 12, and 13. Major flares in the region on March 1 (CFI = 9, 11 and 13) were accompanied by low energy particle emission. In the next rotation, activity diminishes, the spot (though complex) is small, and there is no major activity.

1558	82	10618	Mar 10	S15	22310	8

Region 10618 is a major plage in the southern hemisphere in the longitude zone (60°-90°) which has favored the occurrence of important solar activity and energetic particle emission since early in 1969. Flares accompanied by energetic protons occur in the region on March 6 (CFI = 10), and March 7.

Subsequent returns of this plage in later rotations do not produce any major solar activity.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1970	1559	3	10675	Apr 13	N16	23200	7
	1560	6	10725	May 10	N15	13310	8

These regions - 10675 and its subsequent return as 10725 - represent an increase in solar activity in a longitude zone (~ 0°) which has been inactive for more than a year and a half. The "interruption" is temporary, however, since activity subsides after two rotations. Three major CFI flares occur in region 10675. One of these, on April 8 (CFI = 8) was accompanied by low energy particle emission.

	1559	60	10670	Apr 09	N11	11221	7
	1559	55	10669	Apr 09	S15	13421	11

These are regions north and south that are almost co-longitudinal, and are in the "favored" active longitude zone of 60°-90°. A major flare (CFI = 14) occurs in region 10670 near the west limb on April 15, accompanied by energetic particle emission and a weak PCA event. Region 10669, in the southern hemisphere, is a large and very bright plage, with a large and complex spot. Minor flares in region 10669 on April 6 and April 7 are accompanied by moderate proton events.

	1561	128	10760	May 28	S09	23200	7
	1562	135	10798	Jun 23	S08		

Region 10760 is one of the few regions in the southern hemisphere in which any major activity has occurred thus far in 1970. The "ancestor" of 10760 (in rotation 1560) developed in the midst of old plage descended from active region 10618 (see rotation 1558, above). Flares with energetic protons occurred on May 30 (CFI = 7) and June 2 at the west limb (CFI = 10). Low energy proton events on June 5 are attributed to "beyond the west limb" activity in 10760 on the invisible hemisphere. A moderate PCA event accompanied the flare of May 30.

Region 10798 is a return of active region 10760. On June 25, a flare of importance 2n occurs in region 10798, which is "spotless" on that day. This flare was accompanied by energetic particle emission, and weak PCA.

	1561	215	10789	Jun 17	N19	45410	14

During the latter half of 1970, major solar activity in the northern hemisphere now spreads to important solar plages located at all longitudes on the sun. Region 10789 has developed in a previously inactive longitude zone. The region is rich in the production of flares and x-rays, and contains a very large and complex spot. The plage is very bright. Ten major CFI flares occur in the region between June 13 and June 17, as the region traverses the eastern half of the disk. A major flare on June 14 (CFI = 11) was accompanied by energetic protons. A gradual rise and fall in low energy proton flux (between June 12 and June 26) is attributed to the disk transit of region 10789.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1970	1562	95	10801	Jun 27	N12	11100	3
	1563	95	10845	Jul 24	N12	24312	12
	1564	97	10882	Aug 20	N10	12200	5

A new resurgence of activity at the "favored" longitude of ~ 90° begins in the northern hemisphere with the development of this "family" of plages. Region 10845 is large and very bright, and contains a large and complex spot with a δ configuration. Eleven major CFI flares occur in the region, between July 19 and July 27, as the region traverses the disk. Many of these flares have CFI's $\geq$ 10. Major flares on July 20, 21, 23 and 27 are accompanied by energetic particle emission. A flare on July 23 (CFI = 12) produced a moderate PCA event.

When the plage returns in rotation 1564, as region 10882, plage and spot are diminished in area, but the spot is still complex. After east limb passage on August 13, the spot decreases rapidly in area. A bright limb flare, with coronal loops (CFI = 14) occurs on August 12, when the region is just beyond the NE limb. This flare was accompanied by very energetic proton emission.

A major flare on August 14 (CFI = 12), when the region is at E74°, is also accompanied by energetic particle emission, and moderate PCA. [Note - almost simultaneously, a major flare (CFI = 11) occurs in active region 10865 near the west limb (see below), so the source of the particle emission may be moot.]

	1562	40	10808	Jul 01	N24	23310	9

A large, bright plage containing a moderately large and complex spot with a δ configuration. Seven major CFI flares occur in the region, between June 28 and July 7. Flares accompanied by energetic particle emission occurred on June 28, July 1, 2, 6, 7 and 8.

	1564	235	10865	Aug 09	N18	1431-	$\geq$ 9
	1565	238	10918	Sep 05	N18	12412	10
	1567	250	11002	Oct 29	N18	33311	11

Region 10865 represents a resurgence of activity in old plage descended from active region 10789 (see rotation 1562, above). The bright plage contains a magnetically complex spot which grows on the disk, increasing rapidly in area on and after August 13. CFI flares occur in the region on August 10, 12, 14 and 16. A major CFI flare on August 14 (CFI - 12) occurs simultaneously with a major flare in region 10882. These synchronous flares were widely separated on the solar disk (W75 and E74). Energetic particle emission and PCA were reported.

Region 10918 is a return of region 10865. The plage has more than doubled in size, and the complex spot is now quite large, with a δ configuration. Relatively few major flares occur in the region. A CFI flare on September 8 (I = 11) produced a low energy particle event. After diminishing in form and activity in rotation 1566, there is a resurgence of activity and new growth in the plage. As plage 11002, the region is large and bright and contains a large and complex spot with a δ configuration. Four major CFI flares occur in the region, between October 26 and November 4. Flares producing

proton emission (mostly low energy) occur on October 25, 27, 28 and November 1. In subsequent rotations, the plage is fragmented and greatly diminished.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1970	1567	130	11019	Nov 07	S12		

A flare of importance 3b occurred in region 11019 on November 5. This major flare (CFI = 14) was accompanied by very energetic particle emission, and PCA. Although the plage was large and bright, it contained only 2 or 3 very small β-type spots. The important flare was related to a major "disappearing filament" in the region.

1567	35	11029	Nov 14	N15	24423	15
1568	42	11073	Dec 11	N15	22300	7

This large and very bright plage contains the largest sunspot to be observed in 1970 (max. area = 2510 millionths of the hemisphere). The spot is magnetically complex, with a δ configuration. Ten major CFI flares occur in the region, between November 11 and November 17. Major flares on November 15, 16 and 17 were accompanied only by very low energy particle events. Region 11029 was rich in the production of x-rays and was a strong "radio-emitter", especially at meter wavelengths.

The plage returns in rotation 1568 as region 11073, still large and bright, but the complex spot is now reduced in area. A major flare on December 11 (CFI = 10) is accompanied by energetic proton emission and weak PCA.

1568	343	11035	Nov 18	N09	22311	9
1569	355	11077	Dec 14	N10	22300	7

Region 11035 is a large, bright plage containing an average-size complex spot with a δ configuration. Four CFI flares occur in the region, between November 12 and November 23. Flares on November 21 and 23 produce energetic particle emission.

In the next rotation, the plage returns as active region 11077. The plage remains large and bright, the spot complex. Seven major CFI flares occur between December 8 and December 13, as the region traverses the eastern part of the disk. Major flares on December 12 and December 13 (CFI = 11 and 8) are accompanied by energetic particle emission.

1569	284	11084	Dec 20	N18	11201	5

A revival of activity in the northern hemisphere at this longitude. The plage is large and bright, and contains two moderately large β_p-type spots. No major flares are reported during the transit of the region. A surprisingly strong particle event, with weak PCA occurs on December 24. The electron burst is preceded by a flare of importance Sn in region 11084.

NOTE - A moderate and brief geomagnetic disturbance on December 24 (duration only about 6 hours) marks the onset of the first major storm sequence of solar cycle 20. Was there a coronal hole located near region 11084?

Solar activity diminished markedly in 1971. There are many plages, located at all solar longitudes, but relatively few of them are active - in

the production of major flares, x-rays, or radio or particle emission. No flares of importance 3 occurred during 1971. An outstanding feature of the year is the occurrence of the first geomagnetic storm sequence. Some of the most important regions are discussed below.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1971	1569	5	11111	Jan 10	S04	11312	8
	1570	9	11145	Feb 06	S05		

Region 11111 contains a large β_p-type spot. It was a strong emitter of meter wavelength radio radiation. Two flares in the region on January 13 and 14 produced moderate proton emission. Region 11145 is a return of region 11111. It is diminished in area and contains only a small α_p spot. Three flares on February 3, 5 and 6 are accompanied by low energy proton emission.

1570 225 11128 Jan 21 N20 12312 9

Region 11128 is a large bright plage containing a large β_p-type spot. Three major CFI flares occur in the region on January 16, 21 and 24. The major flare on January 24 (CFI = 13) was accompanied by very strong particle emission and a major ground level cosmic ray event.

1572 30 11221 Mar 31 S17 12100 4

Region 11221 is a rather small, but very bright plage. It contains a spot of moderate size which is magnetically complex, with a δ configuration. Two major CFI flares occur in the region. The flare on April 1 (CFI = 8) is accompanied by energetic particle emission and a weak PCA event. The flare on April 6 (CFI $\geq$ 6) produced strong proton events and moderate PCA.

1573 157 11256 Apr 18 N21 12011 5

Region 11256 is a bright plage, containing only a relatively small β-type spot. Four major CFI flares occur in the region (on April 20 and 21), but the indices are $<$ 10. Minor flares on April 21, 22, and 23 produce energetic proton emission.

1574 270 11294 May 07 N14 12221 8

Region 11294 is a very bright plage containing a large and complex spot with a δ configuration. Three major CFI flares occur in the region on May 3, 12 and 13. The flare of May 3 (CFI = 9) produces a low energy proton event. Flares on May 12 and 13 (CFI = 8 and 9) occur when the region is near the west limb and are accompanied by strong particle emission. A strong proton and PCA event on May 16 is attributed to region 11294 on the invisible hemisphere, beyond the west limb.

1576 295 11393 Jun 28 N16

In this small bright region, four major CFI flares occurred on June 29 and 30. Flares on June 29 (CFI = 8 and 9) were accompanied by energetic particle emission.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1971	1578	270	11482	Aug 24	S12	23432	14
	1579	275	11516	Sep 20	S13	12100	4

Region 11482 is the first truly major region to appear on the disk since the passage of region 11128 in January (see rotation 1570). The plage of 11482 is large and very bright. It contains a very large spot (the largest spot of 1971), which is magnetically complex, with a δ configuration. The region does not produce any major CFI flares, but it is rich in x-rays and is a strong emitter of radio radiation, especially at centimeter wavelengths. A gradual rise, with the onset of a long interval of increased proton flux (at low energies) is associated with the transit of region 11482 across the disk. A major solar event occurred on September 1 accompanied by very energetic particle emission, PCA, and a strong ground level cosmic ray event. Although no flare was r eported, an active bright prominence was observed at the NW limb, concomitantly with type II and type IV bursts in the dynamic spectrum. The event is presumed to have had its origin in region 11482, on the invisible hemisphere, about two days beyond the west limb.

Region 11482 returns as region 11516, still a large and bright plage, with a complex spot now greatly reduced in area. Five major CFI flares occur in region 11516, between September 12 and 17, as the region traverses the eastern part of the disk. Flares on September 15 and 18 are accompanied by low energy proton events.

	1579	80	11537	Oct 04	N11		

A renewal of activity in the northern hemisphere at this longitude. (In later rotations, active regions will also appear in the southern hemisphere at this longitude.) A major flare in region 11537 on October 3 (CFI = 12) produced very energetic protons and a small PCA event.

	1581	90	11619	Nov 27	S13	11110	4
	1582	90	11657	Dec 24	S13	11000	2

Region 11619 is a large and very bright plage which has developed in the southern hemisphere, co-longitudinally with the descendents of region 11537 (see above). A moderately large spot of magnetic complexity, with a δ configuration, is located in the region. Two major CFI flares occur on November 23 (CFI = 10) and December 2 (CFI = 9). These flares were accompanied by moderate particle emission.

When the region returns in the next rotation, as 11657, the plage continues to be large and bright, but the spot is greatly reduced in area, and is no longer complex. A major flare on December 29 (CFI = 10), when the region is near the west limb, probably is associated with a low energy proton event.

During 1972 there is a noticeable "thinning out" of the plages, especially in the northern hemisphere. There are now zones on the sun which are completely free of plages for several rotations. Some of the most important regions - associated with the more energetic events - are discussed below.

1972	1583	110	11693	Jan 20	S15	22310	8
	1584	110	11734	Feb 16	S17	23000	5

Region 11693 is a large and very bright plage, with a large and complex

spot with a δ configuration. Seven major CFI flares are reported in the region between January 13 and 23. A flare on January 19 produced energetic particles and PCA. In the next rotation, the plage returns as region 11734. The region continues to be large and bright, but the spot is much smaller and has lost its complexity. Four major CFI flares occur in the region between February 10 and 14. Flares on February 11 (CFI = 6) and February 13 (CFI = 10) are accompanied by moderate proton events.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1972	1584	20	11748	Feb 28	N10	14330	11

Region 11748 has developed in a longitude zone that has been relatively free of major activity since March of 1971. The plage is large and extremely bright and contains a large and complex spot, with a δ configuration. The region is especially rich in x-rays, and is a strong emitter of radio waves at centimeter wavelengths. Eight major CFI flares occur between February 16 and 23, as the region traverses the eastern part of the disk. A major flare on February 22 (CFI = 13) was accompanied by energetic particle emission.

1585	192	11769	Mar 08	S08	13313	11
1586	194	11799	Apr 04	S08		

In its third rotation, region 11769 is a large and very bright plage, containing a large and complex spot. Six major CFI flares occurred in the region on March 5, 6 and 7. Flares on March 5 and 6 (CFI = 9 and 10) produced moderate PCA.

Region 11799 is a return of active region 11769. The plage is still large and bright, but the spots are small and fragmented. A flare in the region on April 10 (CFI = 6) was accompanied by low energy protons.

1588	300	11883	May 20	S14	12422	11
1589	300	11926	Jun 16	S13	12210	6

Region 11883 is a very bright plage in the southern hemisphere, in a longitude zone that has been devoid of major regions since the appearance of the major region 11482 of August 1971 (see rotation 1578). Region 11883 contains a very large and complex spot, with a δ configuration. The region returns in the next rotation as plage 11926, still large and bright, but with its complex spot considerably reduced in size. Major CFI flares on June 12 and 15 (CFI = 10 and 8) are accompanied by energetic proton emission. Another major flare on June 15 (CFI = 8) - a "spotless" flare related to a great filament eruption in the neighborhood of region 11926 - also produced a small PCA event.

1588	167	11895	May 30	N09	22311	9
1589	170	11933	Jun 26	N08	12000	3

Active region 11895 has developed in a longitude zone which has been inactive for more than a year. The plage is extremely bright, and contains a large, complex spot with a δ configuration. Four major CFI flares occur in the region between May 24 and June 6. A major flare on May 28 (CFI = 14) was accompanied by very energetic particle emission, and PCA. Another proton

flare occurred on June 3 (CFI = 10) and a major proton event, with PCA, on June 8 is attributed to region 11895 as a "beyond the west limb" event.

Region 11933 is a return of active region 11895. The plage is still large and bright but the spot is small and no longer is complex. Five major CFI flares occur in region 11933 between June 20 and 25.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1972	1588	87	11911	Jun 06	S12	13320	9

Region 11911 is a large and very bright plage in its third rotation. It contains a large and complex spot with a δ configuration. A minor flare in the region on June 8 produced an energetic proton event.

	1590	14	11976	Aug 04	N13	23432	14

Region 11976 is one of the truly great regions of solar cycle 20. A large and very bright plage, it contains a very large and complex spot with a δ configuration. The region is a strong radiator at both centimeter and meter wavelengths. Ten major CFI flares occur between August 2 and 11, as the region traverses the disk, some with CFI's as great as 12, 13, 15, and 17. The only flares of importance 3 reported in 1972 occur in region 11976 on August 4 (CFI = 17) and August 7 (CFI = 15). These flares produced very energetic particle emission and strong PCA. A ground level cosmic ray event also occurred on August 4. Other major flares in the region were also producers of strong particle emission. Proton events on July 22 and 24 are attributed to activity in 11976 while on the invisible hemisphere (when it must have been undergoing rapid development) before east limb passage. The greatest geomagnetic storms of the year occur as a result of the great flares in 11976.

	1594	310	12094	Oct 30	S13	34431	15

Region 12094, in the southern hemisphere, is a region with a high active region index because of its components. It is rich in the production of x-rays, and is a strong emitter of centimeter wavelength radio radiation. The plage is large and extremely bright and contains a very large spot (the second largest spot of solar cycle 20) of magnetic complexity and δ configuration. Only two major CFI flares were reported in the region, however, on October 27 and 29 (CFI = 3 and 7). Flares of importance 1, with low energy protons, occurred on October 25 and 29. The major flare of October 29 (CFI = 7) was accompanied by more energetic particle emission and moderate PCA. Numerous electron bursts accompanied many of the lesser flares in the region. Major geomagnetic storminess occurred between October 29 and November 2.

	1595	359	12115	Nov 22	S09	12000	3

This small bright plage in its third rotation, containing only a small β_p-type spot, nevertheless produced energetic particle emission with the occurrence of three major CFI flares on November 24, 25 and 28.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1972	1595	105	12136	Dec 12	N12		

With the appearance of this small bright plage at longitude 105°, activity in the northern hemisphere has shifted to a longitude zone which has been inactive for more than a year. Three major CFI flares occur in the region on December 8, 10 and 16. The flare of December 16 (CFI = 10) was accompanied by moderate proton emission.

1973	1596	140	12160	Jan 05	N07	11000	2
		116	12164	Jan 07	N15	11000	2

Throughout much of 1973, activity in the northern hemisphere is dominated by active regions forming and developing in the longitude zone 110°–150°.

Region 12160 develops in this zone in rotation 1596, near the location of region 12164, which is the return of active region 12136 of the previous rotation. Two major CFI flares on January 9 (CFI = 3) and January 11 (CFI = 10) are accompanied by electron bursts. A low energy proton event on January 12 is attributed to region 12160 at the west limb.

	1598	138	12246	Mar 01	N08	12100	4

Another resurgence of activity in the same longitude zone occurs with the development of region 12246, in the midst of old plage descended from region 12164. Region 12246 is very bright. Three major CFI flares occur on February 28 and March 1. The flare on March 1 (CFI = 8) also produced a low energy proton event.

	1599	85	12293	Apr 02	S04	01310	5
	1600	85	12323	Apr 29	S06	01110	3

Region 12293 is a large and extremely bright plage that has appeared in the southern hemisphere in a longitude zone which has been inactive for about 8 solar rotations. The region contains a large and complex spot. The plage returns as region 12323, still large and very bright. The spot is reduced in area, but remains complex with a δ configuration. No major flares, or strong particle emission, are reported in these regions during their disk transits. With the gradual fading of this family of plages, a broad zone in the southern hemisphere, completely devoid of plages, opens up between longitudes ~ 60°–120°.

	1600	325	12306	Apr 11	S09	13112	8
	1601	333	12336	May 07	S12	13320	9

Region 12306 is an extremely bright plage and is a strong producer of x-rays. Three major CFI flares occur in the region on April 10 (CFI = 9) and April 11. The flare on April 11 (CFI = 10) is accompanied by a strong proton event. Region 12306 returns in the next rotation as region 12336. The plage is large and continues to be extremely bright. There is a moderately large and complex spot with a δ configuration in this region. The region continues to be a strong emitter of x-rays. Four major CFI flres occur in the region on May 1, 3 and 5. The flares of May 3 (CFI = 15) and May 5 (CFI = 10) may have produced only very minor low energy proton events.

With the decline in activity in this family of plages, a longitude zone between ~ 300°-360° in the southern hemisphere becomes almost completely devoid of plages for the remainder of the year.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1973	1600	152	12322	Apr 24	N12	13301	8
	1601	150	12352	May 21	N12	22122	9
	1602	148	12387	Jun 17	N15	11100	3

Region 12322 represents a major resurgence of activity in old plage related to active region 12246 (see rotation 1598, above). Region 12322 is a very bright plage, rich in the production of x-rays and low energy particle emission. It contains a large and complex spot with a δ configuration. Eleven major CFI flares occur in the region between April 22 and May 1, many of these flares producing electron and proton events. A major flare of importance 2b on April 29 (CFI = 15) was accompanied by very energetic particle emission, PCA, and a ground level cosmic ray event.

Region 12352 is a return of active region 12322. The plage continues to be large and very bright. The spot is reduced in area, but remains complex with a δ configuration. Four major CFI flares occur in the region on May 17, 18 and 19. The flares of May 18 (CFI = 7) and May 19 (CFI = 13) are accompanied by proton events.

In the next rotation, the plage returns as region 12387. The plage is reduced in area, but remains bright. An east limb flare on June 10 is accompanied by energetic particle emission.

	1603	273	12417	Jul 05	N13	12210	6
	1604	275	12461	Aug 01	N12		

The development of region 12417 represents a renewal of activity in this longitude zone, in the northern hemisphere, after a quiet interval of more than a year. The plage is large and very bright, and contains a large β_p-type spot. No major activity occurs in the region during its transit across the disk. In the next rotation, the plage returns as region 12461, diminished in area and intensity, and almost spotless. The only flare of importance 3 reported in 1973 occurred in this "spotless" plage on July 29, IMP. 3b (CFI = 11). The flare was related to a major "disappearing filament" in the region and was accompanied by moderate particle emission.

	1605	200	12507	Sep 04	S15	01211	5
	1606	197	12540	Oct 01	S14		
	1607	197	12584	Oct 28	S13	11211	6

A resurgence of activity at this longitude in the southern hemisphere. Region 12507 is a large and extremely bright plage containing a large β_p-type spot. A major CFI flare on September 7 (CFI = 12) produced strong proton emission and PCA. In rotation 1606, the plage returns as region 12540. it is diminished in area but continues to be a bright plage. CFI flares on October 4, 5 and 6 are related to type II bursts in the dynamic spectrum, electron bursts, and moderate particle emission. In rotation 1607, the plage returns with renewed vigor, as region 12584. The plage is very bright and contains a large β_p-type spot. Major CFI flares occur on October 30, November 1 and

November 3. The major flare of November 3 (CFI = 11) is accompanied by energetic particle emission.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1974	1613	180	12848	Apr 11	S12	24310	10
	1614	187	12906	May 8	S12	22011	6
	1615	192	12972	Jun 4	S13		

In 1974, major solar activity is confined primarily to the southern hemisphere, the longitude zone 150°-200° continuing to be the most active. Two families of plages develop within this longitude zone, beginning with region 12848 in rotation 1613. Region 12848 is a large and very bright plage, and contains a large and complex $\beta\gamma$ spot with a σ configuration. Although it is the source of numerous flares, and is a strong producer of x-rays, the region is devoid of any energetic particle emission. The plage returns in rotation 1614 as region 12906, extremely large in area, and still very bright, although the spot is now greatly reduced in size and no longer is complex. Two major CFI flares occur in region 12906 on May 1 (at E75°, importance 2b, CFI = 6), and on May 13 (at W65°, importance 2n, CFI = 7). The flare on May 13 occurs when the region is "spotless" (the spot, which has been diminishing in area during disk transit, has disappeared by May 12). Nevertheless, this flare is accompanied by the ejection of electrons, and by low energy particle emission.

In rotation 1615, the plage returns as region 12972, now greatly reduced in area and intensity. A scattering of small α spots in the region have all disappeared by June 6. On June 8, a major flare event occurs in this spotless region, consisting of "parallel ribbons of bright plage along both sides of an active filament" becoming an eruptive prominence and bright surge at the limb. The event is reported as an "unconfirmed" flare of importance 3, and is accompanied by electron and strong proton emission, and PCA.

1615	165	12977	Jun 6	S14	12001	4
1616	157	13043	Jul 4	S14	35311	13

Region 12977 develops near (and following) the location of old region 12972 (see above). In rotation 1616, it returns as active region 13043, the most active region of 1974, and one of the great regions of solar cycle 20. Region 13043 is a large and very bright plage, a great flare producer, and extremely rich in x-rays. The plage contains a large and complex $\beta\gamma$ spot, with a σ configuration. In its transit across the disk, 27 major CFI flares occur in region 13043, between June 30 and July 9. Nine of these flares have CFI's $\geq$ 10 and are accompanied by major electron and proton emission. Great flares on July 3, 4 and 5 (CFI = 14), also produced PCA. (Flares on July 3 and 4 were observed in white light). Major geomagnetic disturbance occurred on July 4, 5 and 6. Although the region returns in three subsequent rotations, it is greatly reduced in area and intensity, and is no longer active.

1616	347	13002	Jun 19	S16

A major flare of importance 3n occurs in region 13002 on June 23. A $\beta\rho$ spot of modest size has been diminishing rapidly in area since CM passage and by June 22 is < 50 millionths of the hemisphere. Flares in the region on

June 19 and 21 are accompanied by the emission of low energy protons and are characterized by filament activation. The flare of importance 3 on June 23 is essentially a "spotless" flare (by June 24, the spot has disappeared), CFI = 7, with low energy particle emission.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1974	1619	263	13225	Sep 15	N07	22321	10
	1620	270	13280	Oct 12	N10	23331	12
	1621	278	13324	Nov 7	N09	11000	2

After a quiet interval of more than a year, the only activity in the northern hemisphere during 1974 begins with the development of active region 13225 in rotation 1619 in September. Region 13225 is an extremely bright plage, and contains a large and complex γ spot with a σ configuration. Nine major CFI flares occur in the region between September 10 and 23, as the plage transits the solar disk. There is a general increase in low energy particle flux during the disk passage of the region. Strong proton emission occurs with major flares on September 10 (CFI = 14), September 13 (CFI = 12), September 19 (CFI = 12) and September 23 (CFI = 12). PCA is reported following the flares of September 10, 13 and 19.

In rotation 1620, region 13225 returns as active region 13280 - very large and very bright, with the spot still large and complex and with σ configuration. Seven major CFI flares occur in region 13280 between October 5 and 12, as the region traverses the eastern portion of the disk. Enhanced low energy particle flux continues. Two flares on October 11 (CFI = 10) are accompanied by the ejection of electrons and protons.

When the plage returns again in rotation 1621, as region 13324, it is greatly reduced in area and intensity, and the spots are small and fragmented. A rise and fall in low energy particle flux is still noticeable, during the disk transit of the region. The plage is very active as it approaches east limb passage on October 31, when an "eruptive prominence event" may have been responsible for energetic particle emission on that day. The plage becomes spotless after November 9, and although it returns for two more rotations, it has dwindled into inactivity.

1620 25 13310 Oct 31 S07 11000 2

A major "spotless" flare (CFI = 11) occurs in region 13310 on November 5 (at W78°). Electrons, protons > 60 MeV, and PCA are reported with this flare.

1621 245 13339 Nov 10 N38

The first high-latitude new cycle spot of cycle 21 is observed in region 13339, which forms on the disk, near the west limb, on November 16.

1975 1631 308 13786 Aug 5 N06 12321 9

During 1975, solar activity is greatly diminished. Broad latitude zones in both the northern and southern hemispheres have become inactive. Plages are smaller, their latitudes closer to the equator, and spots are fewer in number. An occasional new cycle spot is observed at high latitude, but is

seen for only one or two days. An upsurge in old cycle activity occurs after mid-year in the northern hemisphere.

In rotation 1631, region 13786 is a large and very bright plage in its third rotation. It contains a moderately large and complex spot with a σ configuration. Two major CFI flares occur in the region. Enhanced low energy particle flux is observed during the disk transit of the region. A flare on August 3 (CFI = 9), produces more energetic proton emission.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1975	1631	260	13790	Aug 9	N09	12331	10

Region 13790 is a "twin" to active region 13786 in area, brightness, and flare and x-ray production. It contains a large β_p-type spot which occassionally becomes complex, and also may contribute to the long interval of enhanced low energy flux noted above. Two CFI flares occur in region 13790 on August 3 when the region is very close to the east limb, and may contribute to the energetic particle emission mentioned above.

	1631	168	13811	Aug 16	N28	12000	3

Region 13811 is the first new cycle (cycle 21) region to show any significant major activity. The region forms on the disk in the west on August 19. The plage is small, but bright, and contains a small β_p spot. Eight CFI flares occur on August 21 and 22, as the region approaches the west limb. Two of these flares have CFI's of 11, and are accompanied by highly energetic proton emission.

	1635	343	13937	Nov 20	S07	11222	8

Region 13937 is the only "active" region that has appeared in the southern hemisphere throughout 1975. Indeed, the southern hemisphere has been relatively "quiet" for over a year and a half. The plage of 13937 is of modest size, but is very bright, and contains a complex β_p spot with a σ configuration. Eight CFI flares occur in the region between November 14 and 21, as the region transits the eastern portion of the solar disk. An increase in low energy particle flux is observed during disk transit. A flare on November 21 (CFI = 10) produces highly energetic proton emission.

1976	1636	284	14029	Jan 18	S12	12110	5

Although 1976 is the year of solar minimum between old cycle 20 and new cycle 21, there are still occasions when outbreaks of solar activity occur.

Region 14029 is the last significant old cycle region to develop in the southern hemisphere in the longitude zone between 240°-330°. The plage is very bright, and contains a complex spot of modest size. Two major CFI flares occur in the region, on January 12 and 17.

1976	1639	198	14127	Mar 19	N05	03211	7
	1640	205	14161	Apr 15	N05	01110	3
	1641	214	14203	May 11	N03	01100	2

Regions 14127, 14161 and 14203 form a "family" of old cycle plages in the

northern hemisphere at a longitude that has been devoid of any major activity for more than a year. There appears to be enhanced low energy particle flux coincident with the disk transit of region 14161. A CFI flare in this region on April 20 (at W77°, CFI = 6) is associated with low energy proton emission.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1976	1639	38	14143	Mar 31	S07	14322	12
	1640	46	14179	Apr 27	S08	02100	3

The greatest activity of the year 1976 occurred in the two southern regions 14143 and 14179, in a longitude zone which has been free of any major activity for many months. Region 14143 is in its second rotation, having formed on the disk in the west during the previous rotation. The plage of 14143 is very bright, and contains a large and complex spot. During its disk transit, there is a noticeable enhancement of low energy particle flux. Eight major CFI flares occur in region 14143, between March 23 and 31. Major flares on March 23 (at E90°, CFI = 12), March 25 (CFI = 9) and March 28 (CFI = 10) are accompanied by strong proton emission.

The plage returns in rotation 1640 as region 14179, now diminished in area and intensity, but still active. Although the spot is smaller in size, it remains geomagnetically complex. Four major CFI flares occur in region 14179 on April 29, 30, and May 1. A major flare on April 30 (at W45°, CFI = 11) was accompanied by highly energetic particle emission, as well as a ground level cosmic ray event.

	1644	127	14352	Aug 8	N19	01212	6
	1645	123	14395	Sep 4	N21	01001	2

During the second half of the year 1976, new cycle regions predominated over the occurrence of old cycle regions. They now occur at all longitudes and at latitudes ranging from the teens up to 35°. Region 14352 is the first member of a new cycle "family" of plages that persists for 4 solar rotations. Region 14352 is a very bright plage, containing a complex $\beta\gamma$ spot of moderate size. In rotation 1645, the plage returns as region 14395. The spot is now much smaller and only of type α. A major CFI flare occurs in region 14395 on September 6 (CFI = 6), accompanied by low energy particle emission.

	1644	18	14366	Aug 16	S03

Region 14366 is an old cycle plage that forms on the disk near the central meridian on August 15. A major CFI flare occurs on August 22 (CFI = 8), when the region is at the west limb. This flare produced a major electron burst, and very energetic proton emission.

	1648	147	14528	Nov 23	N12

The new cycle (cycle 21) has developed rapidly during the second half of 1976. By rotation 1648, the outbreak of new cycle plages has occurred at a latitude as low as 12°.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1977	1650	206	14607	Jan 12	S27	01011	3
	1651	165	14637	Feb 12	S42	02111	5
	1653	22	14726	Apr 18	S22	13110	6

Although the new cycle is advancing, during the first part of 1977 there are still broad longitude zones in both northern and southern hemispheres which remain free of spots and plages, and the most important so-called "active" regions are located in the southern hemisphere. These regions are listed here. The most significant plage is region 14726 which shows a major increase in flare activity and the production of x-rays. The plage is of moderate size, but is very bright and contains a small complex γ spot. Three major CFI flares occurred in region 14726 on April 12 (at E82°, CFI = 9), April 16 (CFI = 5), and April 21 (CFI = 2). The flare on April 16 was accompanied by a low energy proton event.

	1656	200	14815	Jun 25	S23	12110	5

By the middle of 1977, solar activity undergoes a marked increase, with more active regions appearing at previously inactive longitudes.

Region 14815 is very bright and is in its second rotation, having formed on the disk previously in May. The region contains a small β_p spot (which occasionally becomes complex), with a σ configuration.

	1656	145	14822	Jun 30	N16	13331	11

Region 14822 is the first major region to appear in the northern hemisphere since August 1976. The plage is very bright and contains a large and complex spot. This spot is the first truly large spot of the new cycle (max. area > 1000 millionths of the hemisphere). The plage is a strong x-ray producer, and a strong emitter of centimeter radiation. No major CFI flares are reported in the region. There is enhanced low energy particle flux during the transit of the region across the disk.

	1658	323	14888	Aug 9	N24	12120	6

Active region 14888 has developed in the northern hemisphere in a longitude zone (300°-360°) which has been devoid of any major activity for more than a year and a half. The plage is bright and contains an average-sized β_p spot with a σ configuration.

	1659	198	14943	Sep 15	N08	13331	11
	1660	205	14979	Oct 12	N13	03110	5

Region 14943 is the most outstanding region of the year, and will be one of the truly great regions of cycle 21. The plage is large and very bright, is rich in x-rays, and is a strong emitter of centimeter radiation. The large spot (max. area = 1100) is complex, with a σ configuration. Its low latitude (N08°) leaves it open to question as to whether it belongs to old cycle 20 or to the new cycle. Since the neutral line runs about east to west, it is difficult to decide whether the polarities are like those of the old cycle, or like the new. If it is an old cycle spot (and plage), it is most unusual. Region 14943 is very active. Seven major CFI flares occur in the region

between September 5 and 24 (before the east limb appearance of the region, and beyond the west limb). Enhanced low energy particle flux occurs during the disk transit of the region. Truly major flares occur on September 7, 9, 16, 19 and 20 (CFI = 12, 11, 13, 13, 11) accompanied by highly energetic particle emission.

On September 24, when the region is one day beyond the west limb, an event occurs (for which no flare is reported), which produces a ground level cosmic ray increase.

In the next rotation, region 14943 returns as active region 14979. The plage continues to be very large and bright. The spot remains complex though now greatly reduced in area. A major CFI flare on October 12 (CFI = 11) was accompanied by highly energetic particle emission.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1977	1660	348	14963	Oct 1	N16	02011	4
	1660	340	14967	Oct 2	N33	12000	3

Regions 14963 and 14967 are small active regions that have developed in the inactive zone (300°-360°) previously mentioned in connection with region 14888 (see above). A major flare in region 14967 on October 6 (CFI = 11) was accompanied by energetic proton emission.

	1661	65	15031	Nov 19	N26	01031	5

Region 15031 has developed in a longitude zone in the northern hemisphere (0°-60°) which has remained inactive since the latter half of 1975. Plage and spot grow rapidly on the disk after November 16. A major flare on November 22 (CFI = 12) was accompanied by strong particle emission and a ground level increase in cosmic ray intensity.

1977	1662	194	15049	Dec 6	S23		
1978	1663	201	15081	Jan 2	S19	23011	7

Region 15049, and its "descendent" 15081, continue activity in the southern hemisphere in the active longitude zone ~ 160°-220°. A major flare in region 15049 on December 6 (CFI = 8) was accompanied by electrons and low energy proton emission. Major CFI flares also occur on December 28 and December 30, when the plage returns as region 15081 in the next rotation.

1977	1662	138	15056	Dec 11	S25	23211	9

The appearance of region 15056 continues the spread of activity in the southern hemisphere to previously mostly inactive longitudes. The region is in its second rotation, having formed on the disk on November 9 in rotation 1661. The plage is bright and contains a β-type spot which occasionally becomes complex, with a σ configuration. Three major CFI flares occur in the region, on December 8, 10, and 17.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1977	1663	350	15074	Dec 21	S28	11001	3

This high-latitude southern region forms on the disk on ~ December 22 and spot and plage then grow rapidly. Major CFI flares occur on December 26 and 27, as the region approaches the west limb. The flare on December 27 (CFI = 8) was apparently accompanied by strong particle emission.

1978

During 1978, there was a marked increase in major solar activity in both the northern and southern hemispheres, as the solar cycle advanced rapidly. For the first three months of 1978, there continued to be longitude zones which remained devoid of any significant plages (270°-330°, and 90°-120°), but after April 1978 plage development spread to all longitudes, in both hemispheres. For the most part, however, the greatest activity occurred in regions in the northern hemisphere. After September 1978, there was a shift in major activity towards the southern hemisphere.

	1663	201	15081	Jan 02	S19	23011	7

Some of the major active regions of 1978 will be mentioned here. Region 15081 has been discussed before. In its third rotation, it is in the active longitude zone related to the location of the great active region of September 1977 (region 14943, rotation 1659). Eight major CFI flares occur in region 15081, between December 26 and January 9 (east limb to west limb), the especially major flares of January 7 and 8 having CFI's of 10 and 12. A major "behind the west limb" event occurred on January 10.

1664	34	15139	Feb 11	N17	44433	18
1665	39	15175	Mar 11	N18		
1666	30	15221	Apr 07	N21	13230	9

This major region (15139) has developed in a longitude zone in the northern hemisphere where there has been very little major activity except for the existence of region 15031 of November 1977 in rotation 1661 (in which the ground level cosmic ray event of November 22, 1977 occurred). Region 15139 is a large and very bright plage, very "rich" in everything - flares, x-rays, radio emission - and contains a very large and magnetically complex spot ($\beta\gamma$). Seven major CFI flares occur between February 7 and February 17, as the region traverses the disk. The major flare of February 13 (CFI = 12) was accompanied by strong proton emission and PCA. In rotation 1666, the plage returns, with renewed vigor, as region 15221. Major CFI flares occur on April 8 (CFI = 12), and April 11 (CFI = 13). The flare of April 11 was accompanied by strong proton emission, and a PCA event. "Descendents" of this major active region continue to appear for about 5 more rotations, but no further significant activity occurs.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1978	1664	80	15134	Feb 08	N27	12011	5
	1665	72	15172	Mar 08	N22	22121	8
	1667	73	15266	May 02	N24	34441	16
	1668	75	15314	May 28	N18	23231	11
	1669	77	15368	Jun 24	N19	12000	3

The appearance of region 15134 in rotation 1664 in February begins the development of one of the great plage "families" of 1978 (also located in the longitude zone of the cosmic ray region of November 1977).

After a period of decline and inactivity in rotation 1666, there is a resurgence of activity in the old plage and the development of new plage, in rotation 1667, containing a large and complex spot with a δ configuration. Region 15266 is one of the truly great regions of cycle 21. Two great flares of importance 3b occur in the region on April 28 and April 30. A total of 16 major CFI flares occur during the transit of the region across the disk, between April 25 and May 9. Eight of these flares have CFI's $\geq$ 10. Bright loops were observed above the region as it was coming around the east limb on April 23. The 3b flare of April 28 (CFI = 18) initiated a major particle event, with PCA, which continued through the 29th and 30th - no doubt augmented by the major flares of April 29 and 30 (CFI = 15). A sudden commencement on April 30 marked the onset of a strong geomagnetic disturbance that continues for 5 days. A flare on May 7 (at W72, CFI = 13) was accompanied by strong proton emission and a ground level cosmic ray event. Major flare activity in region 15266 continues on May 8 and May 9 (CFI = 12 and 10) as the plage goes over the west limb. West limb passage was marked by "spectacular surges and loop prominences".

In the next rotation, the plage returns as region 15314 - continuing as a major active region, with 5 major CFI flares occuring between May 23 and June 2. A flare of importance 3b on May 31 (CFI = 12) was accompanied by strong proton emission. A flare in the region on June 2 also probably was responsible for an energetic proton event and weak PCA.

	1667	278	15235	Apr 15	N17	14002	7

Region 15235, located in old plage that has persisted for 7 (or more) rotations on the opposite hemisphere from the location of the great region 15266, has experienced a resurgence, with the growth of new and very bright plage and a new β-type spot. Six CFI flares occur in the region, between April 11 and April 20.

	1669	48	15375	Jun 26	S20	13210	7

Region 15375 is the first major active region to develop at this longitude in the southern hemisphere in more than a year. Its appearance marks the onset of expanding major southern activity into new longitude zones. Four major CFI flares occur in the region on June 26, 27 and 28.

	1670	165	15403	Jul 15	N18	55411	16

Region 15403, in the northern hemisphere, is the most active region of 1978, in terms of numbers of flares (of IMP $\geq$ 1), and SID's (x-ray production). The plage contains a large and magnetically complex spot, with

a δ configuration. Nineteen CFI flares occur in the region, between July 7 and July 18. Most of the major flare activity occurs while the region is far to the east (between E90 and E45°). Many of these flares have CFI's ≥ 10. A great flare of importance 3b occurred on July 10 (CFI = 15), and a flare of importance 2b on July 11 also had a CFI of 15. No energetic particle emission was reported with any of the major flare events in region 15403. No significant geomagnetic disturbance occurred, except for a brief storm on July 13-14.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1978	1672	190	15509	Sep 05	S31	23211	9

Region 15509 is a major plage that has developed in the southern hemisphere, at a high latitude. The region is large and bright, and contains a β-type spot which occasionally becomes complex. Activity in the southern hemisphere is spreading to all longitude zones.

	1672	7	15543	Sep 19	N35	12340	10

A major region in the northern hemisphere has developed in a longitude zone (at ~ 0°) which has been devoid of any major activity since the start of the new cycle (in 1976). The plage is very bright, and contains a large, complex βγ spot. It is a strong radio emitter at centimeter wavelengths. Located at a very high latitude, the region has a short lifetime of only two rotations. A flare of importance 3b occurs in the region on September 23 (CFI = 13), accompanied by strong proton emission, strong PCA (9.6 db), and a ground level cosmic ray event.

	1673	157	15570	Oct 05	S14	12210	6
	1673	50	15587	Oct 13	S18	12210	6

These regions (15570 and 15587) represent the continued increase in activity in the southern hemisphere, as the activity spreads to different longitudes. Both regions contain complex γ-type spots of moderate size. Four major CFI flares occur in region 15570, between October 1 and October 9. The flare on October 9 (CFI = 9) was accompanied by energetic particle emission. Six major CFI flares occur in region 15587, between October 6 and October 18.

	1675	85	15687	Dec 04	S17	12201	6
	1676	89	15733	Dec 31	S18	11111	5

Region 15687 is in its second rotation, and is a member of a long-lived "family" of plages that has formed in the southern hemisphere at ~ L_o = 90°. The plage is large and very bright, and contains a complex βγ spot of moderate size. The plage returns in rotation 1676 as region 15733 - a large, bright plage which contains a complex βγ spot. A major CFI flare occurred on December 27 (CFI = 11). No particle emission was reported.

	1675	32	15694	Dec 08	S23	34201	10

Region 15694, in the southern hemisphere, is a very bright plage that contains a large β-type spot. The plage is rich in x-rays, and produces numerous flares of importance ≥ 1. Six major CFI flares occur in the region,

between December 3 and 13. An important flare on December 11 (2b, CFI = 13) was accompanied by energetic particle emission.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1978	1676	333	15697	Dec 13	S16	22324	13
1979	1677	330	15748	Jan 09	S17	12210	6
	1678	329	15800	Feb 06	S20		
	1679	320	15856	Mar 06	S23	11000	2

The development of active region 15697 has carried the extension of solar activity in the southern hemisphere to a longitude zone in which there has been no previous major activity since the beginning of the cycle. The plage is large and bright, and contains a large and complex $\beta\gamma$ spot with a δ configuration. Seven major CFI flares occur in the region, between December 10 and December 18. Several major flares occur simultaneously with the flares of region 15694, especially those of December 11 (CFI = 9) and December 13 (CFI = 8). The plage returns in rotation 1677, much reduced in area, but still bright. The spot is smaller, but remains magnetically complex. In rotation 1678, the plage is smaller and less bright, and the region (now 15800) is almost spotless. The only activity in the region is an isolated major flare of importance 3n on February 1 (CFI = 8), when no spots are present. When the plage returns again, in rotation 1679, as region 15856, it is considerably reduced in area and intensity, and contains only a small α spot. Another isolated major flare of importance 3n (CFI = 11), occurs in the region on March 1, accompanied by energetic particle emission.

1979

1979 is the year of maximum for the present solar cycle (cycle 21). Statistical maximum in the Zurich sunspot numbers is in December 1979. Throughout 1979, active regions occur with increased frequency at all solar longitudes in both the northern and southern hemispheres. There is considerably more major activity, however, in the northern hemisphere than in the south, especially in the longitude zone between 100°-210°. Some of the most active regions will be mentioned below - with and without comments.

1979	1677	350	15749	Jan 08	N10	01101	3
	1678	355	15802	Feb 04	N12	11120	5

Spot and plage in region 15749 grow rapidly on disk after central meridian passage.

The spot in region 15802 is complex (γ).

1677	300	15754	Jan 12	N19	22010	5
1678	293	15807	Feb 09	N16	22221	9
1679	293	15863	Mar 08	N16	11000	2

Three major flres occur in region 15754 on January 8, 13 and 14 (CFI = 10, 7, 6).

The spot in region 15807 is larger in area, and is complex. Flare and x-ray production has increased.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1979	1677	177	15772	Jan 21	N20	11121	6
	1678	175	15823	Feb 18	N19	22212	9
	1679	164	15877	Mar 17	N15	12010	4

Region 15772 contains a complex γ-type of moderate size. In region 15823 the spot is larger, still complex (γ), with a δ configuration. Three major CFI flares occur on February 18, 19 and 20. The flare on February 18 (CFI = 12) occurs simultaneously with a similar major flare in region 15830 (see below). Region 15823 returns in rotation 1679 as a part of the very extensive plage 15877.

1677	133	15777	Jan 24	N14	11121	6
1678	144	15830	Feb 20	N15	33411	12
1679	164	15877	Mar 17	N15	12010	4
1680	172	15933	Apr 13	N23	11000	2
1681	180	15990	May 10	N23	12030	6
1682	180	16051	Jun 06	N20	23331	12

Moderately large spot in region 15777 has occasional complex γ characteristics. In the next rotation, region 15830, now much larger in area, contains one of the largest spots of the year - a very large γ spot. The region is rich in number of flares and x-rays. Six major CFI flares occur in region 15830 between February 16 and February 22. The major flare of February 16 (importance 3b, CFI = 15 at E59) produced a major energetic particle event (with delayed onset) of long duration, probably augmented by the major flares on February 18 (CFI = 10 and 12). "Simultaneous flares" occur frequently in regions 15830 and 15823 (see above).

By rotation 1679, the two major active regions (15830 and 15823) have merged into the very large plage 15877, which now contains numerous small spots. In rotations 1680 and 1681, the plage continues to decrease in area and intensity. By rotation 1682, there is a resurgence of activity, with the development of new plage and the growth of a large and complex γ spot with a δ configuration. Four major flares occur in region 16051 on June 3, 4, 5 and 10. The flare on June 5 (importance 2b at E14, CFI = 12), was accompanied by a strong proton event, and PCA. A flare of importance 3b (CFI = 8) occurred in the region on June 10. In subsequent rotations, the plage declines rapidly in area and intensity.

1678	287	16808	Feb 09	S20	12121	7
1679	288	16864	Mar 08	S16	11000	2

Activity in the southern hemisphere. Region 16808 contains a complex γ spot of average size. Two CFI flares occur on February 5 (CFI = 8).

1679	320	15856	Mar 06	S23	11000	2
1680	318	15918	Apr 02	S27	23431	13
1681	313	15968	Apr 30	S26	11030	5

Region 15856 is old plage, "descended" from active region 15697 of December 1978. On March 1, a "spotless" flare of importance 3n occurs in region 15856. A resurgence in activity within this old plage begins in rotation 1679, and develops into the very active region 15918 by the next rotation.

Region 15918 contains a very large γ spot, with a δ configuration. A major flare on April 3 (CFI = 10), was accompanied by a strong proton event and PCA.

YEAR	ROT. NO	L_o (DEG)	McMATH PLAGE	CMP	LAT	REGION PROFILE	ARI
1979	1679	118	15887	Mar 21	N07	23220	9
	1680	138	15937	Apr 15	N04	22340	11

Region 15887 is new plage which has developed in the northern hemisphere (in the active longitude zone) at a very low latitude. The region contains a complex γ-type spot with a δ configuration. Three major CFI flares occur on March 22, 26 and 27. When the region returns in rotation 1680, the spot has doubled in size and remains complex. Three major CFI flares occur in region 15937 on April 9, 14 and 15. Although remnants of the plage continue to exist for many subsequent rotations, no further major activity occurs.

	1681	338	15967	Apr 28	N17	22321	10

Region 15967 is a major new plage in the northern hemisphere. It contains a large and complex βγ spot. Five major CFI flares occur in the region, between April 26 and May 3. A flare on April 27 (CFI = 13) was accompanied by energetic particle emission.

	1681	283	15974	May 02	N16	12331	10

Active region 15974 formed on the disk, near the west limb, in the previous rotation. Region 15974 contains a large and complex βγ spot. Major CFI flares occur simultaneously on April 29 and May 3 in regions 15967 and 15974 (CFI = 8 and 10). Although the plage continues to exist for two more rotations, no additional major activity occurs.

	1681	152	15996	May 12	S21	01020	3
	1682	163	16052	Jun 08	S21	11111	5
	1683	160	16112	Jul 05	S23	11000	2

Region 15996 grows on the disk in area and intensity, after C.M. passage. It returns in rotation 1682 as large and bright plage 16052 which contains two rather large β-type spots. Two CFI flares occur in region 16112 (in the next rotation) on June 27 and July 5 (CFI = 1 and 4, with type II radio bursts).

	1681	104	16014	May 16	N16	11110	4
	1682	105	16067	Jun 12	N16	11312	8
	1683	100	16123	Jul 09	N17	12000	3

Region 16014 first appears as a small plage on the disk near the east limb and grows rapidly. A small β-type spot occasionally becomes complex. In the next rotation, the plage (now region 16067) has grown in area and intensity, and contains one of the largest spots of the year - a large β spot, sometimes becoming βγ. No major CFI flares occur in these active regions.

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1979	1682	212	16046	Jun 04	N17	11101	4
	1683	215	16104	Jul 01	N16	11100	3
	1682	92	16065	Jun 13	S16	01201	4

Region 16065 contains a moderately large βγ spot. Two CFI flares occur on June 18 (CFI = 7 and 5) accompanied by moderate particle emission.

1683	172	16117	Jul 04	N18	01100	2
1684	178	16171	Jul 30	N18	11010	3
1685	183	16238	Aug 26	N19	11000	2

Region 16117 is mostly new plage that has developed in the following "remnants" of active region 16051 of the previous rotation. Region 16117 contains a moderately large β-type spot which occasionally shows βγ-δ characteristics. Two CFI flares occur on July 5 and 7. The flare on July 7 (CFI = 6) produced an energetic proton event.

1683	122	16122	Jul 08	N10	11101	4

Region 16122 contains a complex βγ spot of moderate size, with a δ configuration. Two CFI flares occur on July 4 (CFI = 10 and 8).

1684	349	16161	Jul 18	N17	11110	4
1685	350	16208	Aug 14	N16	02300	5
1686	352	16275	Sep 10	N15	01200	3
1687	358	16336	Oct 06	N14	11100	3
1687	5	16398	Nov 02	N15	11201	5

A long-lived "family" of plages in the northern hemisphere. Region 16208 contains a large βγ spot with a δ configuration. The spot continues to be large and complex (βγ) in rotation 1686, but diminishes in area as it transits the disk. When the spot returns in October, it is small but still complex, and finally disappears on the disk. Region 16336 returns in November with renewed vigor. A large β-type spot has developed in region 16398, and the plage is considerably larger and brighter. Although remnants of the plage continue to exist for several more rotations, these regions are small in area and relatively spotless.

1684	245	16164	Jul 26	S14	11100	3
1685	244	16231	Aug 22	S16	11000	2
1685	270	16224	Aug 20	S26	22301	8

Region 16224 is an important new southern plage containing a large and complex βγ spot with a δ configuration. The spot, at a relatively high latitude, exhibited reversed polarities during most of its transit across the disk. Eight major CFI flares occurred in the region on August 13, 14 and 16, while the region was still far to the east (between E90 and E47°).

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1979	1685	195	16239	Aug 26	N06	23440	13
	1686	197	16298	Sep 22	N06	24420	12
	1687	199	16368	Oct 19	N05		
	1688	210	16421	Nov 14	N12	11100	3

Region 16239 continues the chain of active northern regions in the active longitude zone between 100° and 200°. It is a new, large and very bright plage that has appeared at low latitudes, near the equator, and contains a very large and complex γ spot with a δ configuration. Five major CFI flares occur between August 18 and 26, from east limb appearance to C.M. Flares on August 18 (E90, CFI = 10) and August 20 (CFI = 12) were accompanied by energetic particle emission and PCA.

The plage returns in rotation 1686 as active region 16298. The plage has nearly doubled in area and the spot is still very large and complex (now $\beta\gamma$). Three major CFI flares occur on September 15, 16 and 19. The flare on September 19 is importance 3b (CFI = 9). Proton emission has been in progress since September 14.

In the next rotation, the spot has diminished greatly in area, and disappears on the disk on October 21. In rotation 1688, there is a resurgence of ativity in the leading part of the old plage remnants from region 16368 with the development of a new $\beta\gamma$ spot (of small size) in region 16421.

1685	63	16263	Sep 05	N22	11101	4

Region 16263 contains a large β spot.

1685	32	16267	Sep 07	S21	12000	3

Seven major CFI flares occur in region 16267 between September 2 and 11, during the transit of the plage (CFI's range from 2 to 8, and each flare has a type II radio burst). No energetic particle emission is reported.

1686	302	16279	Sep 14	N13	12211	7
1687	309	16344	Oct 10	N16	22311	9
1688	313	16406	Nov 06	N17	02001	3

Region 16279 contains a large β-type spot. When the plage returns in rotation 1687 as region 16344, it is much more active and the spot is very large and complex - $\beta\gamma$, with a δ configuration. Three major CFI flares occur on October 4, 5 and 7. The flare on October 5 (at E59, CFI = 12) was accompanied by moderate particle emission.

By the next rotation, the spot has simplified to a small αp. A major CFI flare occurs on November 6 (CFI = 11).

1686	123	16315	Sep 27	N18	12211	7

Another active northern region in the favored longitude zone (100°-200°). Region 16315 contains a very large β-type spot.

1686		16324	Sep 30	S22	12100	4
1687		16384	Oct 27	S20	01000	1

YEAR	ROT. NO.	L_o (DEG)	McMATH PLAGE	CMP	LAT.	REGION PROFILE	ARI
1979	1687	330	16341	Oct 09	N24	11101	4

Region 16341 contains a large β-type spot which occasionally becomes complex (βγ).

1687	250	16357	Oct 15	N26	12100	4
1688	230	16419a	Nov 13	N30	12311	8

Region 16419a is a large, bright plage at high latitudes, and contains a large and complex βγ spot. Three major CFI flares occur in region 16419a on November 6, 8 and 15. The flare on November 15 (importance 2b, CFI = 9) was accompanied by energetic protons and a small PCA event.

1687	220	16366	Oct 17	N33	12210	6

Region 16366 contains a large β spot which occasionally becomes complex (βγ).

1687	180	16373	Oct 20	N27	23411	11
1688	170	16426	Nov 17	N30		

Active region 16373 is rich in the production of flares and x-rays. The plage contains a very large and complex βγ spot with a δ configuration. Two major CFI flares occur on October 19 (CFI = 7). The region formed on the disk, in the previous rotation, near the central meridian. In rotation 1688, the spot is smaller and has simplified into an αp.

1688	276	16413	Nov 09	S15	34401	12
1689	280	16467	Dec 06	S16	01110	3

Active region 16413 is a great southern plage, with numerous flares of importance $\geq$ 1, and strong x-rays. The region contains a very large βγ spot with a δ configuration. Nine major CFI flares occur in the region between November 4 and 12. Flares on November 8, 9 and 10 (CFI = 10, 11 and 13) and November 12 (CFI = 8) are accompanied by energetic particle events.

1688	240	16418	Nov 12	S16	02422	10
1689	242	16478	Dec 09	S16	01110	3

Active region 16418 contains the largest spot of the year (maximum area 1970 millionths of the hemisphere, mean area ~ 1500). The spot is complex βγ. The region has a flare on November 12 (CFI = 9) which occurs simultaneously with a major flare in region 16413.

On November 8, 9, 10 and 11, the daily vlaues of the 10 cm. flux (Ottawa, corrected) exceeded 300 (max. value 367 on November 10). This is a rare occurrence - similar to circumstances in March and April 1947, during the disk passage of two of the greatest sunspots ever observed (max. area in March = 4554 millionths of the hemisphere, and on its return in April = 6132). The high flux in November must be related to the disk passage of the two large spots in regions 16413 and 16418 (max. area 1720 and 1970 respectively).

III. Evolutionary Charts of Solar Activity 1964–1979; Northern and Southern Hemispheres, SEPARATE.

LEGEND

Location of centroid of CaK plage (heliolongitude ± 5°)

Active region of same area-intensity index, but with higher level of flare activity

Active region associated with at least one high energy flare particle event (PCA or GLE)

Return of center of activity, defined by relatively similar longitude and latitude on successive rotations

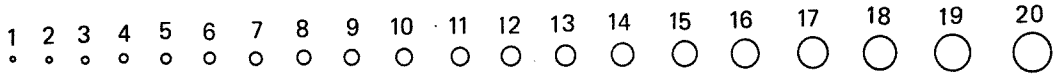
Old and dying plage followed by resurgence of new center of activity in the same location, or, transient plage (duration < 14 days) associated with other, more permanent center of activity

Representative disc-transit CaK plage area-intensity measure based on daily values reported by McMath-Hulbert Observatory

$$k = \frac{A}{500} + 2\ (\ I - 3)$$

where A = corrected area (in millionths of a solar hemisphere) and I = intensity (1 = faint, 5 = very bright)

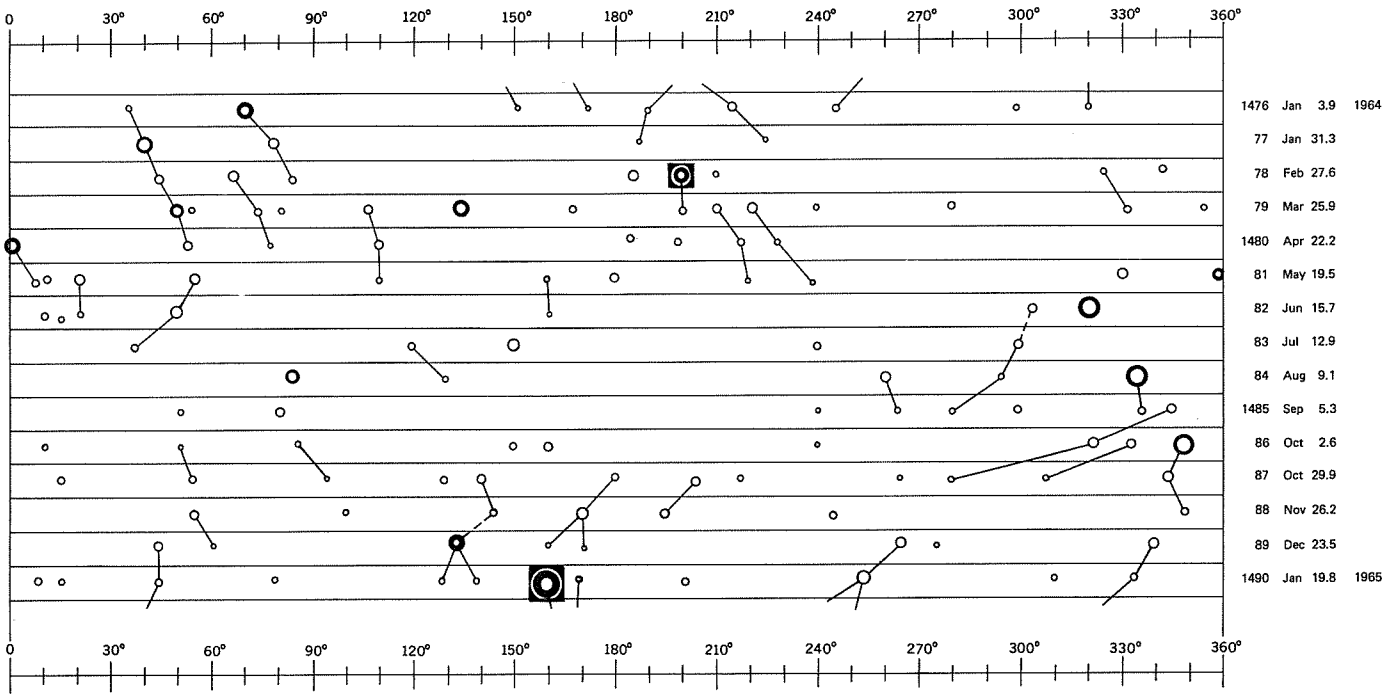
k-values (to chart scale)



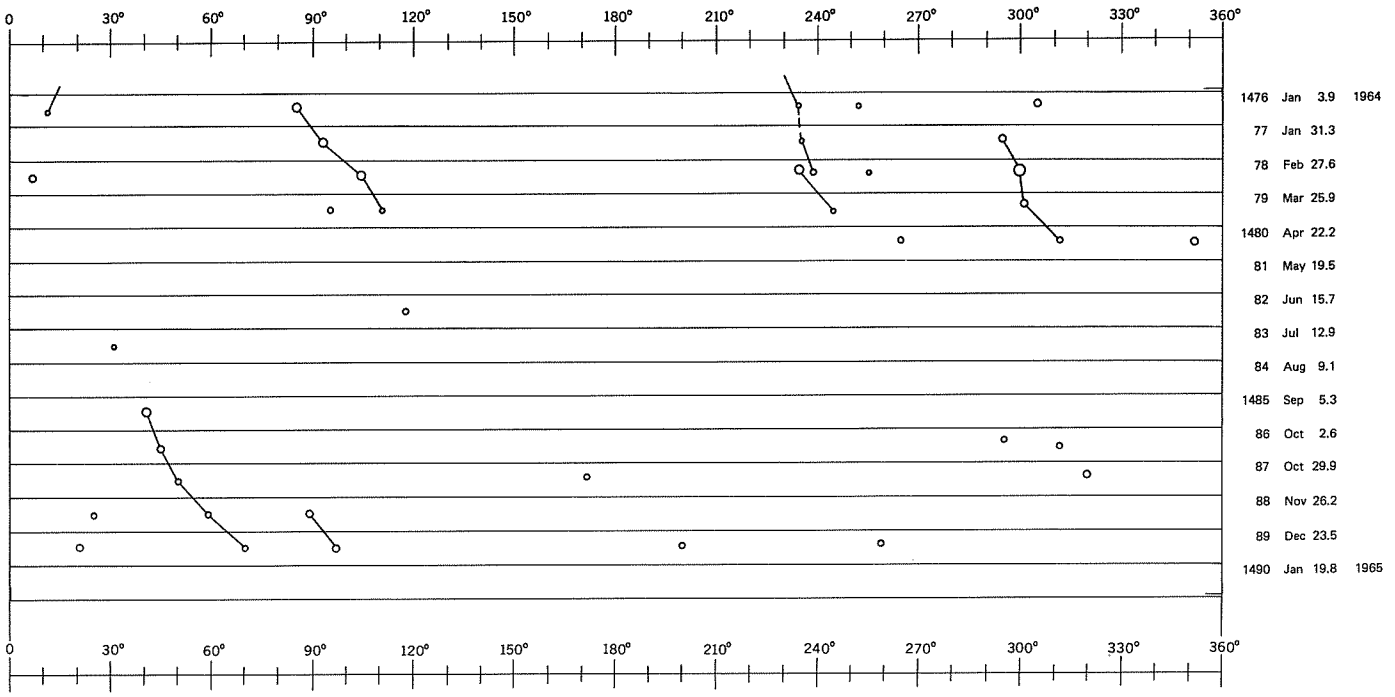
1964

In this year of sun spot minimum, there was only one region of significant activity: Rotation 1478, Plage 7182, CMP March 11; L_o = 200°, Lat N04°. This region, belonging to old Cycle 19, produced a PCA flare on March 16.

1964 Northern Hemisphere



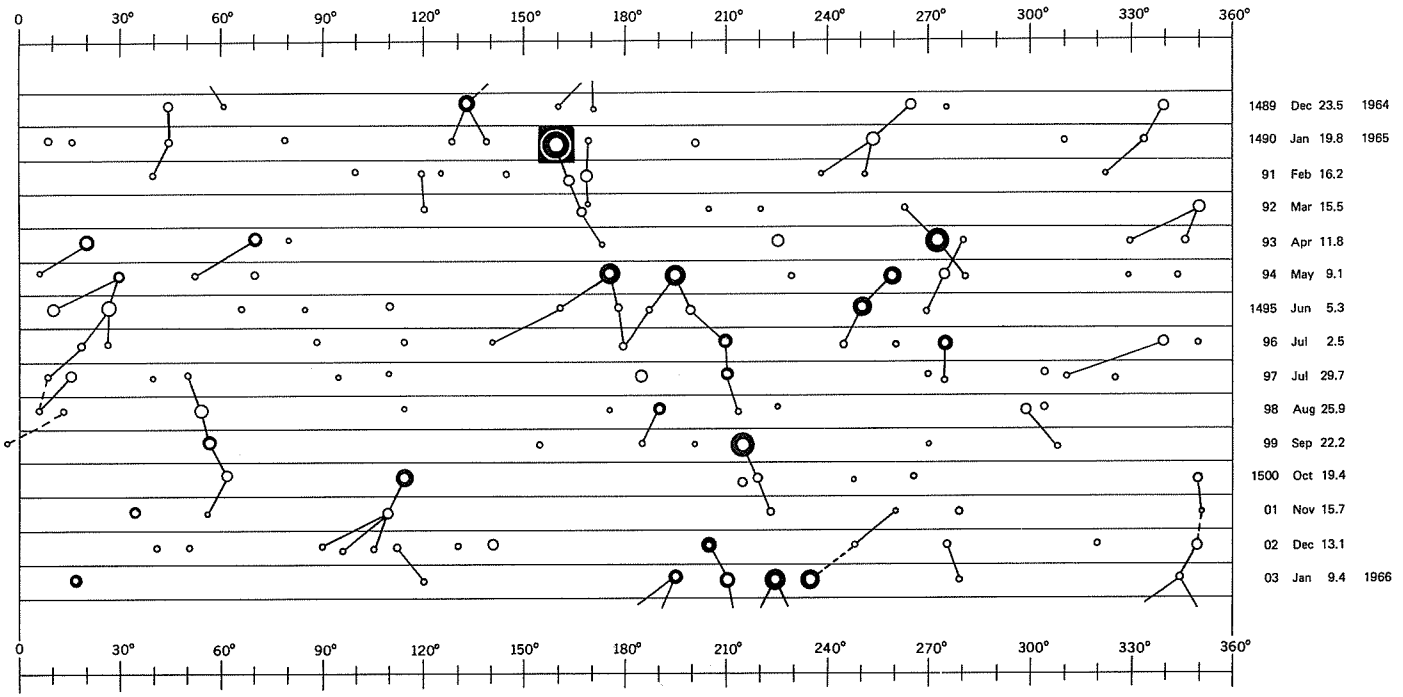
1964 Southern Hemisphere



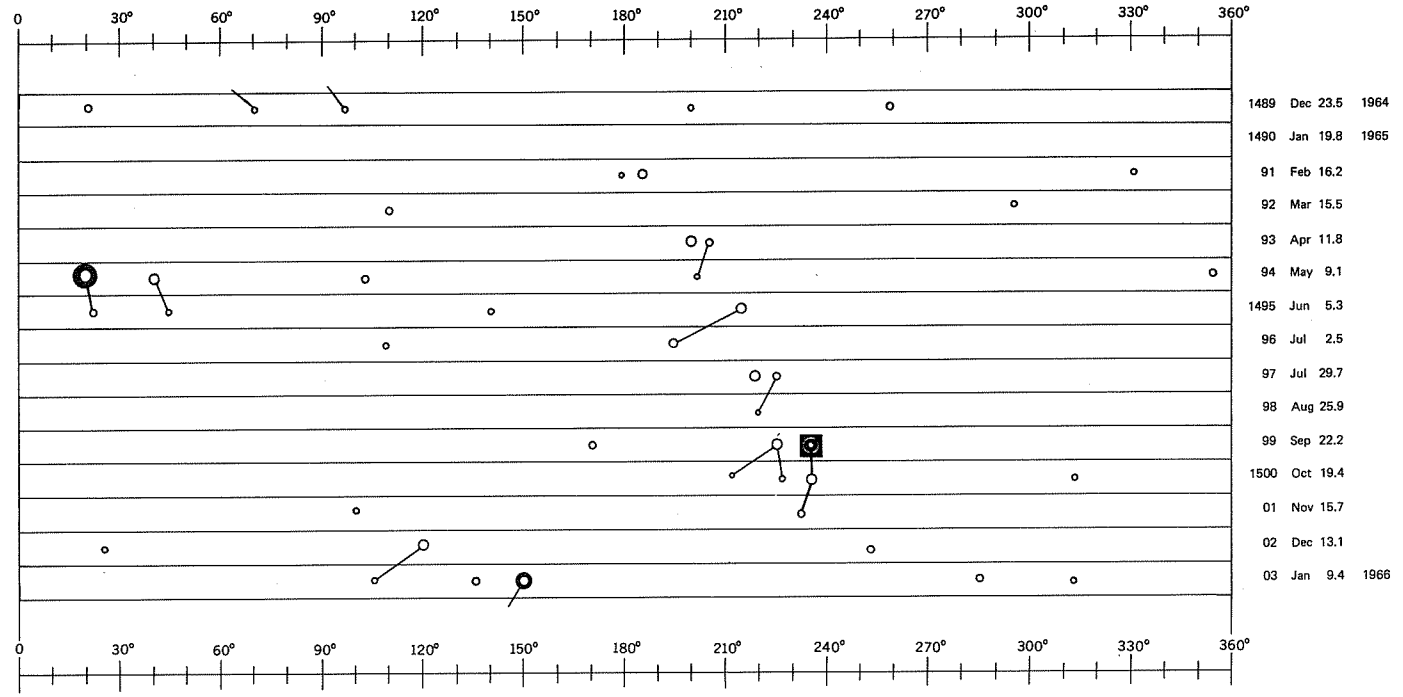
1965

Major activity was primarily in the northern hemisphere in a zone from 160° to 270° longitude. It included significant old cycle activity (with a PCA flare) in Rotation 1490 and significant new cycle activity in 1494.

1965 Northern Hemisphere



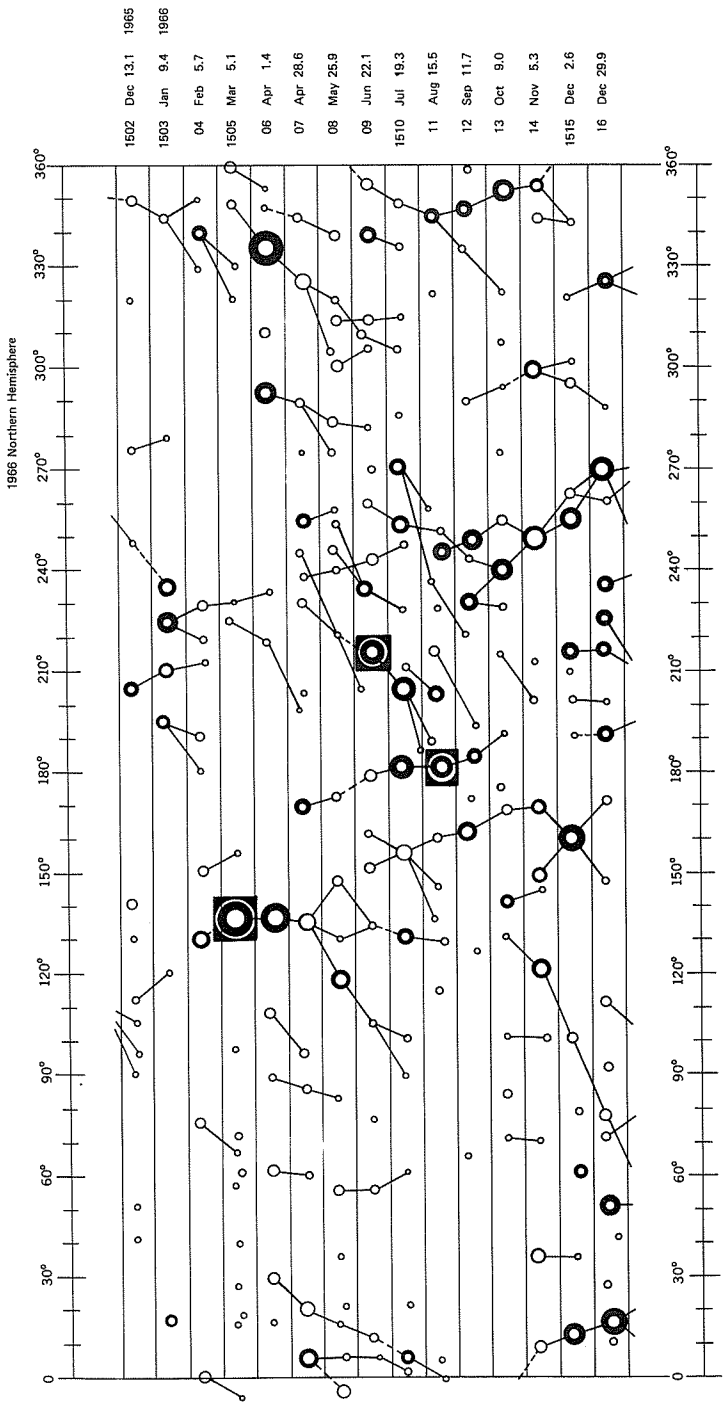
1965 Southern Hemisphere



1966

Major activity increased, but continued to be concentrated in the northern hemisphere and in longitude zone 130° to 270°.

1966


1966 Northern Hemisphere
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1503 Jan 9.4 1966
04 Feb 5.7
1505 Mar 5.1
06 Apr 1.4
07 Apr 28.6
08 May 25.9
09 Jun 22.1
1510 Jul 19.3
11 Aug 15.5
12 Sep 11.7
13 Oct 9.0
14 Nov 5.3
1515 Dec 2.6
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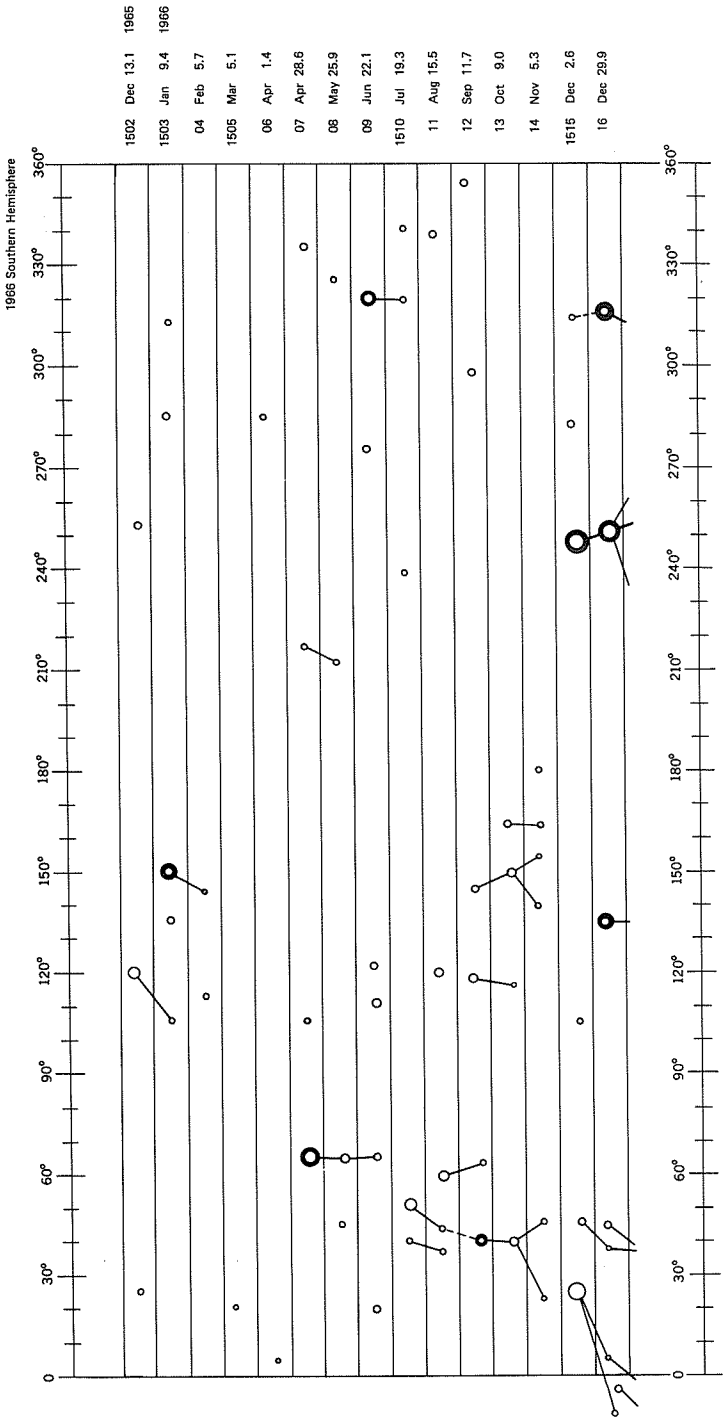
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04 Feb 5.7
1505 Mar 5.1
06 Apr 1.4
07 Apr 28.6
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09 Jun 22.1
1510 Jul 19.3
11 Aug 15.5
12 Sep 11.7
13 Oct 9.0
14 Nov 5.3
1515 Dec 2.6
16 Dec 29.9
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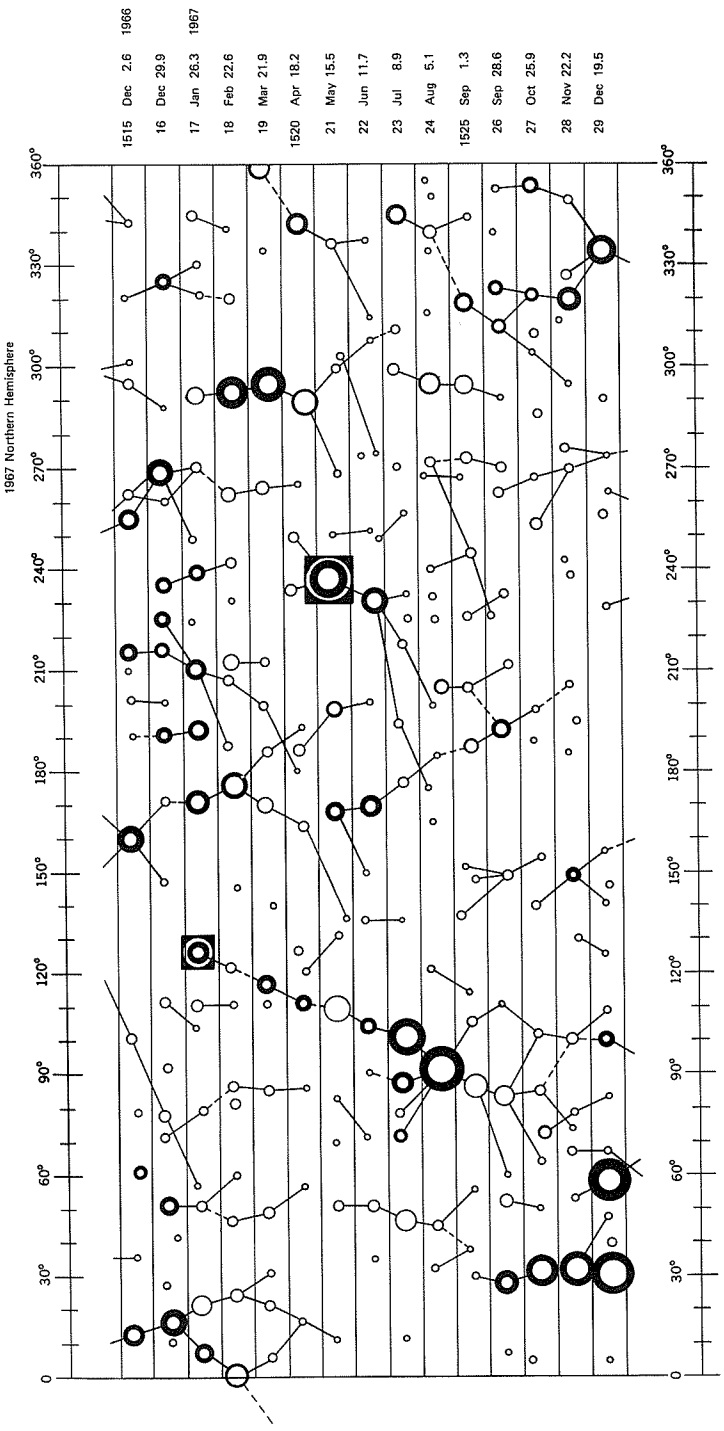
1967

Solar activity increased in both hemispheres and practically all longitudes were represented, although the northern hemisphere still dominated. A long-enduring family of plages began with Region 8687 in Rotation 1517 at longitude 125° and latitude N24 and can be traced for at least 12 rotations. It had the relatively slow rotation rate characteristic of the early part of the cycle.

1967


1967 Northern Hemisphere
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16 Dec 29.9
17 Jan 26.3 1967
18 Feb 22.6
19 Mar 21.9
1520 Apr 18.2
21 May 15.5
22 Jun 11.7
23 Jul 8.9
24 Aug 5.1
1525 Sep 1.3
26 Sep 28.6
27 Oct 25.9
28 Nov 22.2
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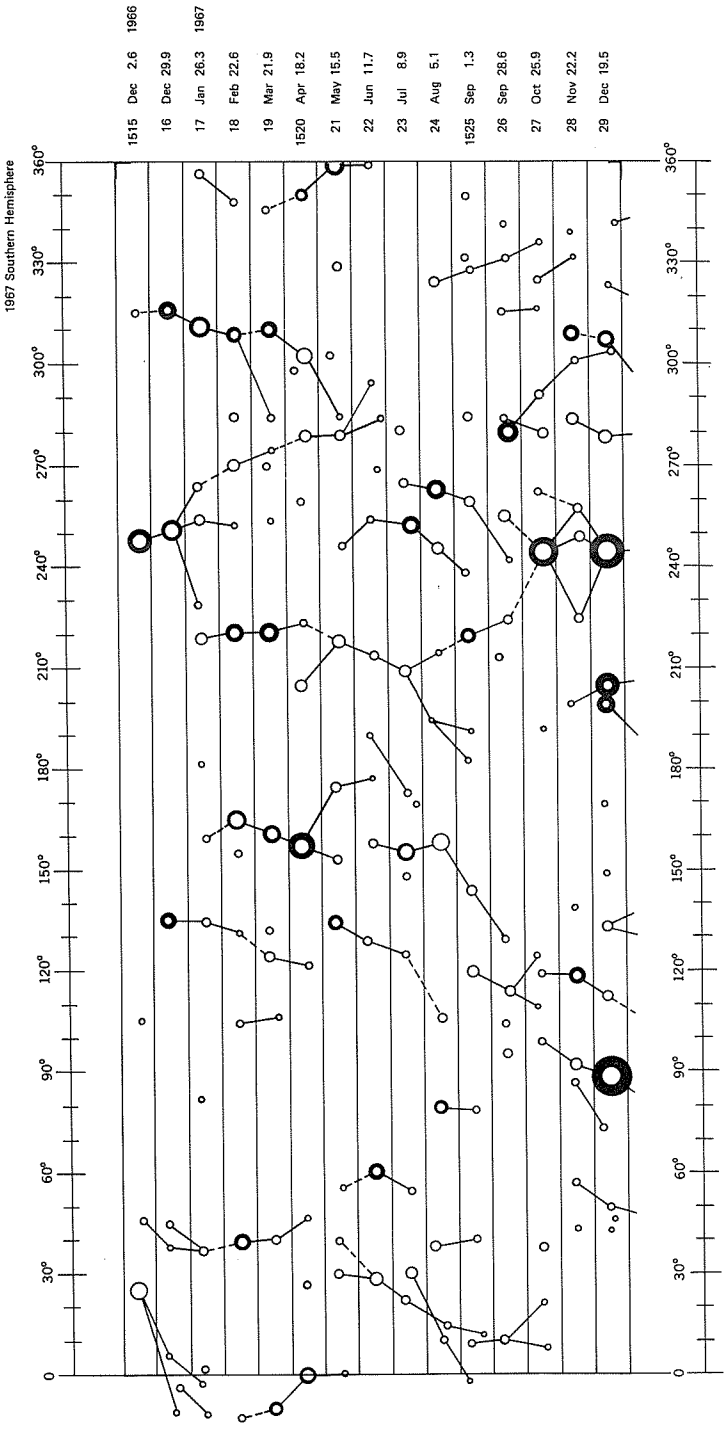
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18 Feb 22.6
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23 Jul 8.9
24 Aug 5.1
1525 Sep 1.3
26 Sep 28.6
27 Oct 25.9
28 Nov 22.2
29 Dec 19.5
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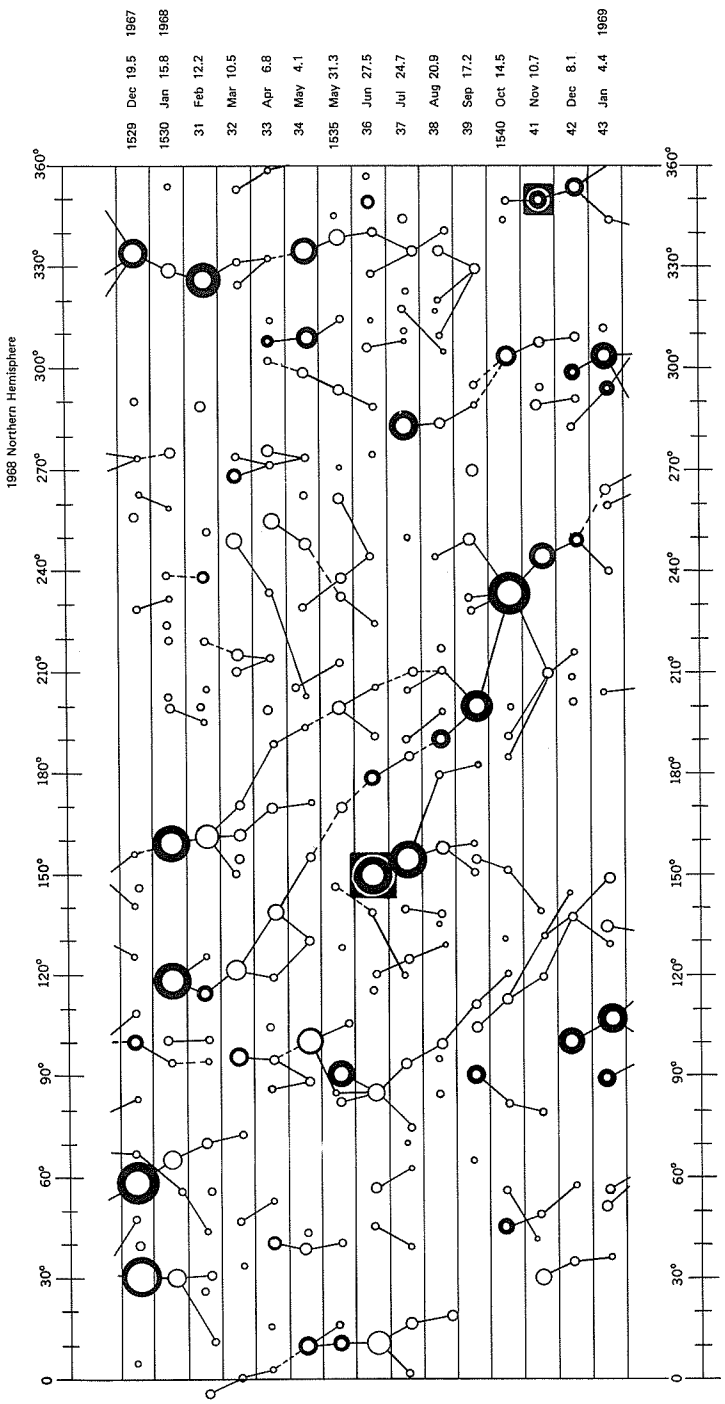
1968

Solar activity was at a high level in both hemispheres and all longitudes were represented. Centers of activity with the faster rotation rates typical of low latitude regions become apparent. In the southern hemisphere, the principal activity occurred in a family of plages that formed inconspicuously in rotation 1536, longitude 160°. These regions displayed significant levels of activity for five successive rotations with maximum activity in Rotation 1540 (Region 9740, $L_o \simeq 175°$ with CMP Oct. 28).

1968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34 May 4.1
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37 Jul 24.7
38 Aug 20.9
39 Sep 17.2
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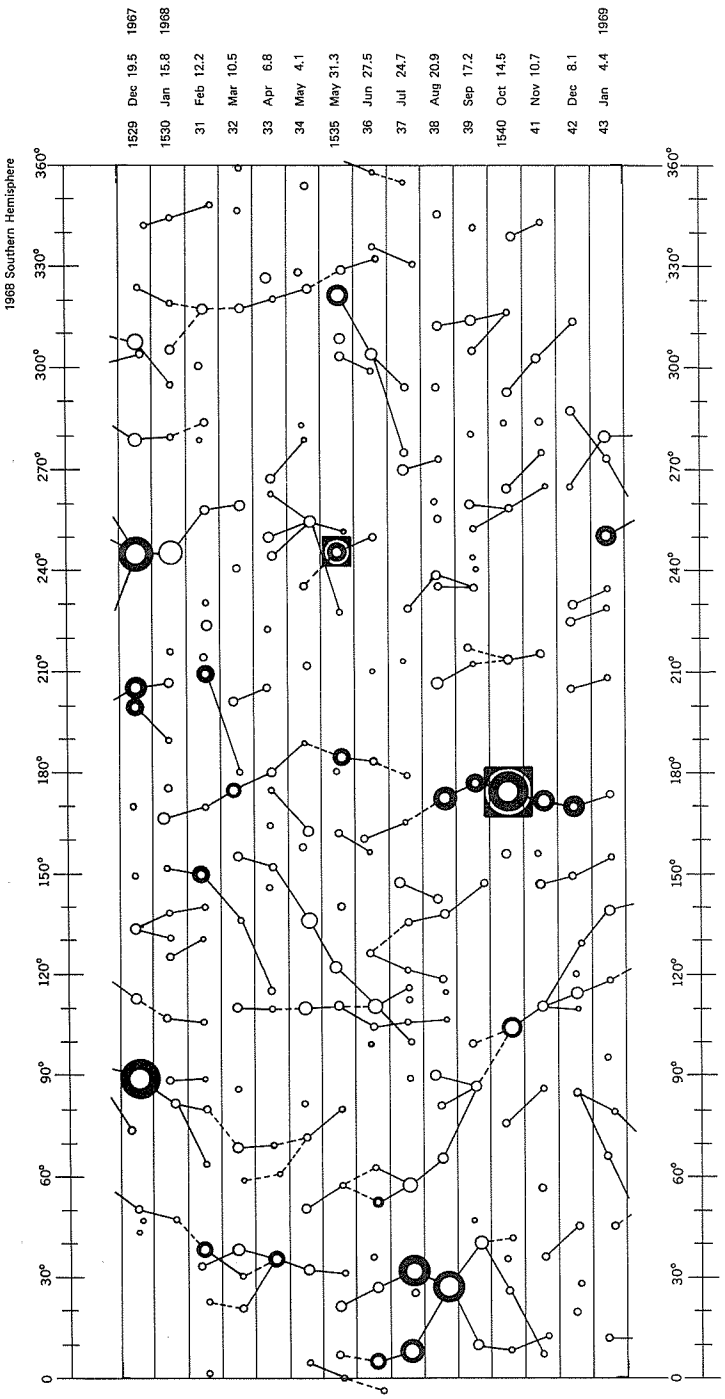
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31 Feb 12.2
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33 Apr 6.8
34 May 4.1
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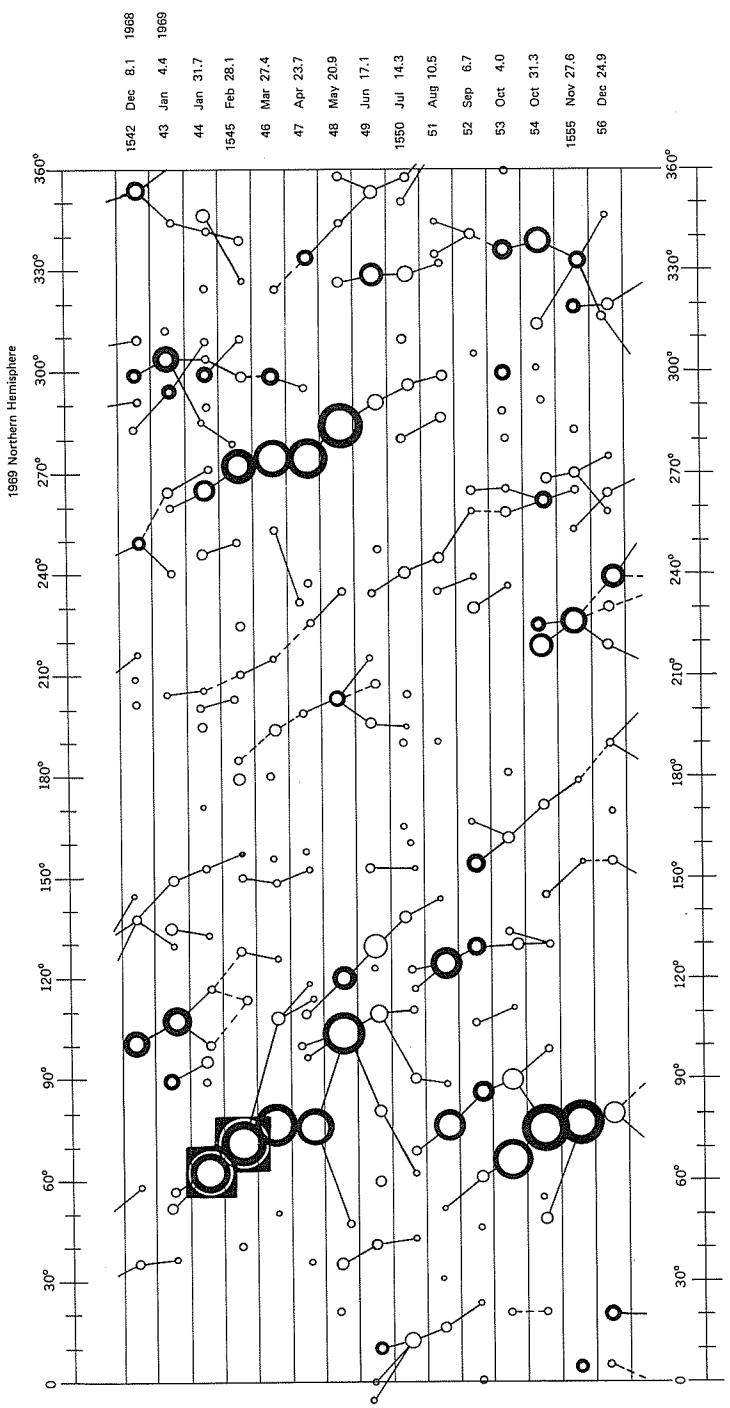
36 Jun 27.5
37 Jul 24.7
38 Aug 20.9
39 Sep 17.2
1540 Oct 14.5
41 Nov 10.7
42 Dec 8.1
43 Jan 4.4 1969
0° 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°

1969

Although activity was high in both northern and southern hemispheres, there were many more great centers of activity in the north than in the south. In the northern hemisphere of the sun, there were three families of plages that displayed great activity in three to four successive rotations. These regions were located in zones on opposite sides of the sun centered in longitudes of approximately 90° and 270°.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47 Apr 23.7
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1550 Jul 14.3
51 Aug 10.5
52 Sep 6.7
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56 Dec 24.9
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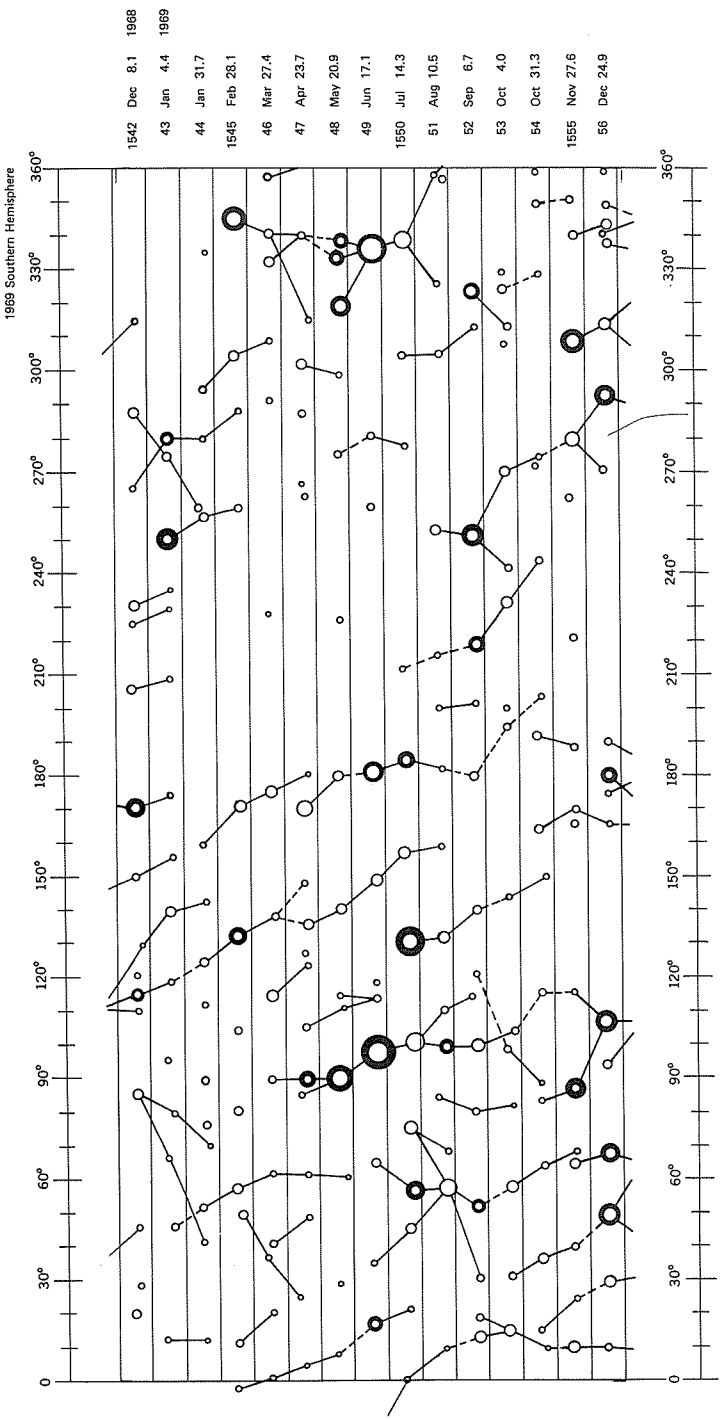
1969 Southern Hemisphere
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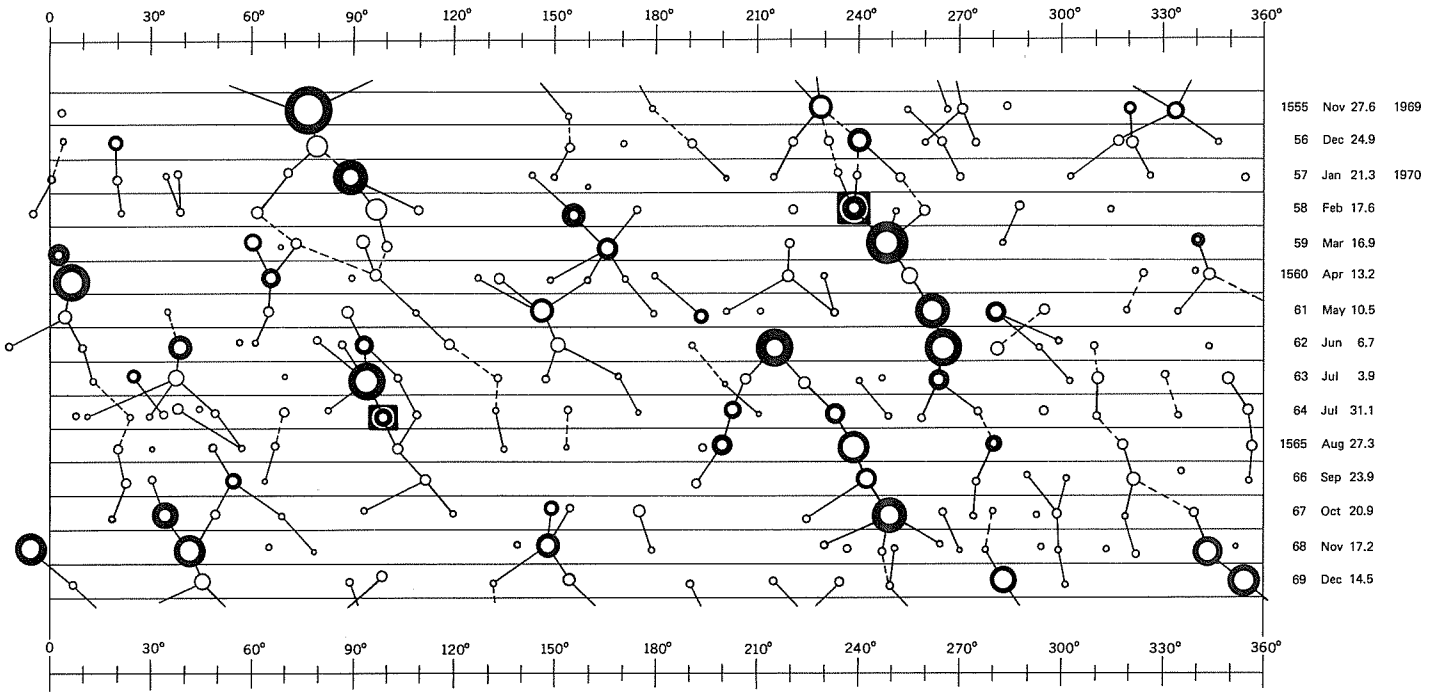
43 Jan 4.4 1969
44 Jan 31.7
1545 Feb 28.1
46 Mar 27.4
47 Apr 23.7
48 May 20.9
49 Jun 17.1
1550 Jul 14.3
51 Aug 10.5
52 Sep 6.7
53 Oct 4.0
54 Oct 31.3
1555 Nov 27.6
56 Dec 24.9
0 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°

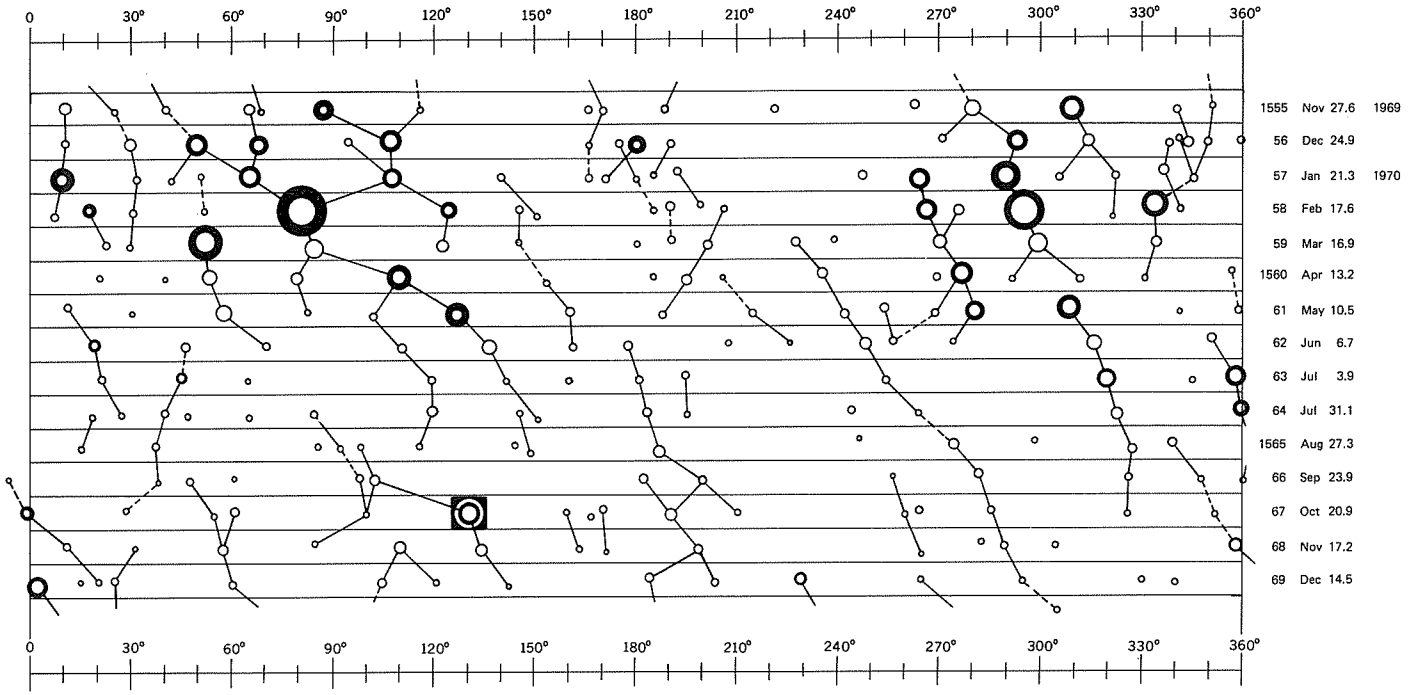
1970

Levels of activity continued high, especially in the northern hemisphere where an apparently large number of families of plages are recorded as having reached high levels of activity for at least one or two rotations. In the southern hemisphere, activity diminished after the middle of the year.

1970 Northern Hemisphere

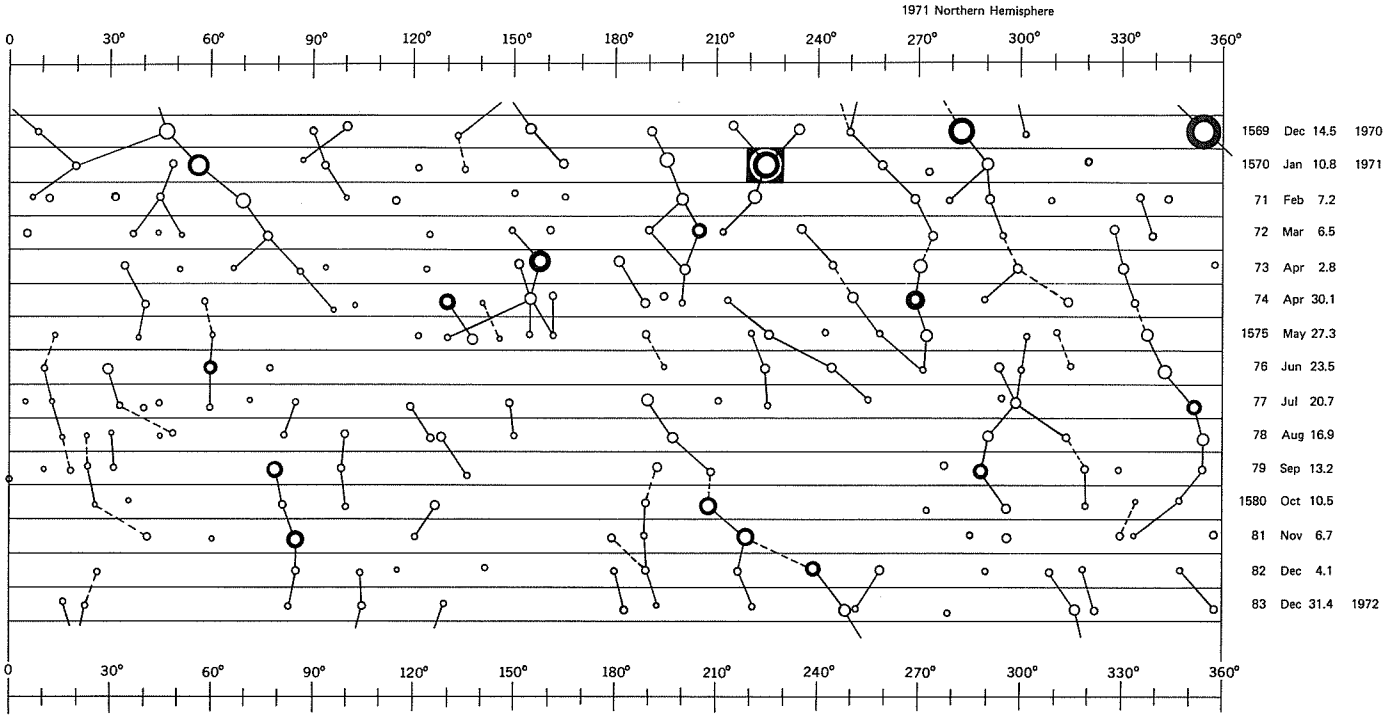


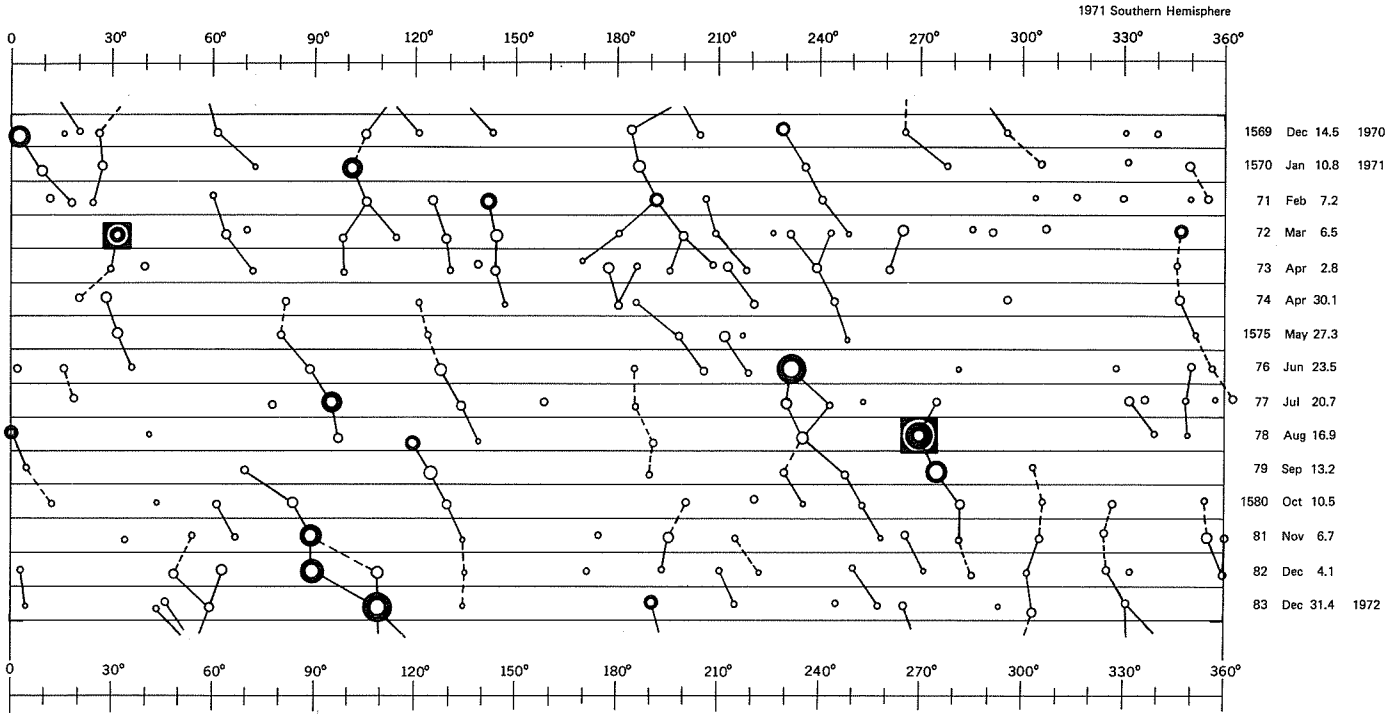
1970 Southern Hemisphere



1971

There was a striking diminution in both northern and southern hemispheres in the number of families of plages that developed significant levels of activity. Although there were many plages, they were not centers of important activity. There were several zones on the sun in 1971 that were relatively free from all plages for at least four rotations.

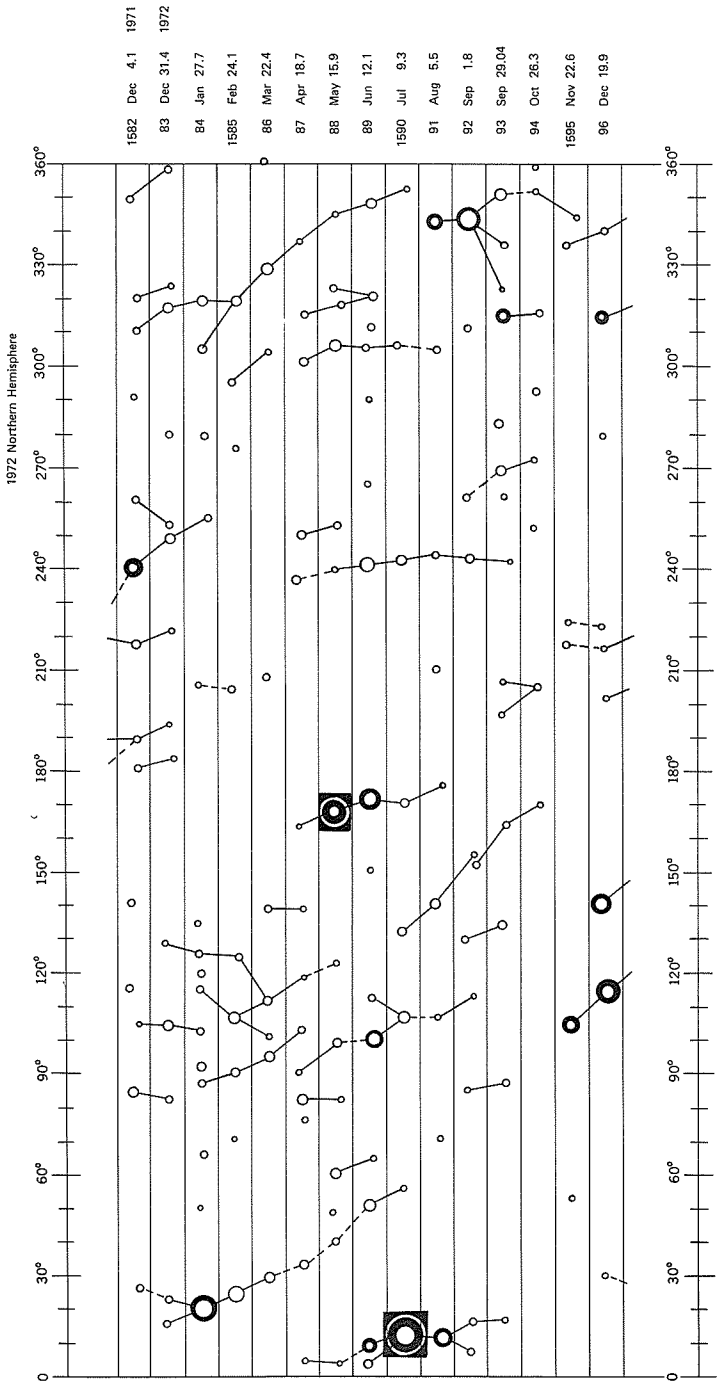

1971 Northern Hemisphere
0 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°
1569 Dec 14.5 1970
1570 Jan 10.8 1971
71 Feb 7.2
72 Mar 6.5
73 Apr 2.8
74 Apr 30.1
1575 May 27.3
76 Jun 23.5
77 Jul 20.7
78 Aug 16.9
79 Sep 13.2
1580 Oct 10.5
81 Nov 6.7
82 Dec 4.1
83 Dec 31.4 1972

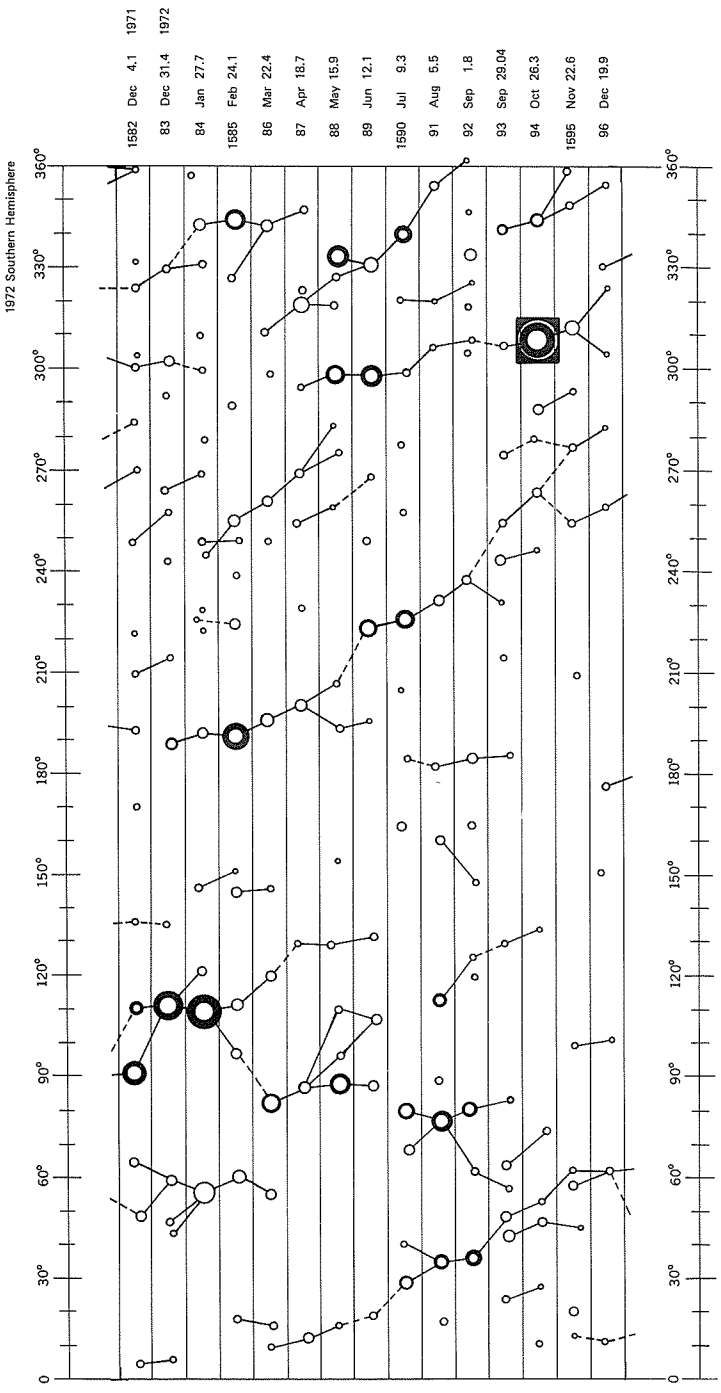

1971 Southern Hemisphere
0 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°
1569 Dec 14.5 1970
1570 Jan 10.8 1971
71 Feb 7.2
72 Mar 6.5
73 Apr 2.8
74 Apr 30.1
1575 May 27.3
76 Jun 23.5
77 Jul 20.7
78 Aug 16.9
79 Sep 13.2
1580 Oct 10.5
81 Nov 6.7
82 Dec 4.1
83 Dec 31.4 1972

1972

The sun continued to have many plages, but relatively few of these regions developed high levels of activity. In the northern hemisphere, there were only two regions of great activity, Plages 11895 and 11976. These regions crossed the central meridian of the sun on May 30 and August 4, respectively. They were on approximately opposite sides of the sun near longitudes 180° and 0°, respectively. In the southern hemisphere, the principal center of activity was Plage 12094 in Rotation 1594 (CMP October 30). The great centers of activity constituted major solar events relatively isolated in both time and heliographic position.

1972


1972 Northern Hemisphere
1582 Dec 4.1 1971
83 Dec 31.4 1972
84 Jan 27.7
1585 Feb 24.1
86 Mar 22.4
87 Apr 18.7
88 May 15.9
89 Jun 12.1
1590 Jul 9.3
91 Aug 5.5
92 Sep 1.8
93 Sep 29.04
94 Oct 26.3
1595 Nov 22.6
96 Dec 19.9
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°


1972 Southern Hemisphere
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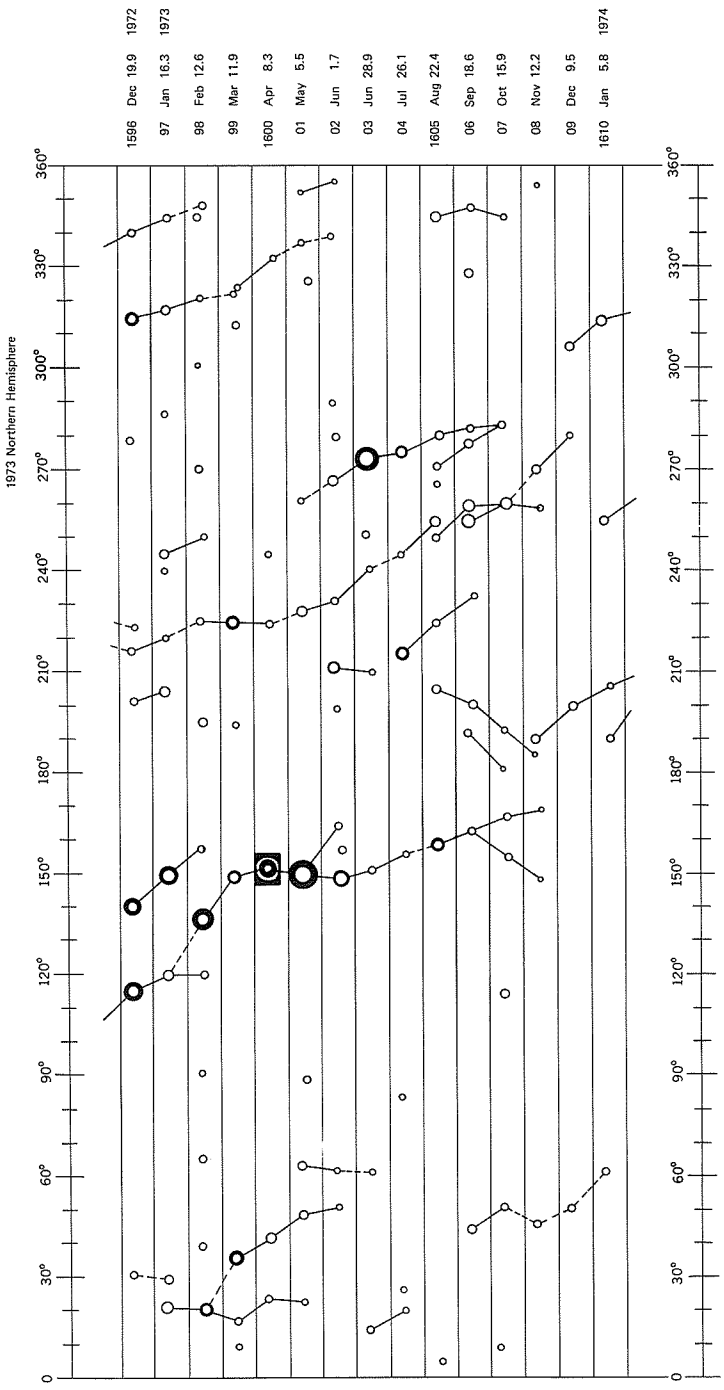
83 Dec 31.4 1972
84 Jan 27.7
1585 Feb 24.1
86 Mar 22.4
87 Apr 18.7
88 May 15.9
89 Jun 12.1
1590 Jul 9.3
91 Aug 5.5
92 Sep 1.8
93 Sep 29.04
94 Oct 26.3
1595 Nov 22.6
96 Dec 19.9
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°

1973

Solar activity diminished markedly. It was located primarily in a zone that extended from approximately 110° to 210°. Activity in this zone in the first half of the year was greater in the northern hemisphere. In the second half of the year, activity in the zone was primarily in southern latitudes. In both northern and southern hemispheres, there were extensive areas on the sun free from plages for many rotations.

1973


1973 Northern Hemisphere
1596 Dec 19.9 1972
97 Jan 16.3 1973
98 Feb 12.6
99 Mar 11.9
1600 Apr 8.3
01 May 5.5
02 Jun 1.7
03 Jun 28.9
04 Jul 26.1
1605 Aug 22.4
06 Sep 18.6
07 Oct 15.9
08 Nov 12.2
09 Dec 9.5
1610 Jan 5.8 1974
0
30°
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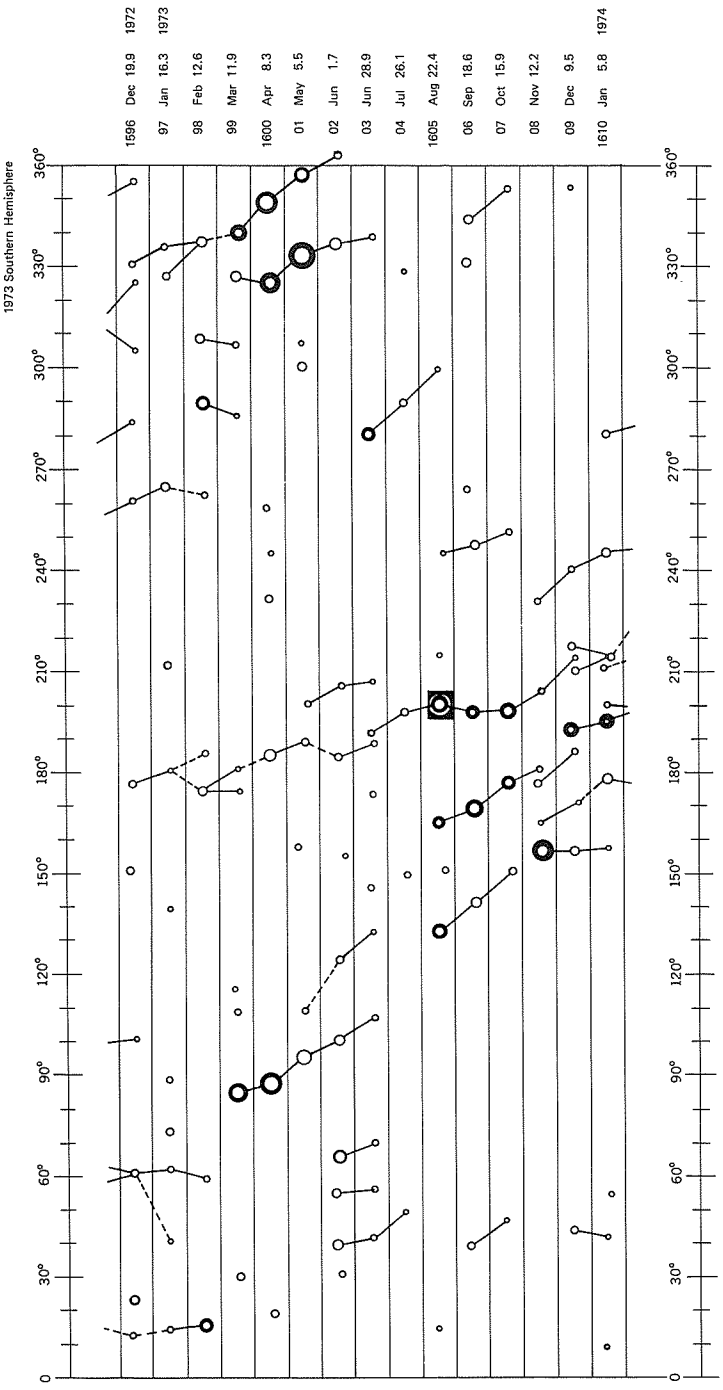
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°


1973 Southern Hemisphere
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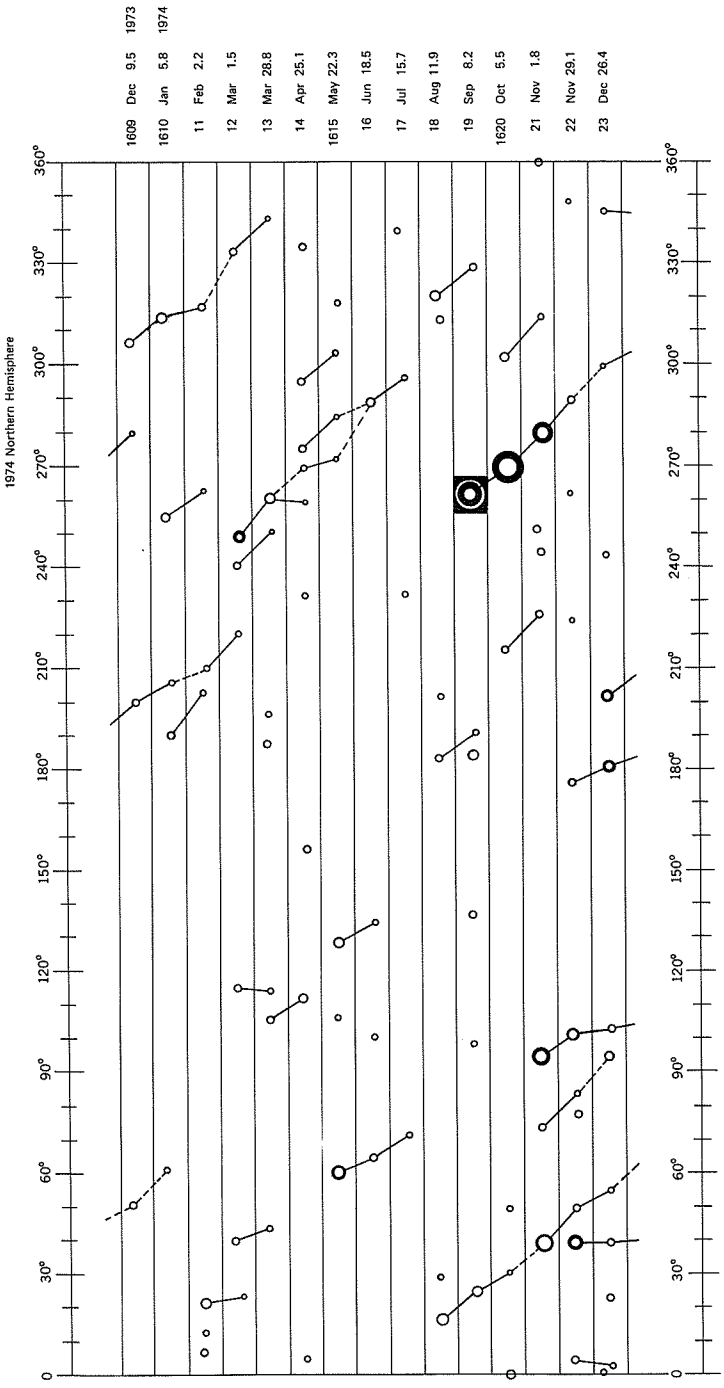
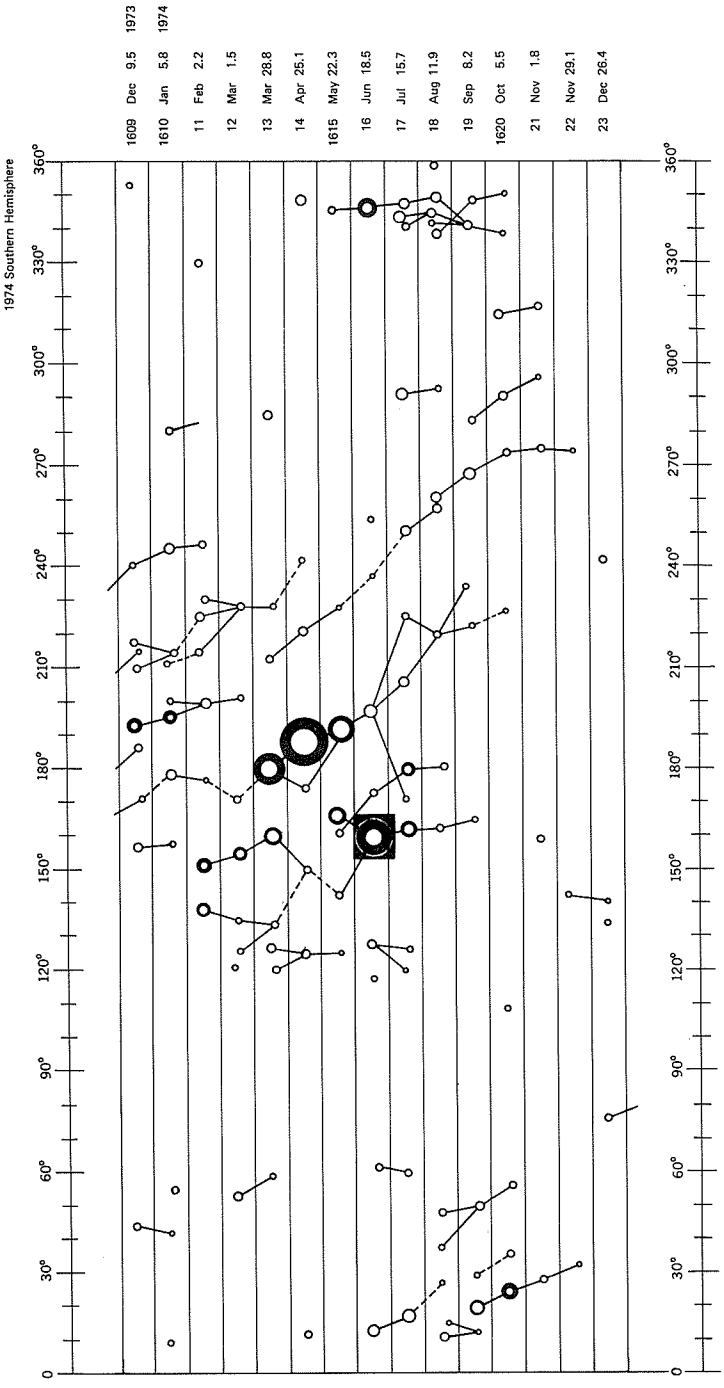
97 Jan 16.3 1973
98 Feb 12.6
99 Mar 11.9
1600 Apr 8.3
01 May 5.5
02 Jun 1.7
03 Jun 28.9
04 Jul 26.1
1605 Aug 22.4
06 Sep 18.6
07 Oct 15.9
08 Nov 12.2
09 Dec 9.5
1610 Jan 5.8 1974
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°

1974

For the first time in Cycle 20, major solar activity appears to have been greater in the southern than in the northern hemisphere. The zone of activity that had begun in mid-1973 in southern latitudes continued in the first half of 1974, and made longitudes 120° to 210° the source of the principal activity on the sun. Regions 12906 and 13043 with CMP on May 8 and July 4, respectively, in Rotations 1614 and 1616, were especially active in the south, while there was one family of plages in the north that produced significant activity, beginning with Plage 13225, CMP September 15, Rotation 1619.

1974

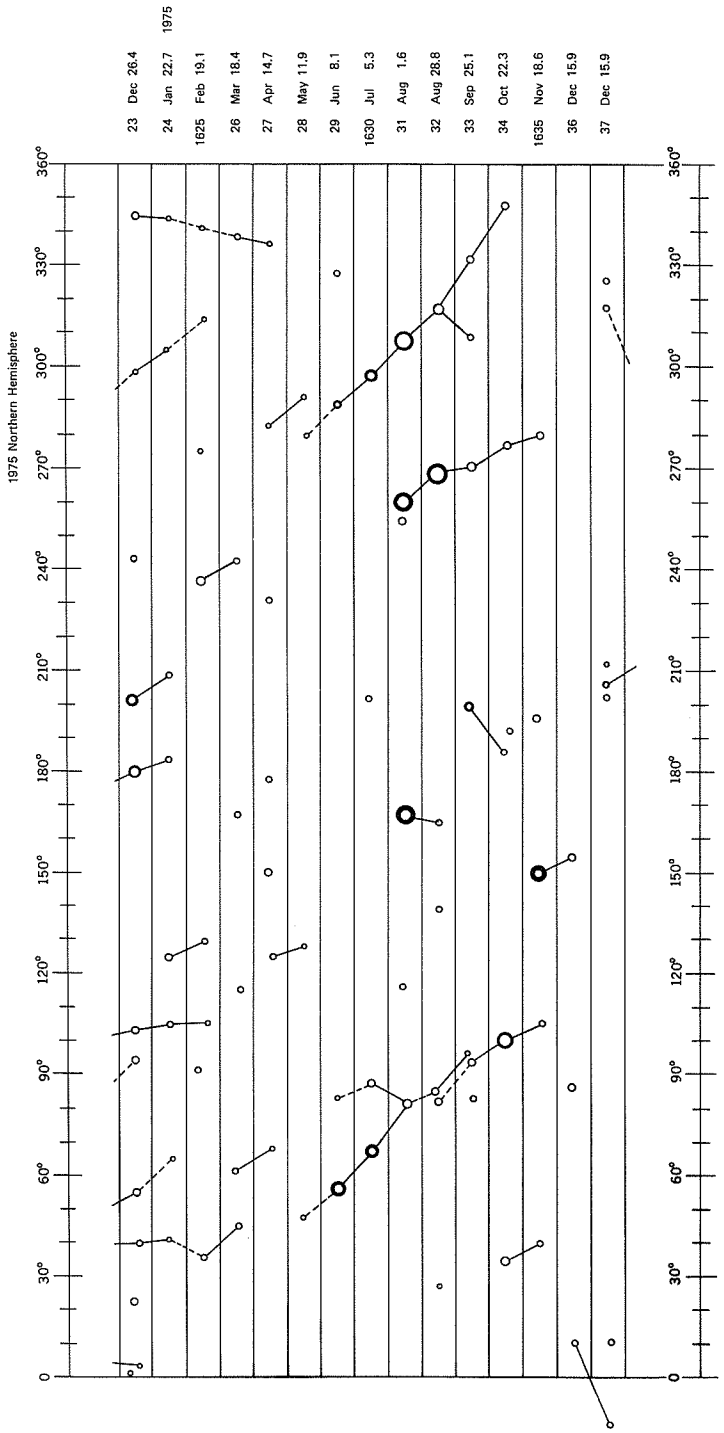

1974 Northern Hemisphere
1609 Dec 9.5 1973
1610 Jan 5.8 1974
11 Feb 2.2
12 Mar 1.5
13 Mar 28.8
14 Apr 25.1
1615 May 22.3
16 Jun 18.5
17 Jul 15.7
18 Aug 11.9
19 Sep 8.2
1620 Oct 5.5
21 Nov 1.8
22 Nov 29.1
23 Dec 26.4
0° 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°


1974 Southern Hemisphere
1609 Dec 9.5 1973
1610 Jan 5.8 1974
11 Feb 2.2
12 Mar 1.5
13 Mar 28.8
14 Apr 25.1
1615 May 22.3
16 Jun 18.5
17 Jul 15.7
18 Aug 11.9
19 Sep 8.2
1620 Oct 5.5
21 Nov 1.8
22 Nov 29.1
23 Dec 26.4
0° 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°

1975

The sun developed numerous plages but none of them became a center of truly major activity. The northern and southern hemispheres were relatively balanced in the production of plages.

1975


1975 Northern Hemisphere
23 Dec 26.4
24 Jan 22.7 1975
1625 Feb 19.1
26 Mar 18.4
27 Apr 14.7
28 May 11.9
29 Jun 8.1
1630 Jul 5.3
31 Aug 1.6
32 Aug 28.8
33 Sep 25.1
34 Oct 22.3
1635 Nov 18.6
36 Dec 15.9
37 Dec 15.9
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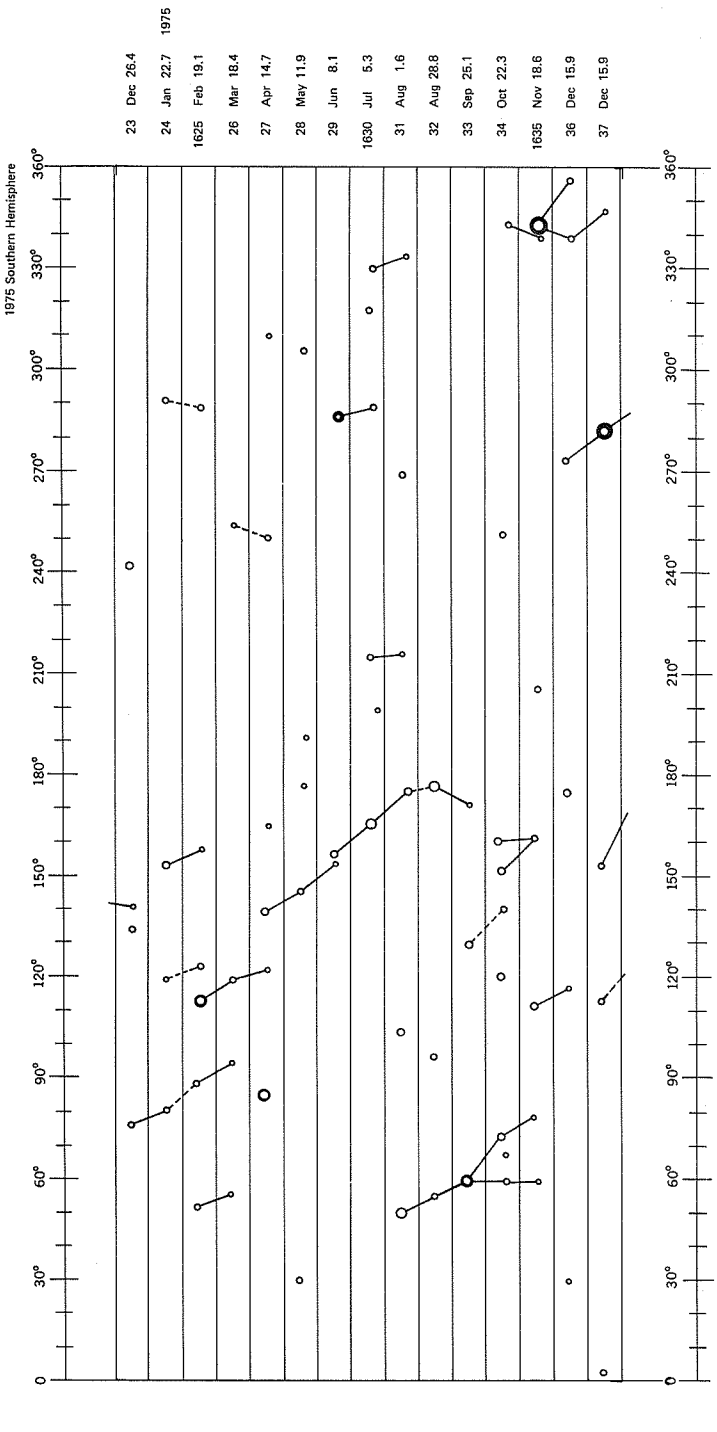
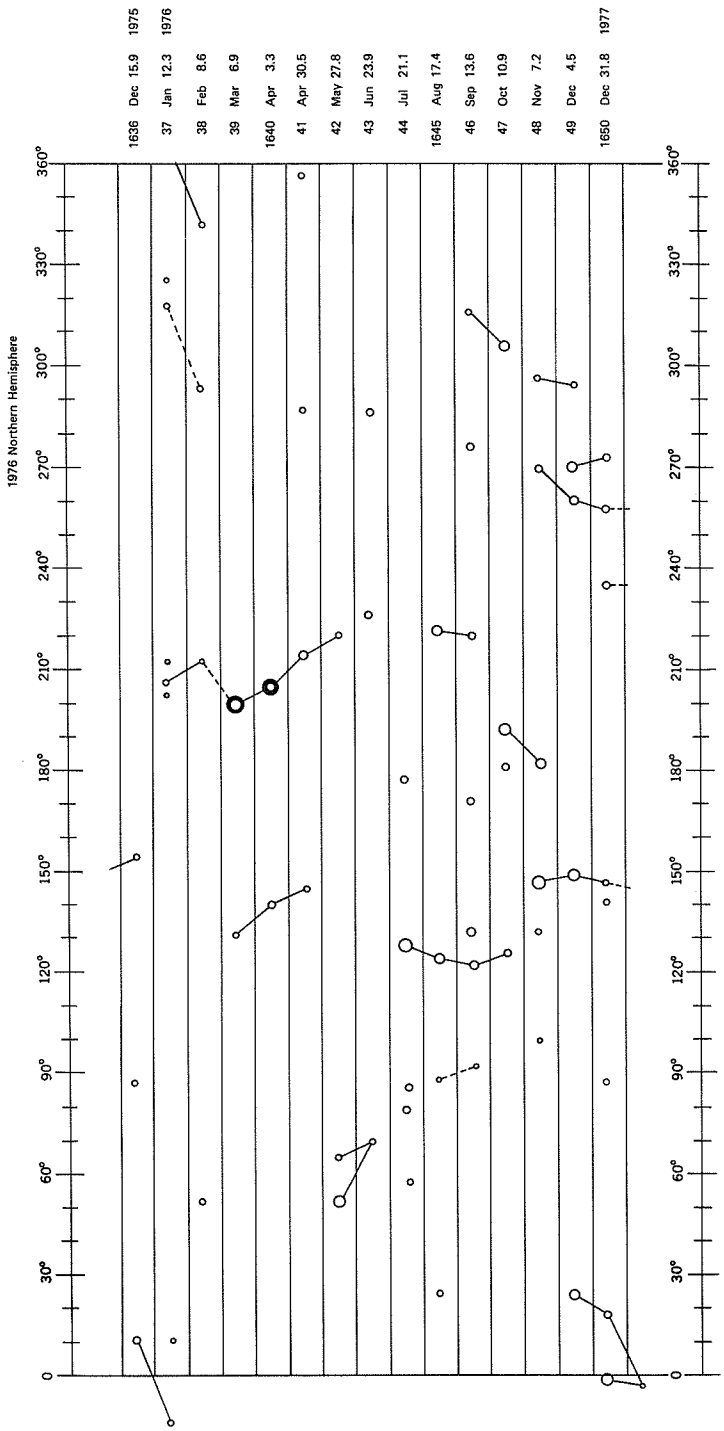
330°
360°

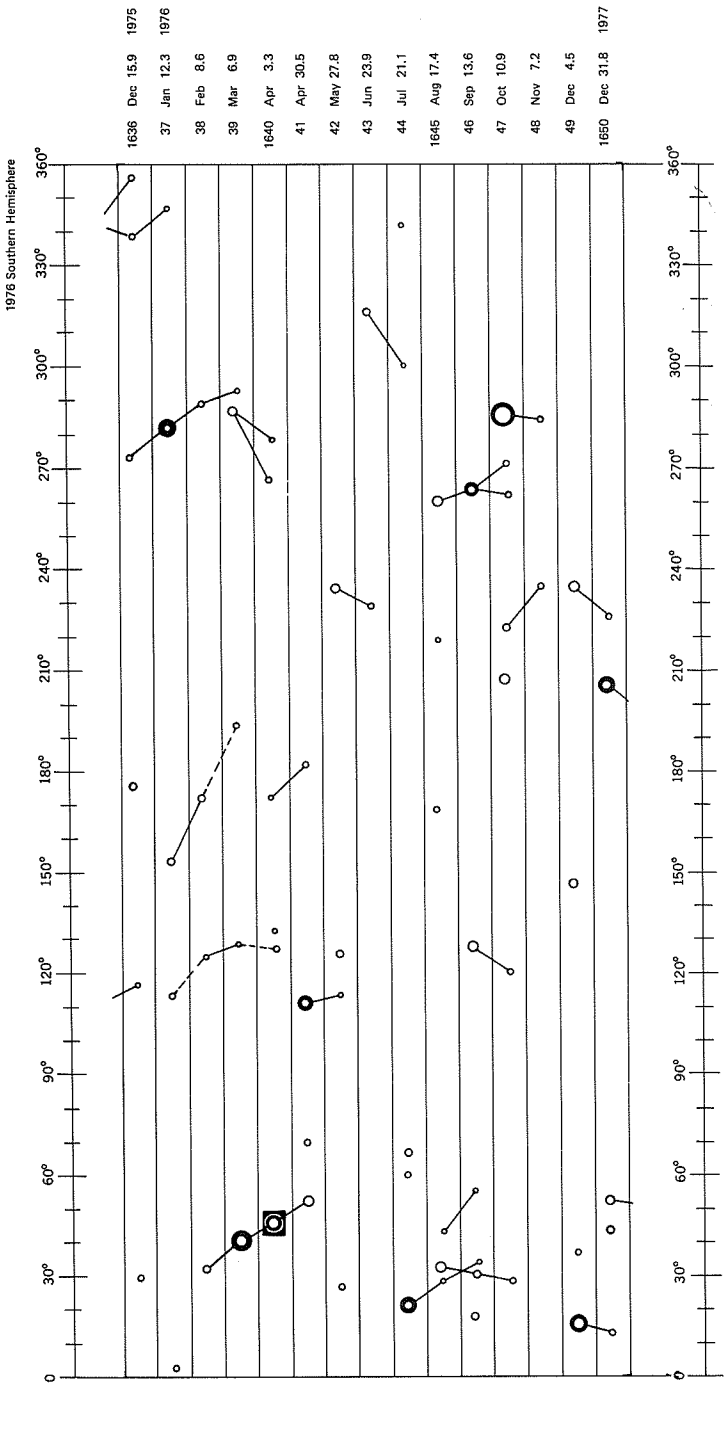

1975 Southern Hemisphere
23 Dec 26.4
24 Jan 22.7 1975
1625 Feb 19.1
26 Mar 18.4
27 Apr 14.7
28 May 11.9
29 Jun 8.1
1630 Jul 5.3
31 Aug 1.6
32 Aug 28.8
33 Sep 25.1
34 Oct 22.3
1635 Nov 18.6
36 Dec 15.9
37 Dec 15.9
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°

1976

Solar activity in the year of sun spot minimum continued to be limited primarily to small plages without marked activity. There were, however, exceptions to this pattern in March and April. There was a flaring region in the north, Plage 14127, CMP March 19, in Rotation 1639. In the south, Plage 14179, CMP April 27, in Rotation 1640, was associated with a high energy particle event.

1976

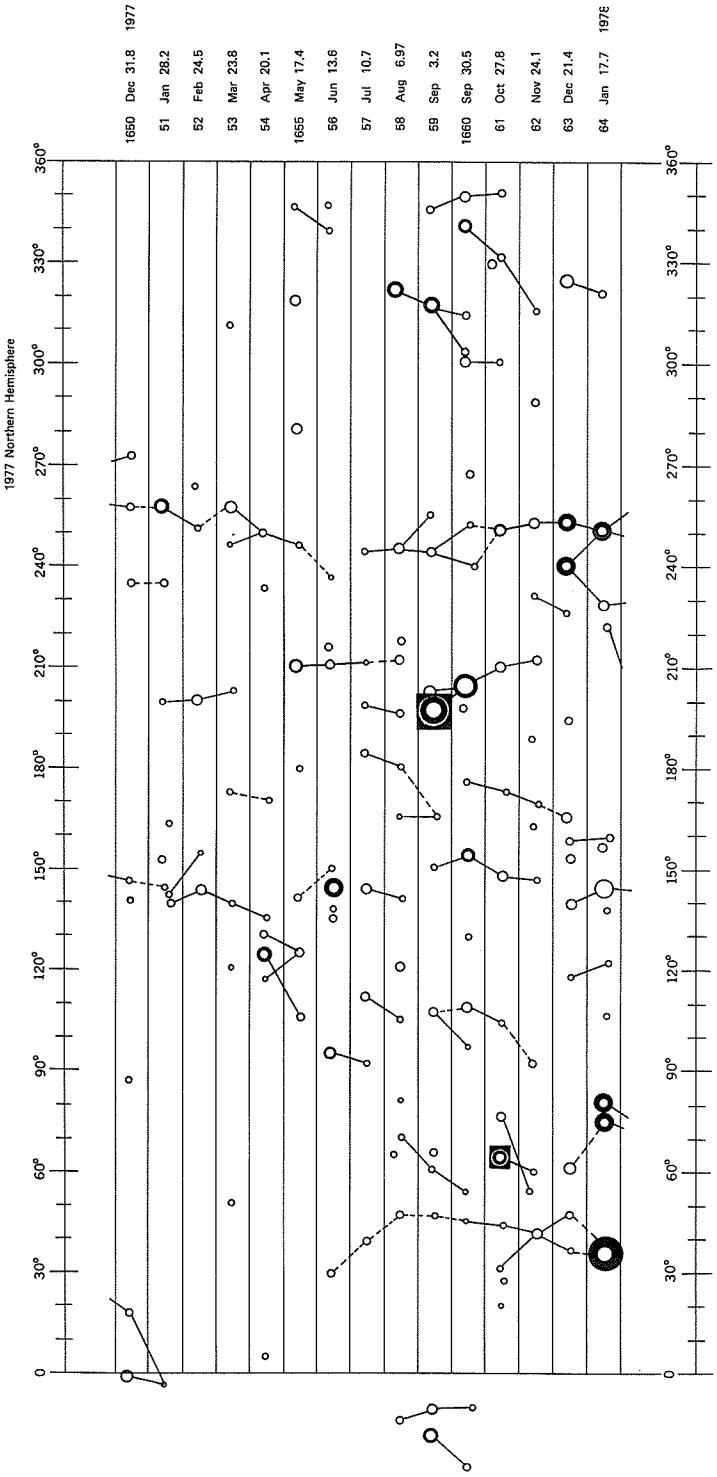

1976 Northern Hemisphere
1636 Dec 15.9 1975
37 Jan 12.3 1976
38 Feb 8.6
39 Mar 6.9
1640 Apr 3.3
41 Apr 30.5
42 May 27.8
43 Jun 23.9
44 Jul 21.1
1645 Aug 17.4
46 Sep 13.6
47 Oct 10.9
48 Nov 7.2
49 Dec 4.5
1650 Dec 31.8 1977
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°

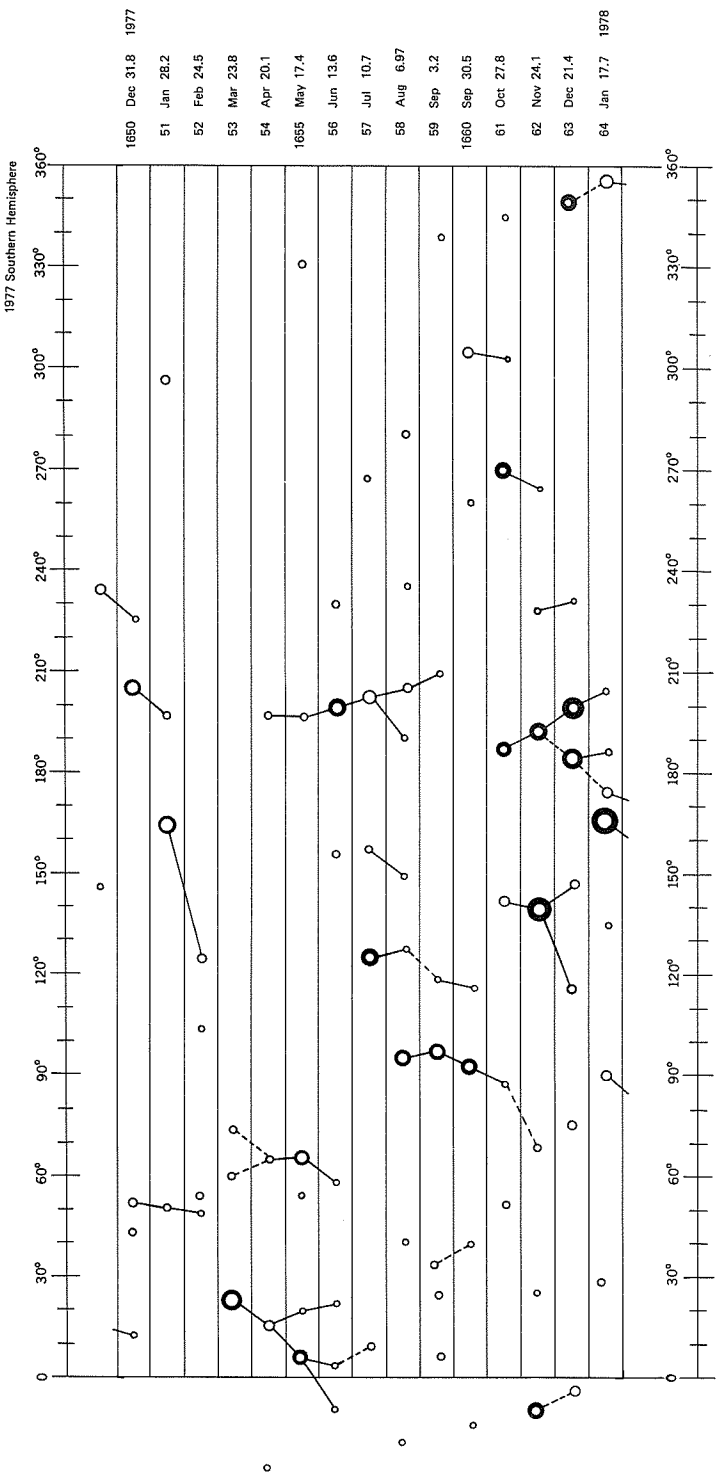

1976 Southern Hemisphere
1636 Dec 15.9 1975
37 Jan 12.3 1976
38 Feb 8.6
39 Mar 6.9
1640 Apr 3.3
41 Apr 30.5
42 May 27.8
43 Jun 23.9
44 Jul 21.1
1645 Aug 17.4
46 Sep 13.6
47 Oct 10.9
48 Nov 7.2
49 Dec 4.5
1650 Dec 31.8 1977
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°

1977

A marked increase in the level of solar activity took place in this first year in Solar Cycle 21 following the year of minimum (1976). This increase was especially marked after mid-1977. In both northern and southern hemispheres, the number of plages that were flare-rich increased in number. Two northern regions, 14943 and 15031 with CMP September 15 and November 19, in rotations 1659 and 1661, respectively, were associated with high energy particle emission.

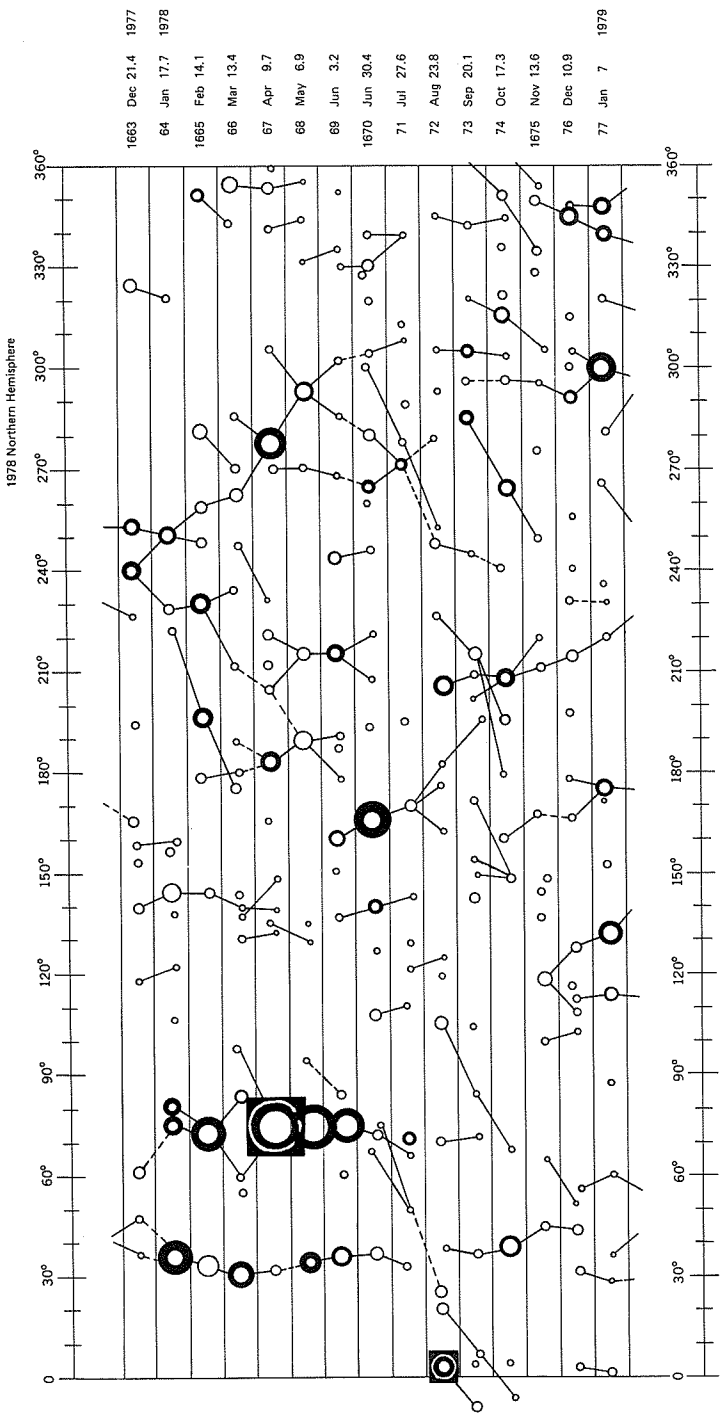
1977

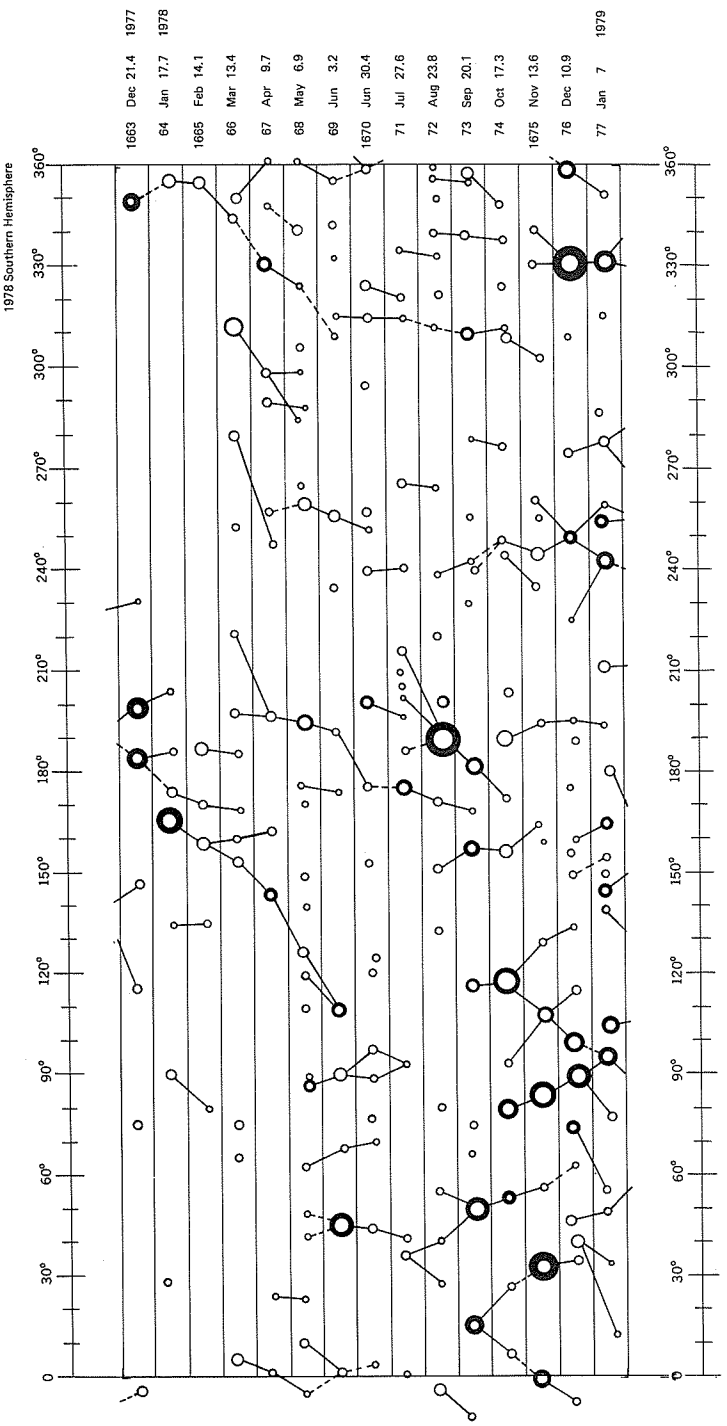

1977 Northern Hemisphere
1650 Dec 31.8 1977
51 Jan 28.2
52 Feb 24.5
53 Mar 23.8
54 Apr 20.1
1655 May 17.4
56 Jun 13.6
57 Jul 10.7
58 Aug 6.97
59 Sep 3.2
1660 Sep 30.5
61 Oct 27.8
62 Nov 24.1
63 Dec 21.4
64 Jan 17.7 1978
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°


1977 Southern Hemisphere
1650 Dec 31.8 1977
51 Jan 28.2
52 Feb 24.5
53 Mar 23.8
54 Apr 20.1
1655 May 17.4
56 Jun 13.6
57 Jul 10.7
58 Aug 6.97
59 Sep 3.2
1660 Sep 30.5
61 Oct 27.8
62 Nov 24.1
63 Dec 21.4
64 Jan 17.7 1978
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°

1978

The number and size of plages and their level of flare production continued to increase. Both northern and southern hemispheres were the sites of many flare centers. The highest level of activity was limited to a family of plages in the northern hemisphere at longitude ~ 75°. Activity in this family reached maximum development in Rotation 1667, and included the high energy particle event in May.

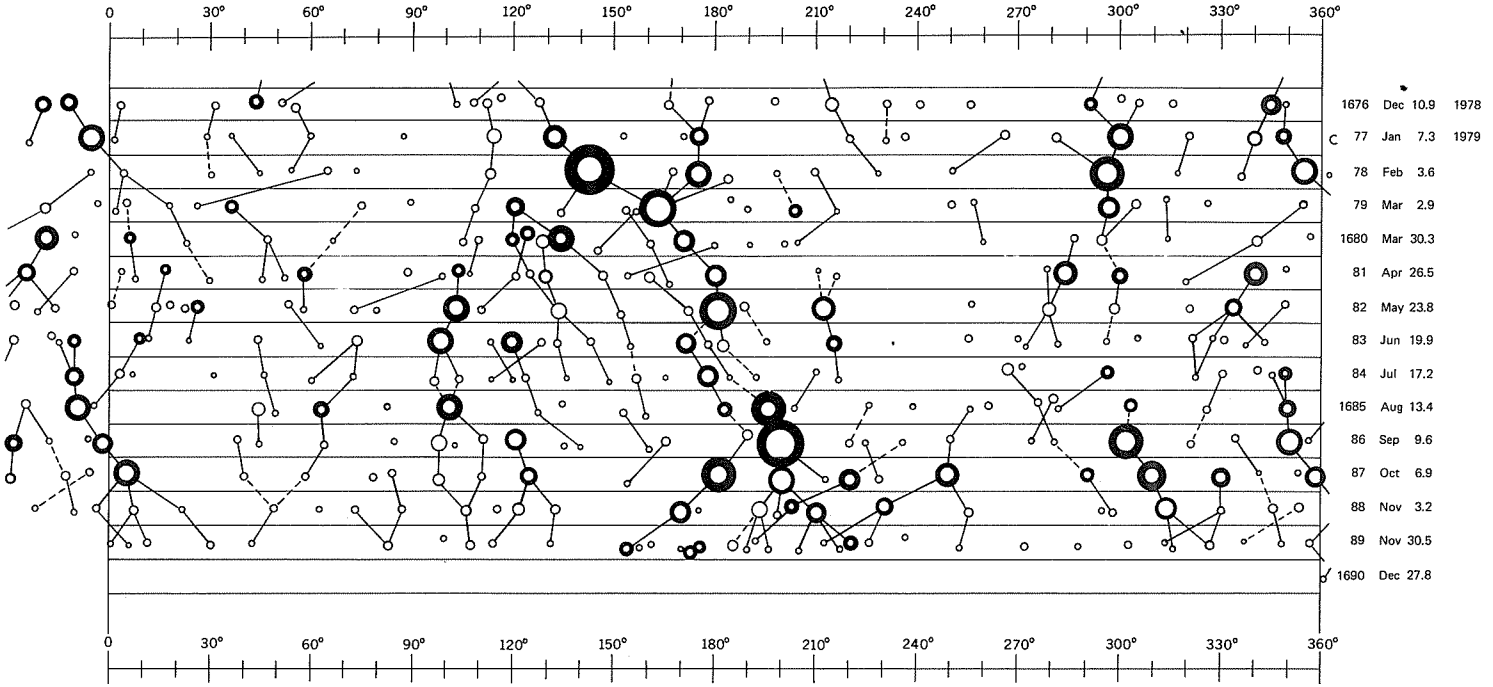

1978 Northern Hemisphere
1663 Dec 21.4 1977
64 Jan 17.7 1978
1665 Feb 14.1
66 Mar 13.4
67 Apr 9.7
68 May 6.9
69 Jun 3.2
1670 Jun 30.4
71 Jul 27.6
72 Aug 23.8
73 Sep 20.1
74 Oct 17.3
1675 Nov 13.6
76 Dec 10.9
77 Jan 7 1979
0° 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°


1978 Southern Hemisphere
1663 Dec 21.4 1977
64 Jan 17.7 1978
1665 Feb 14.1
66 Mar 13.4
67 Apr 9.7
68 May 6.9
69 Jun 3.2
1670 Jun 30.4
71 Jul 27.6
72 Aug 23.8
73 Sep 20.1
74 Oct 17.3
1675 Nov 13.6
76 Dec 10.9
77 Jan 7 1979
0° 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°

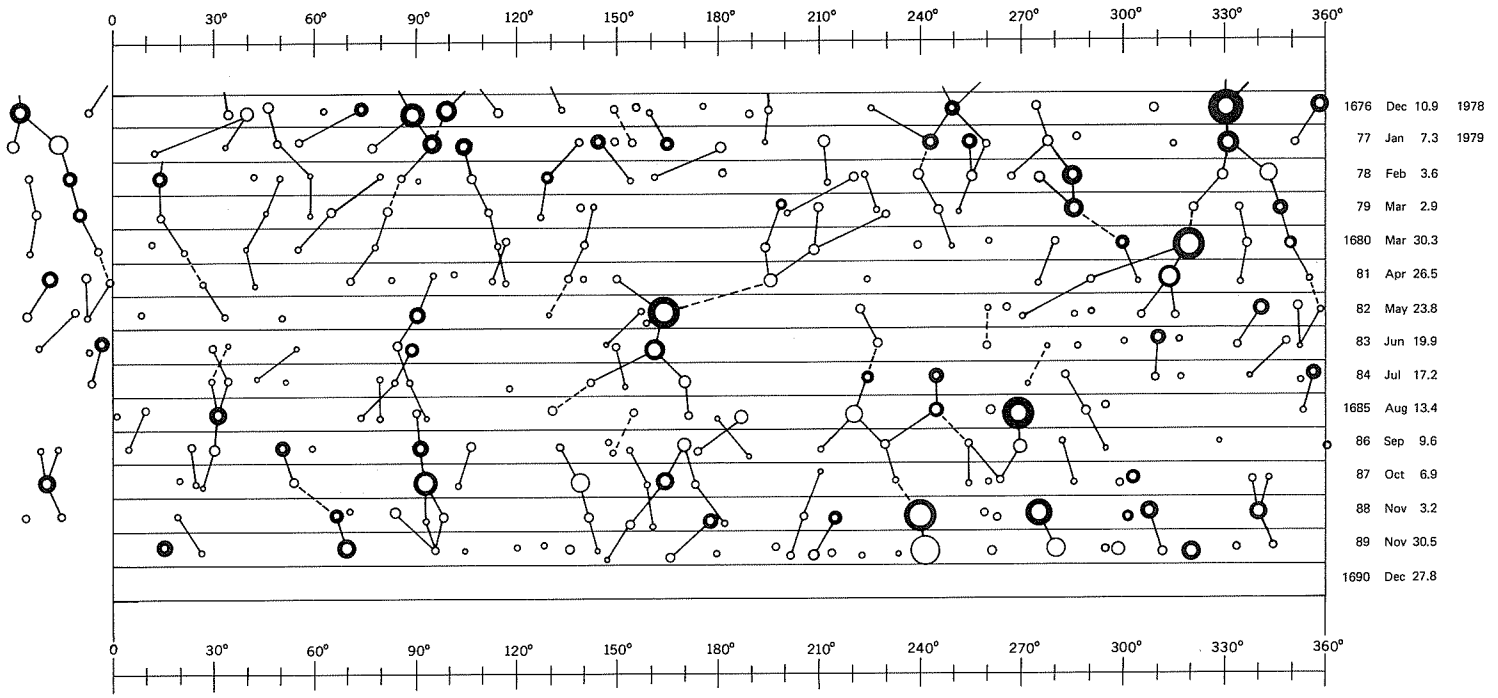
1979

In this year of maximum for Solar Cycle 21, the number of plages and flare-rich centers of activity was very high. Such activity was more abundant in the northern than in the southern hemisphere. Flare-rich regions were especially abundant between longitudes 90° and 200°. There were no known instances of very high energy particle events (PCA or GLE).

1979 Northern Hemisphere



1979 Southern Hemisphere



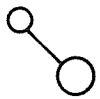
IV. Evolutionary Charts of Solar Activity 1964–1979; Northern and Southern Hemispheres, COMBINED

LEGEND

Location of centroid of CaK plage (heliolongitude ± 5°)

Active region of same area-intensity index, but with higher level of flare activity

Active region associated with at least one high energy flare particle event (PCA or GLE)



Return of center of activity, defined by relatively similar longitude and latitude on successive rotations

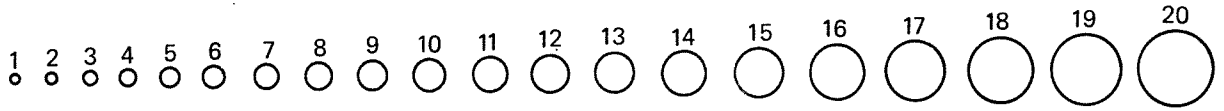
Old and dying plage followed by resurgence of new center of activity in the same location, or, transient plage (duration < 14 days) associated with other, more permanent center of activity

Representative disc-transit CaK plage area-intensity measure based on daily values reported by McMath-Hulbert Observatory

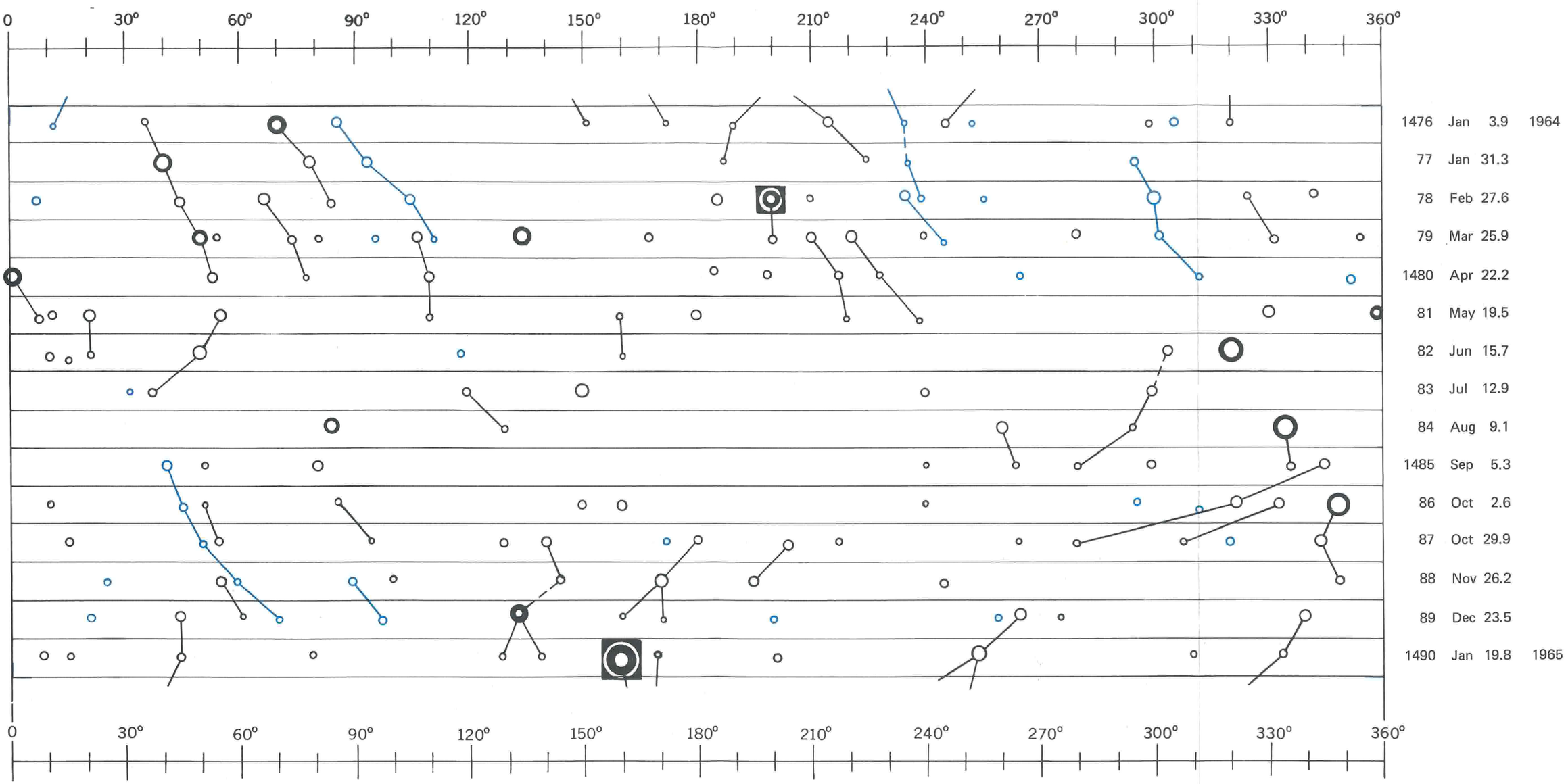
$$k = \frac{A}{500} + 2\ (\ I - 3)$$

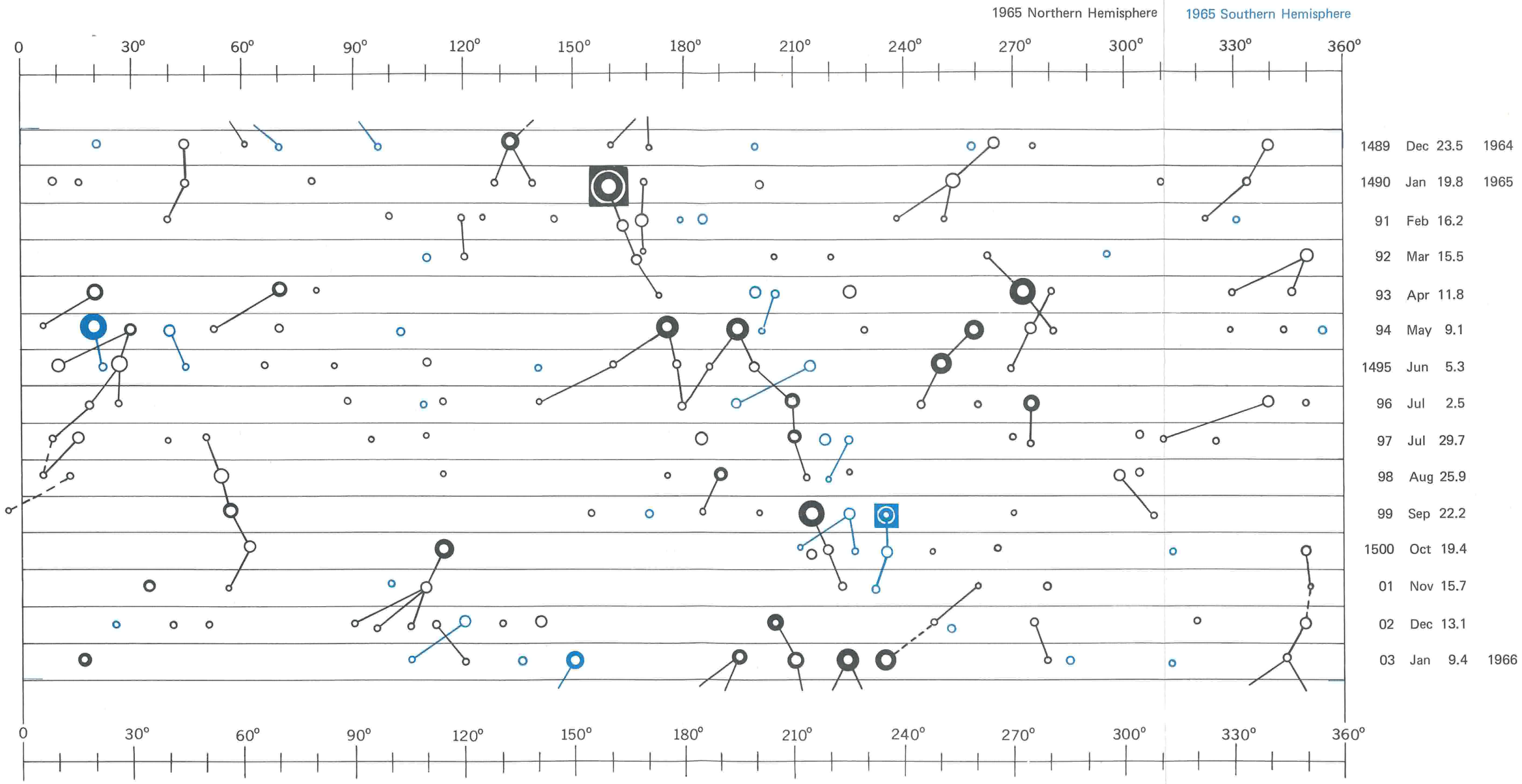
where A = corrected area (in millionths of a solar hemisphere) and I = intensity (1 = faint, 5 = very bright)

k-values (to chart scale)

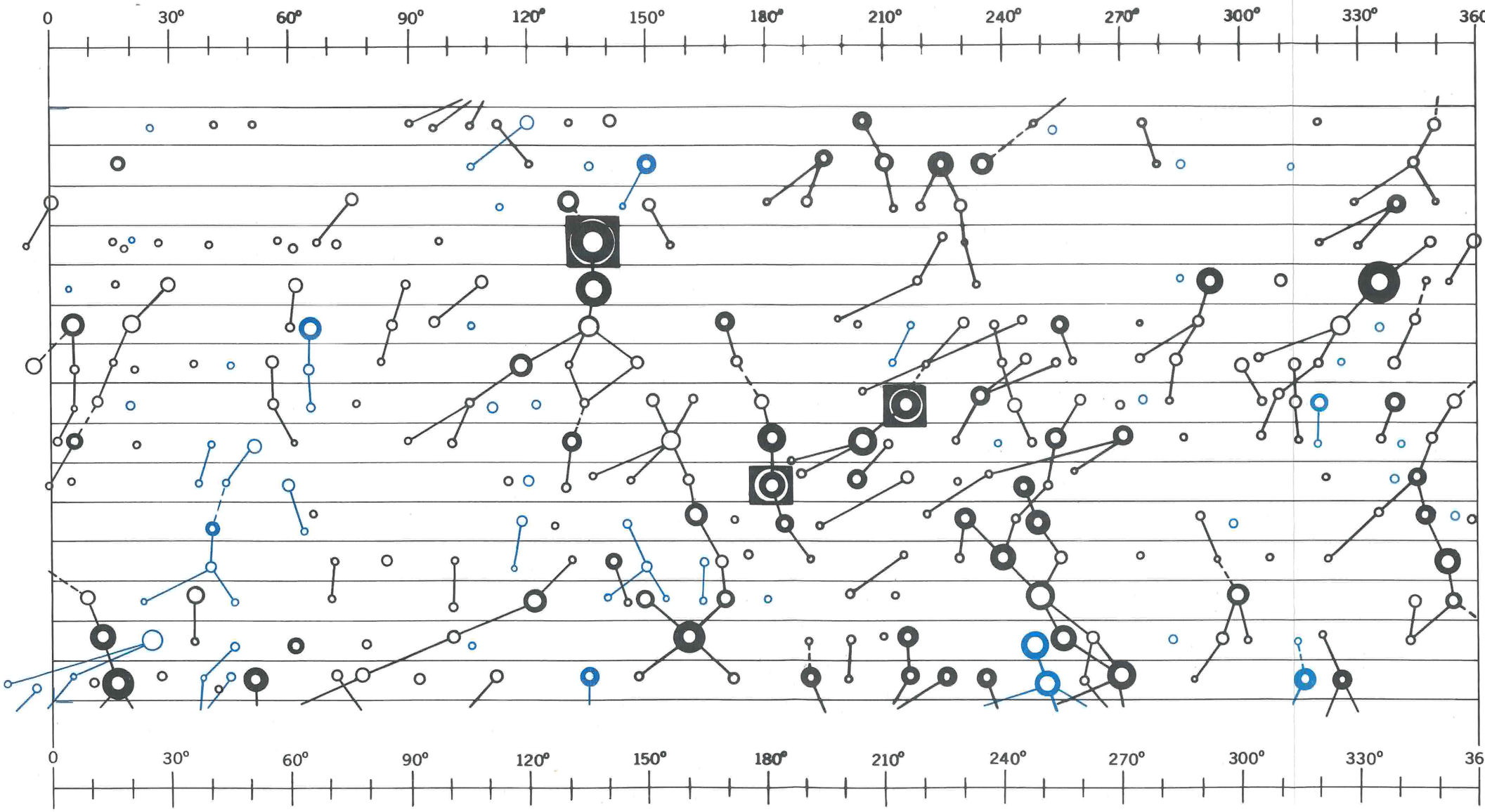


1964 Northern Hemisphere 1964 Southern Hemisphere

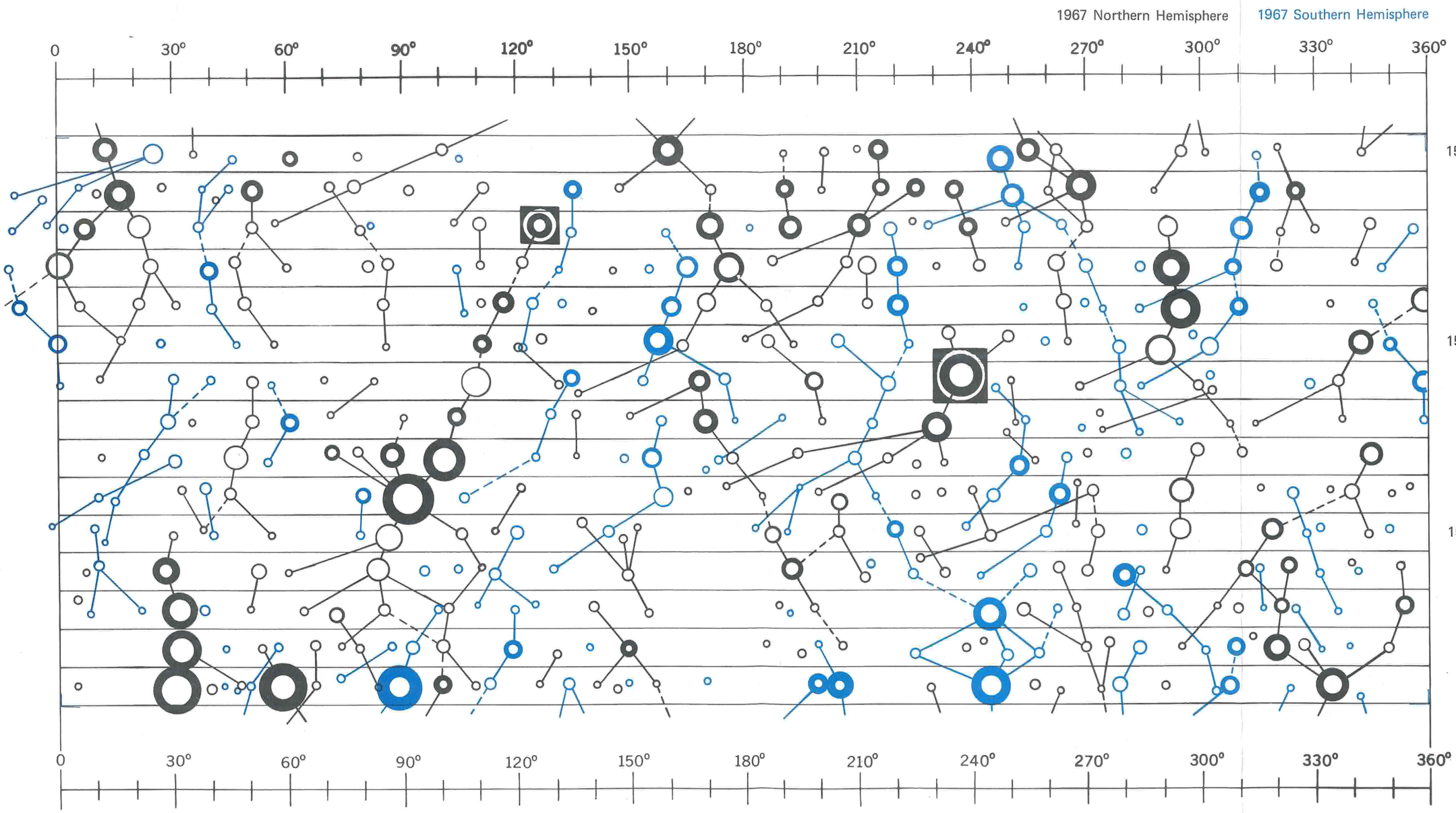



1965 Northern Hemisphere
1965 Southern Hemisphere
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°
1489 Dec 23.5 1964
1490 Jan 19.8 1965
91 Feb 16.2
92 Mar 15.5
93 Apr 11.8
94 May 9.1
1495 Jun 5.3
96 Jul 2.5
97 Jul 29.7
98 Aug 25.9
99 Sep 22.2
1500 Oct 19.4
01 Nov 15.7
02 Dec 13.1
03 Jan 9.4 1966

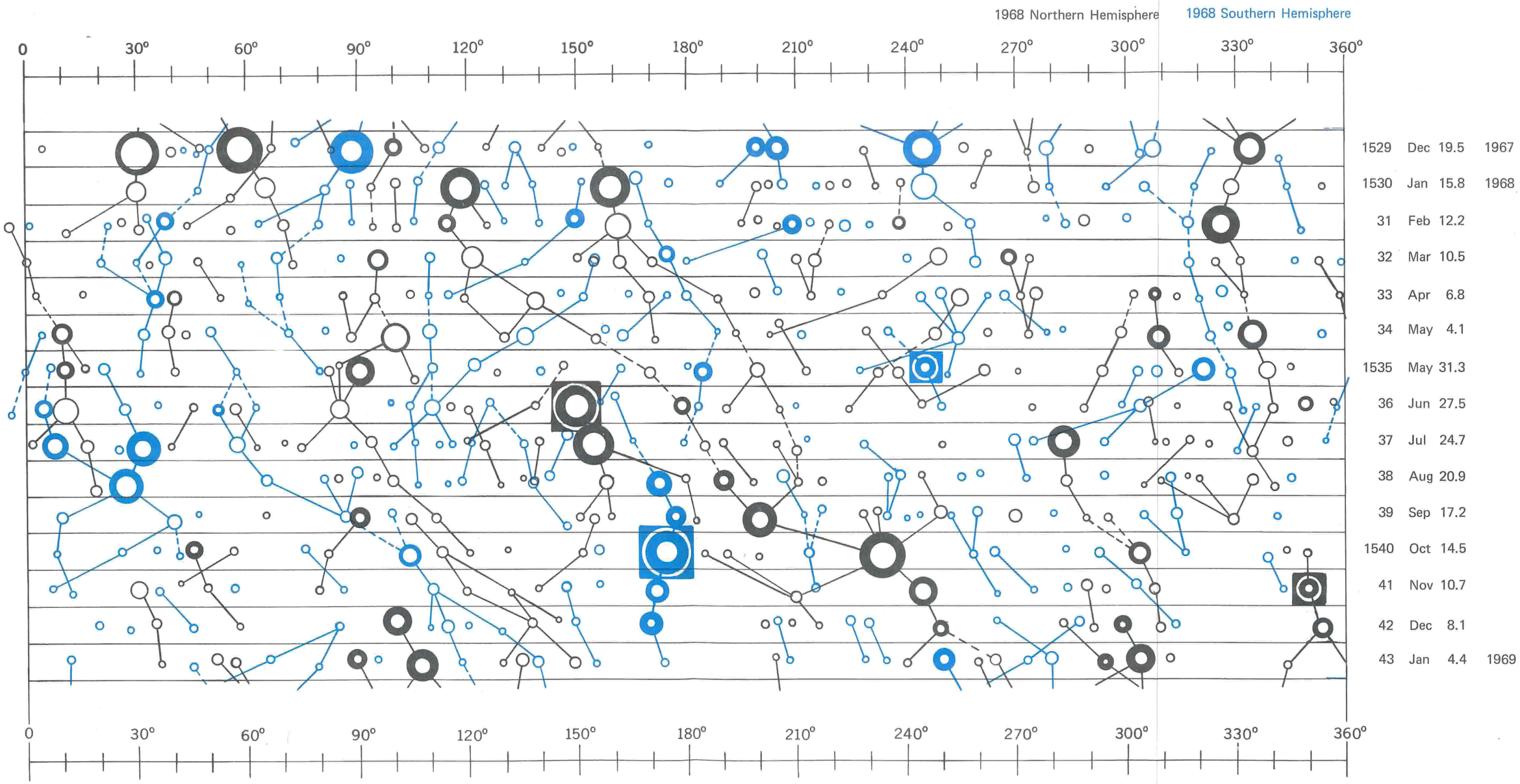
1966 Northern Hemisphere 1966 Southern Hemisphere



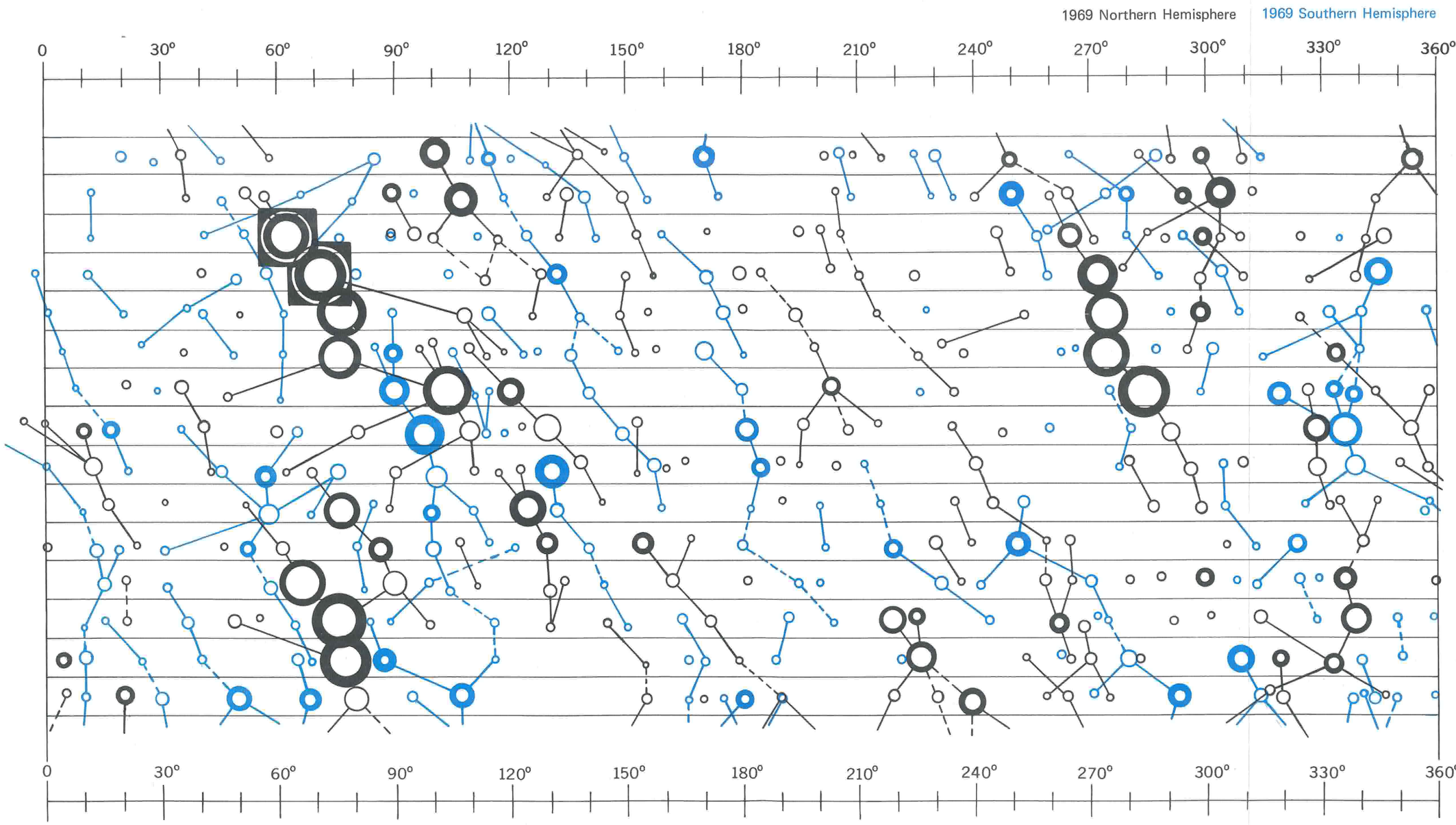
1502	Dec	13.1	1965
1503	Jan	9.4	1966
04	Feb	5.7	
1505	Mar	5.1	
06	Apr	1.4	
07	Apr	28.6	
08	May	25.9	
09	Jun	22.1	
1510	Jul	19.3	
11	Aug	15.5	
12	Sep	11.7	
13	Oct	9.0	
14	Nov	5.3	
1515	Dec	2.6	
16	Dec	29.9	



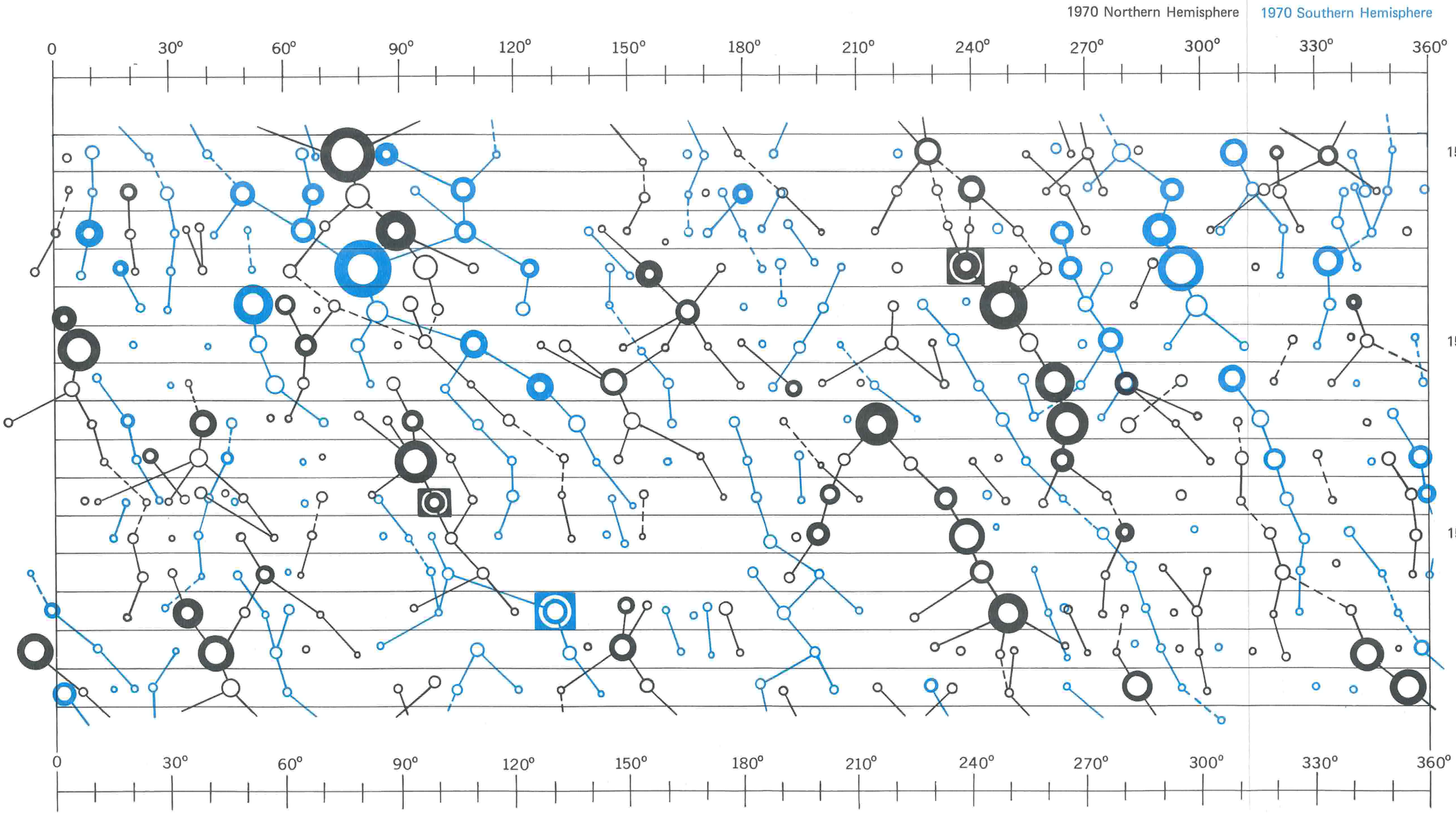
1515	Dec	2.6	1966
16	Dec	29.9	
17	Jan	26.3	1967
18	Feb	22.6	
19	Mar	21.9	
1520	Apr	18.2	
21	May	15.5	
22	Jun	11.7	
23	Jul	8.9	
24	Aug	5.1	
1525	Sep	1.3	
26	Sep	28.6	
27	Oct	25.9	
28	Nov	22.2	
29	Dec	19.5	



1529	Dec	19.5	1967
1530	Jan	15.8	1968
31	Feb	12.2	
32	Mar	10.5	
33	Apr	6.8	
34	May	4.1	
1535	May	31.3	
36	Jun	27.5	
37	Jul	24.7	
38	Aug	20.9	
39	Sep	17.2	
1540	Oct	14.5	
41	Nov	10.7	
42	Dec	8.1	
43	Jan	4.4	1969



1542	Dec	8.1	1968
43	Jan	4.4	1969
44	Jan	31.7	
1545	Feb	28.1	
46	Mar	27.4	
47	Apr	23.7	
48	May	20.9	
49	Jun	17.1	
1550	Jul	14.3	
51	Aug	10.5	
52	Sep	6.7	
53	Oct	4.0	
54	Oct	31.3	
1555	Nov	27.6	
56	Dec	24.9	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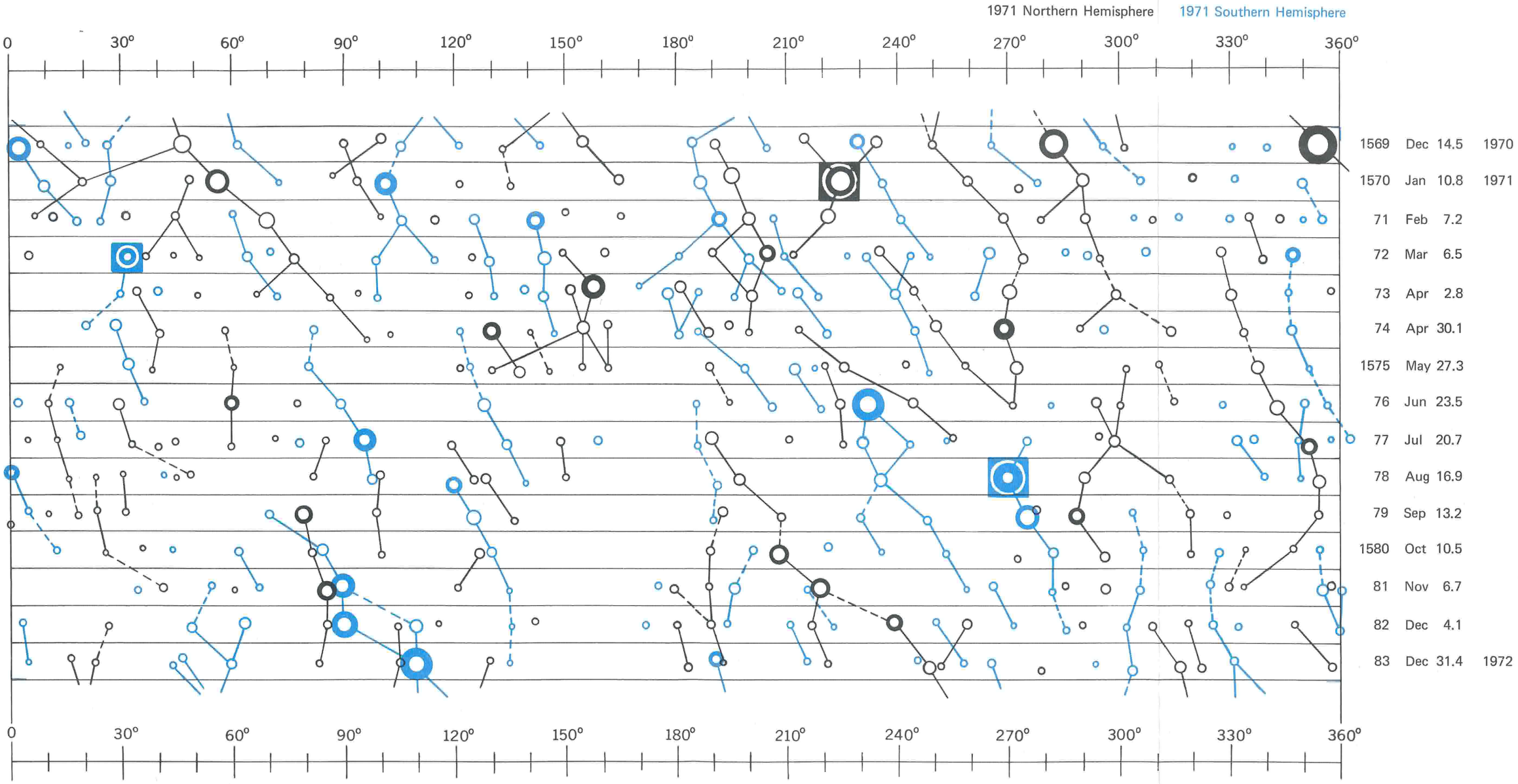
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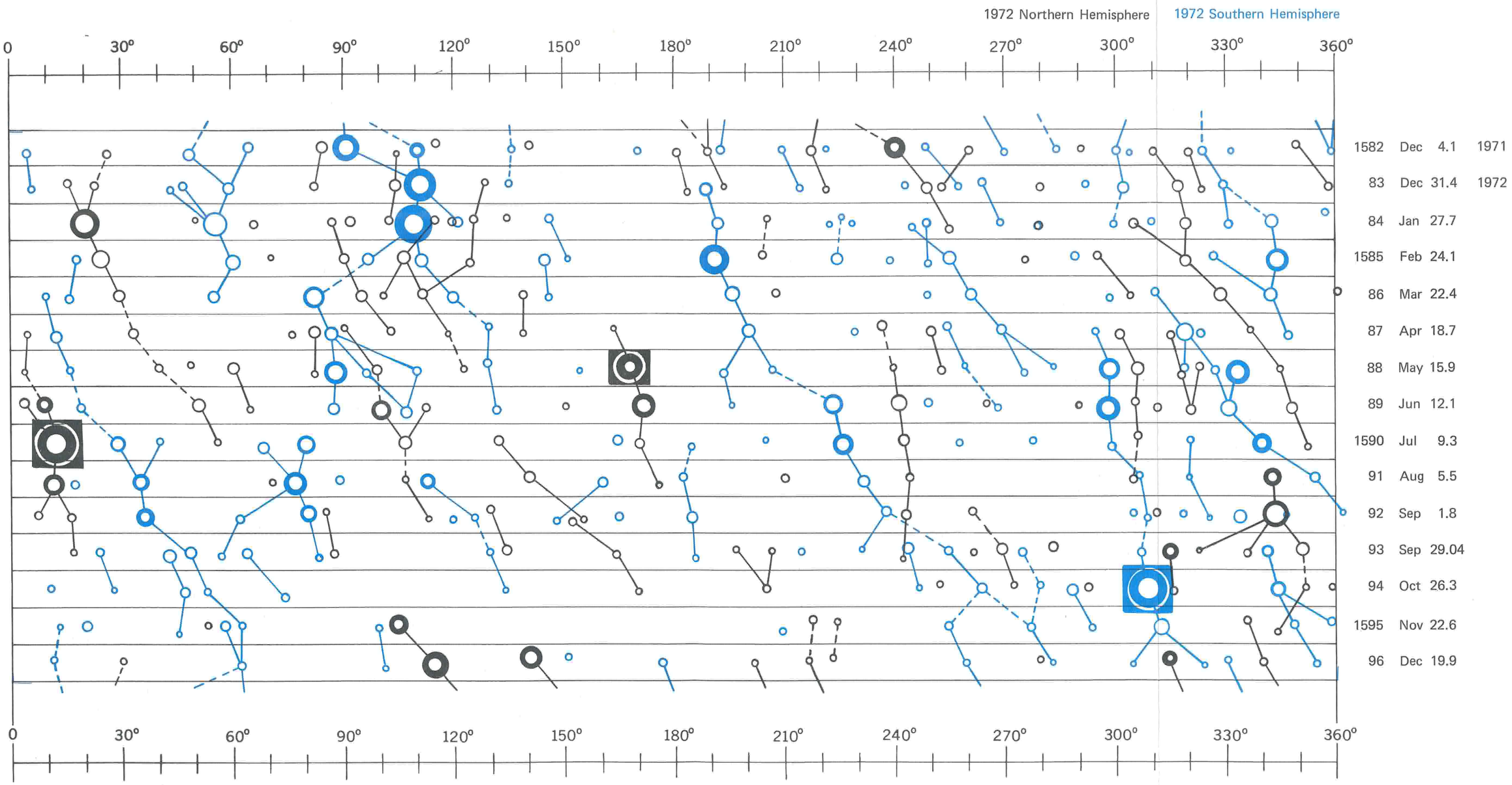
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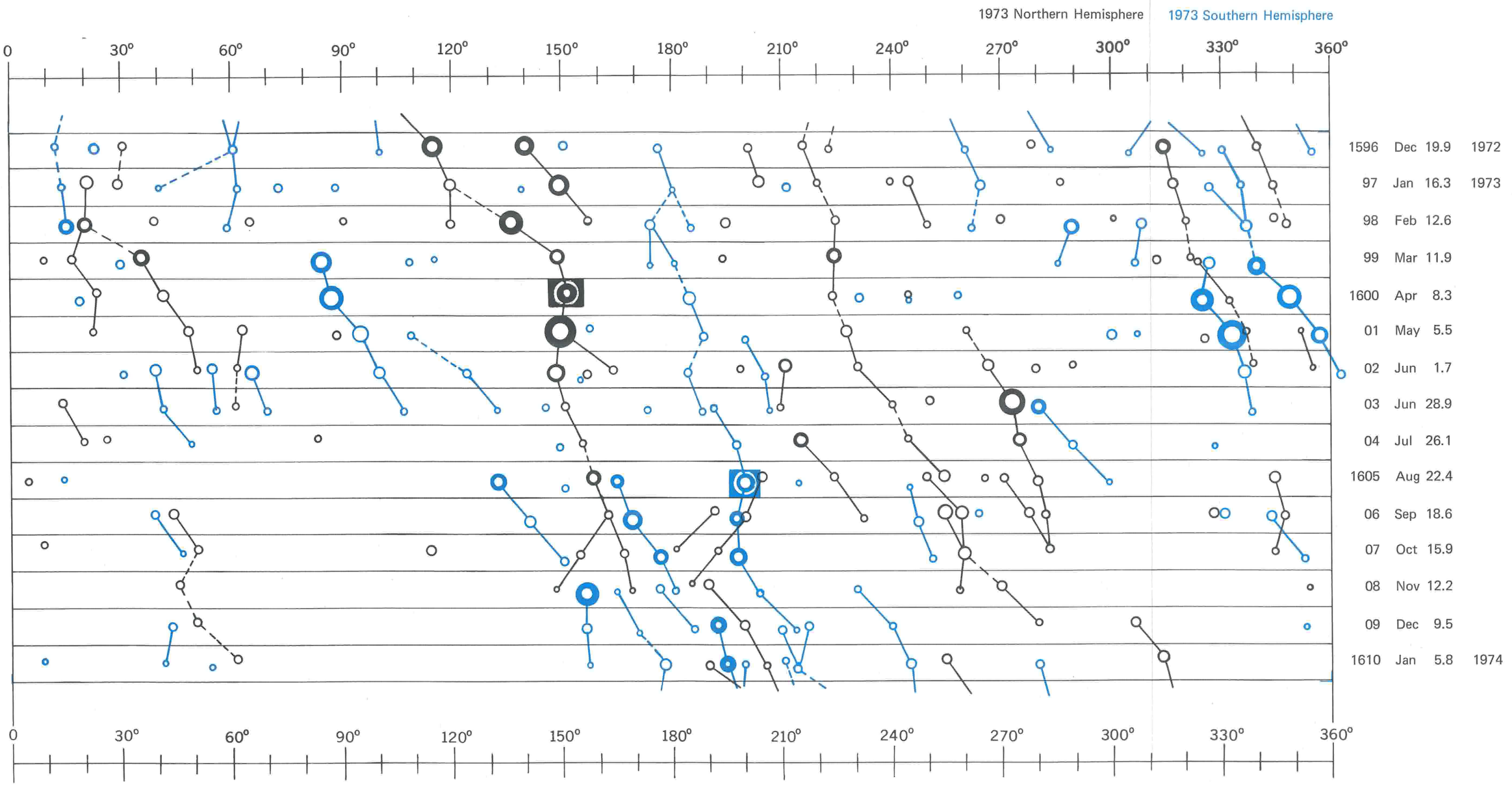
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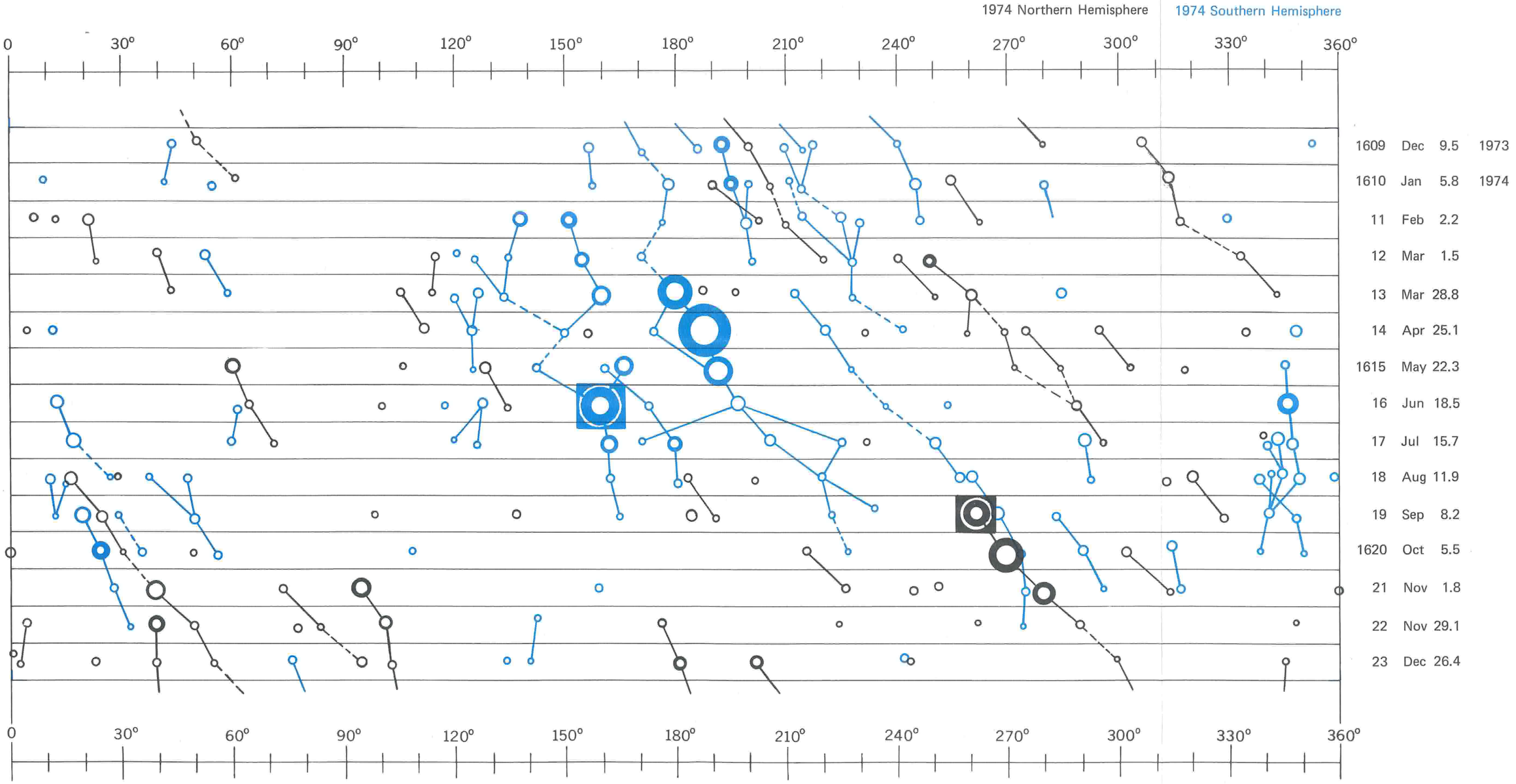
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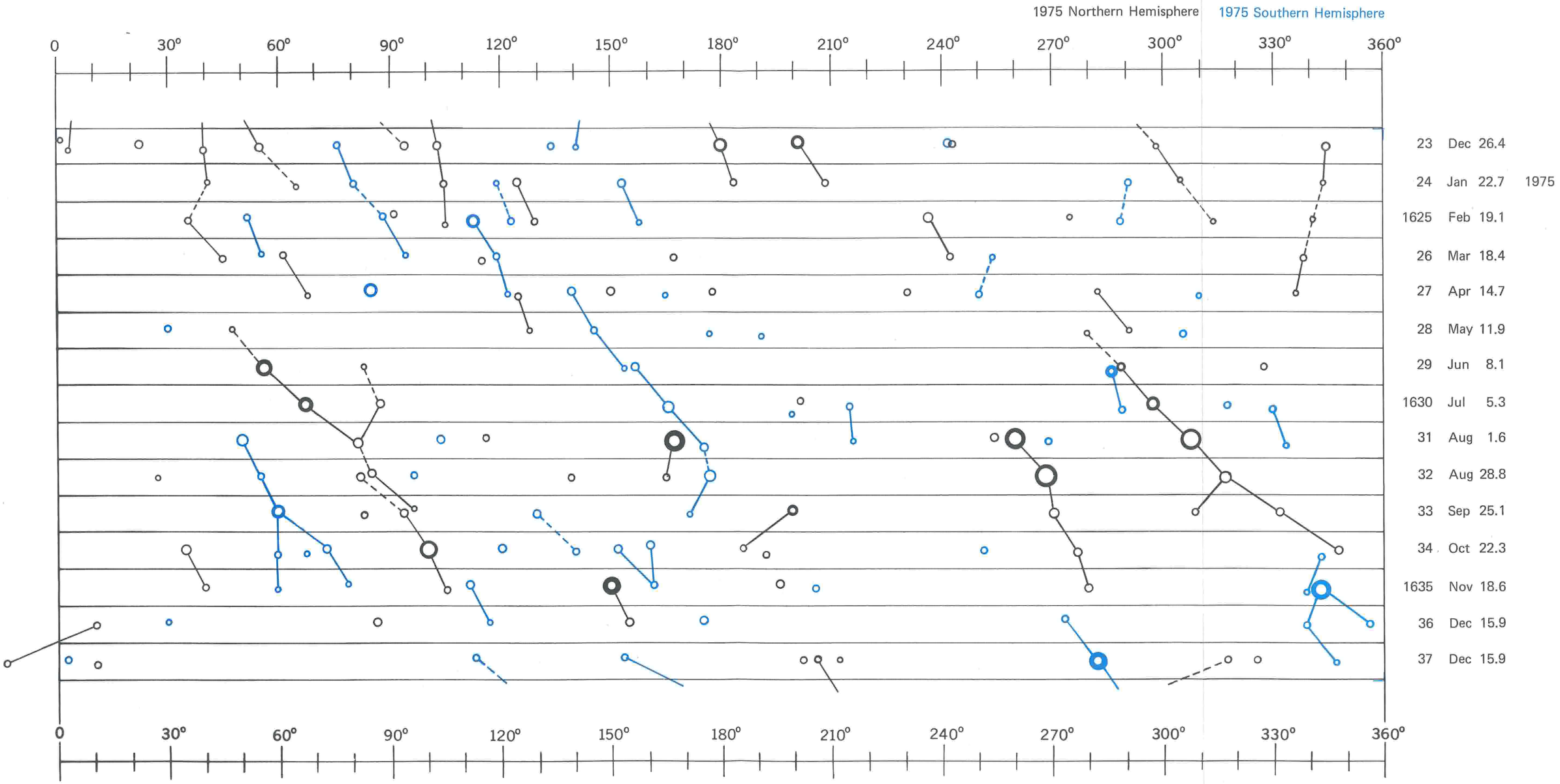
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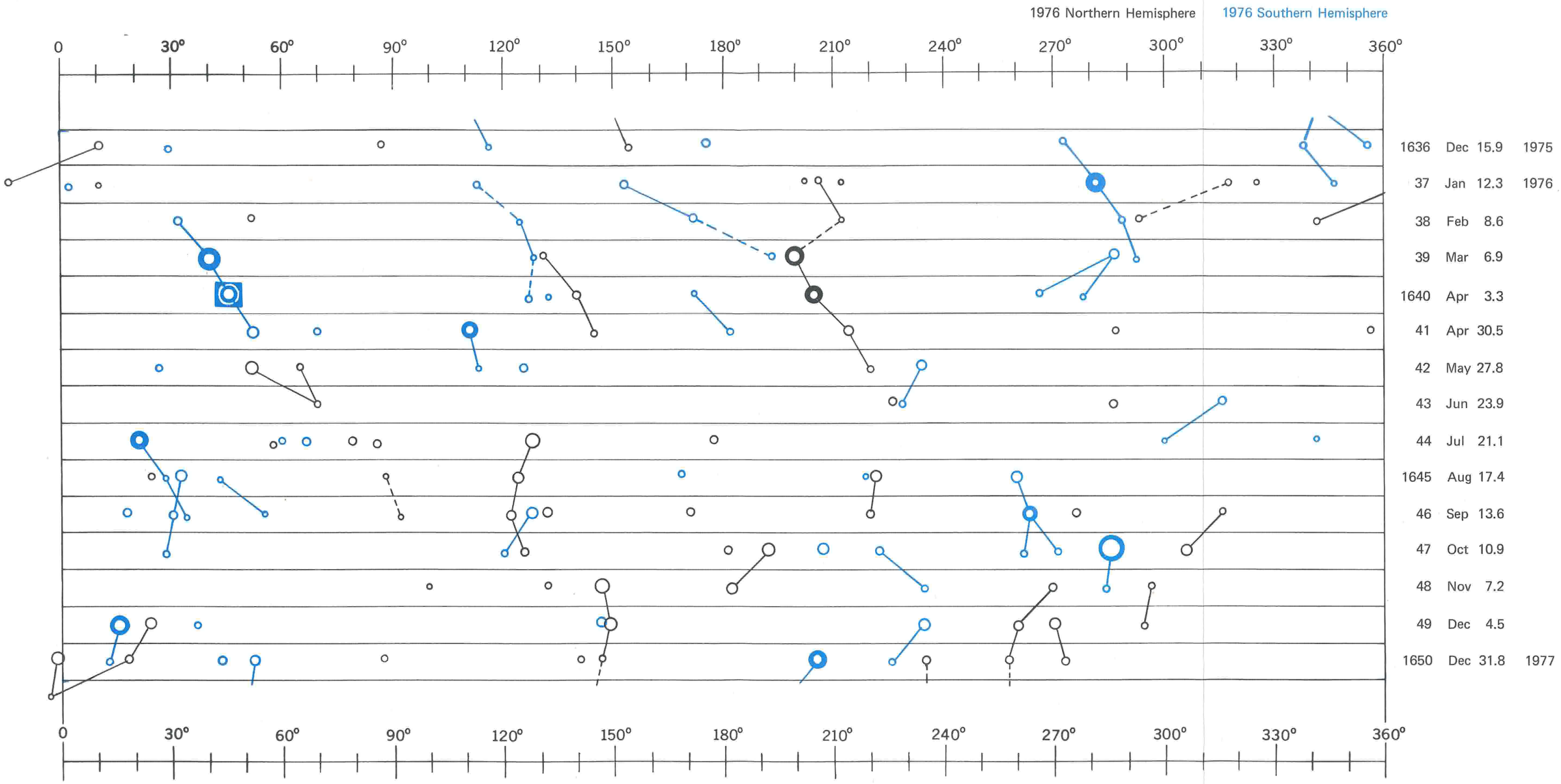
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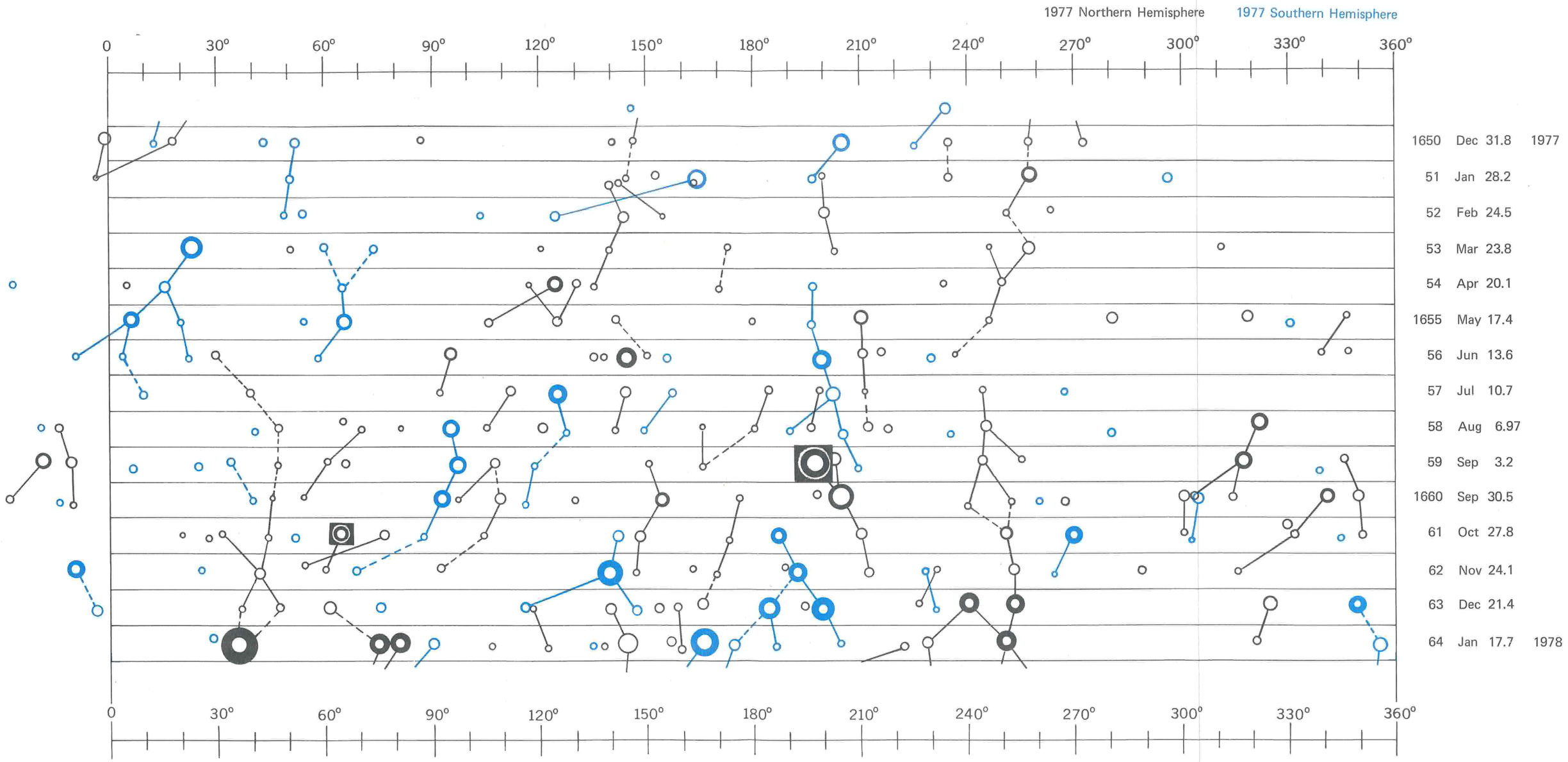
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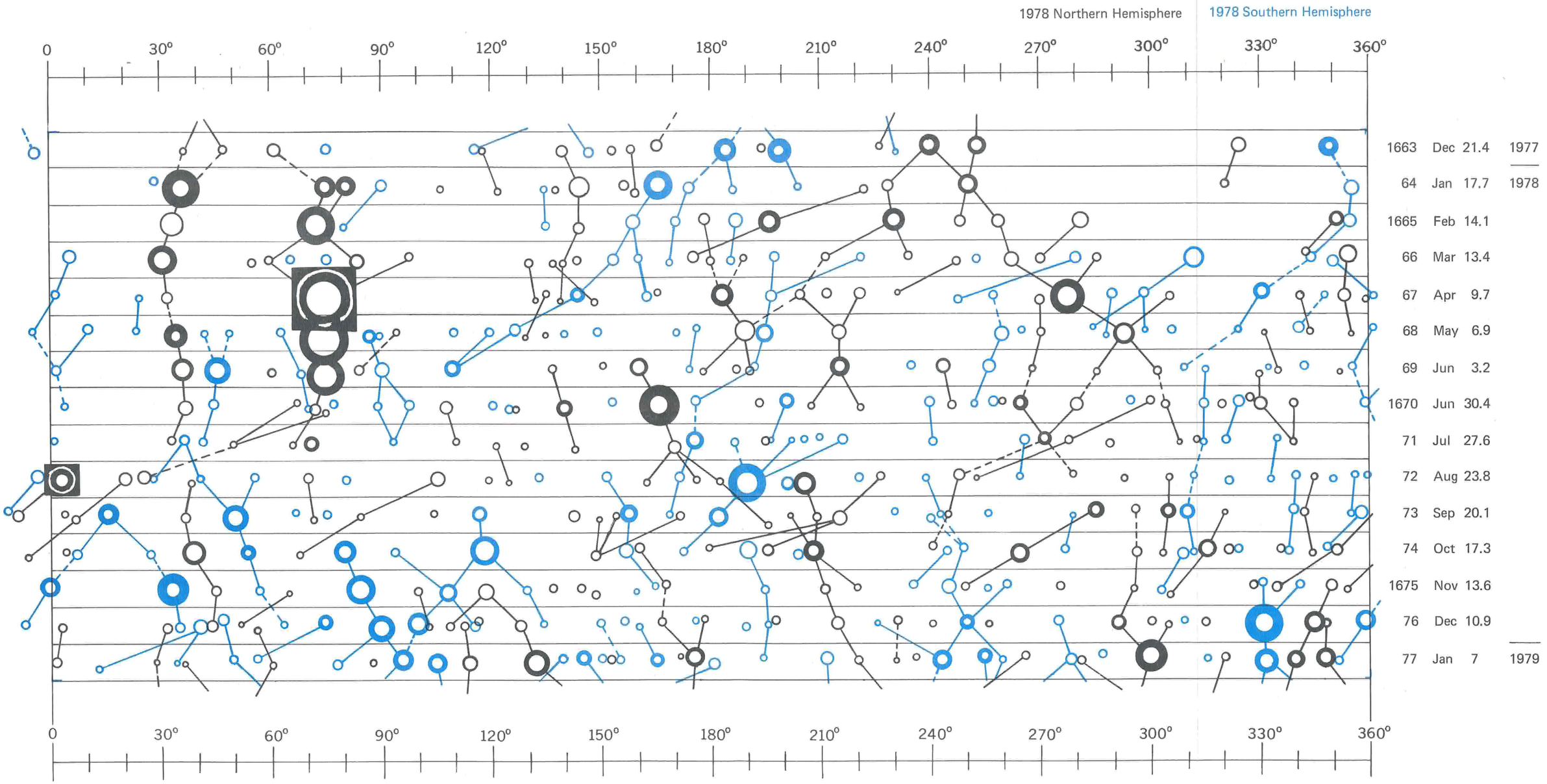
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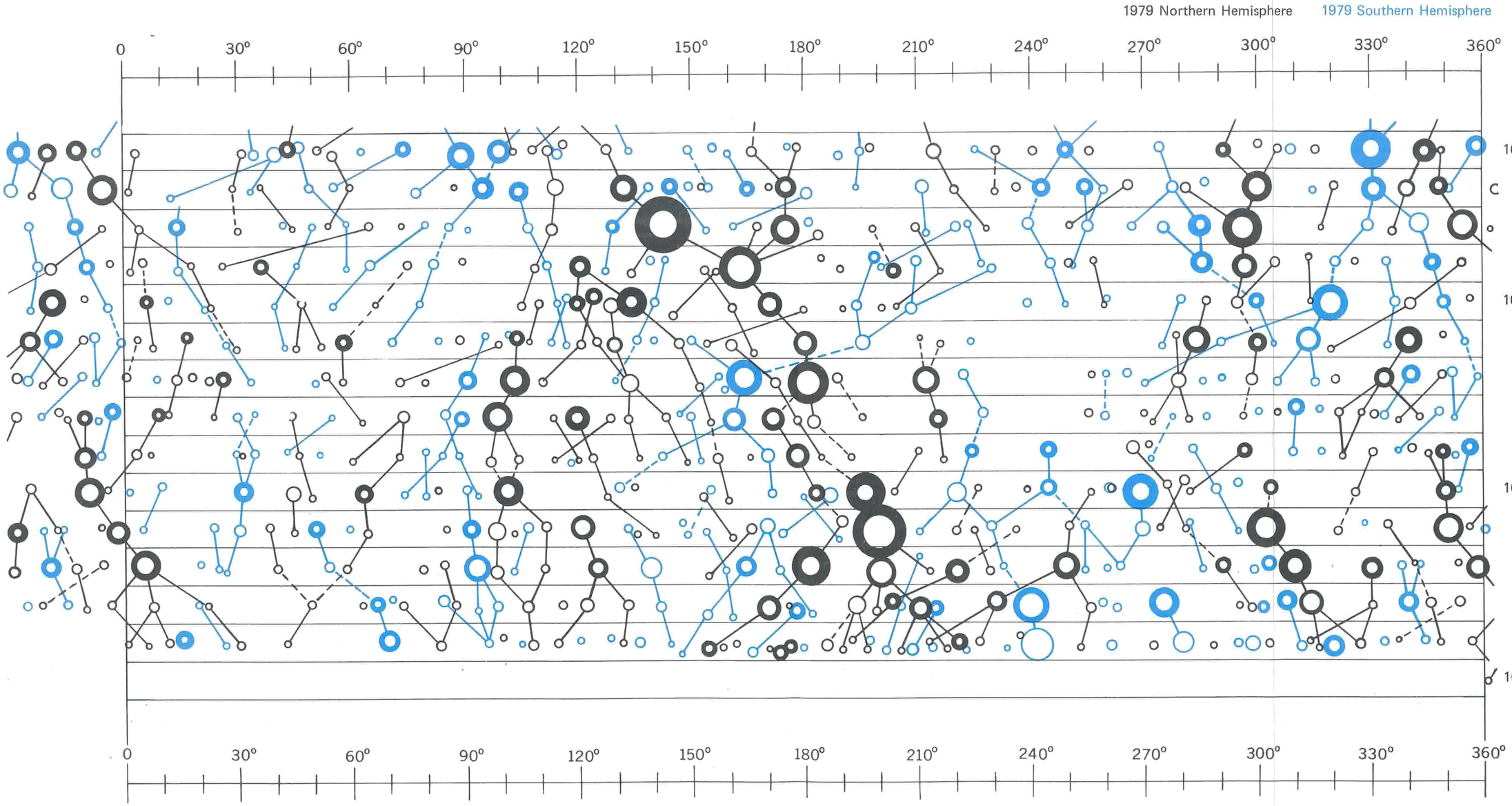
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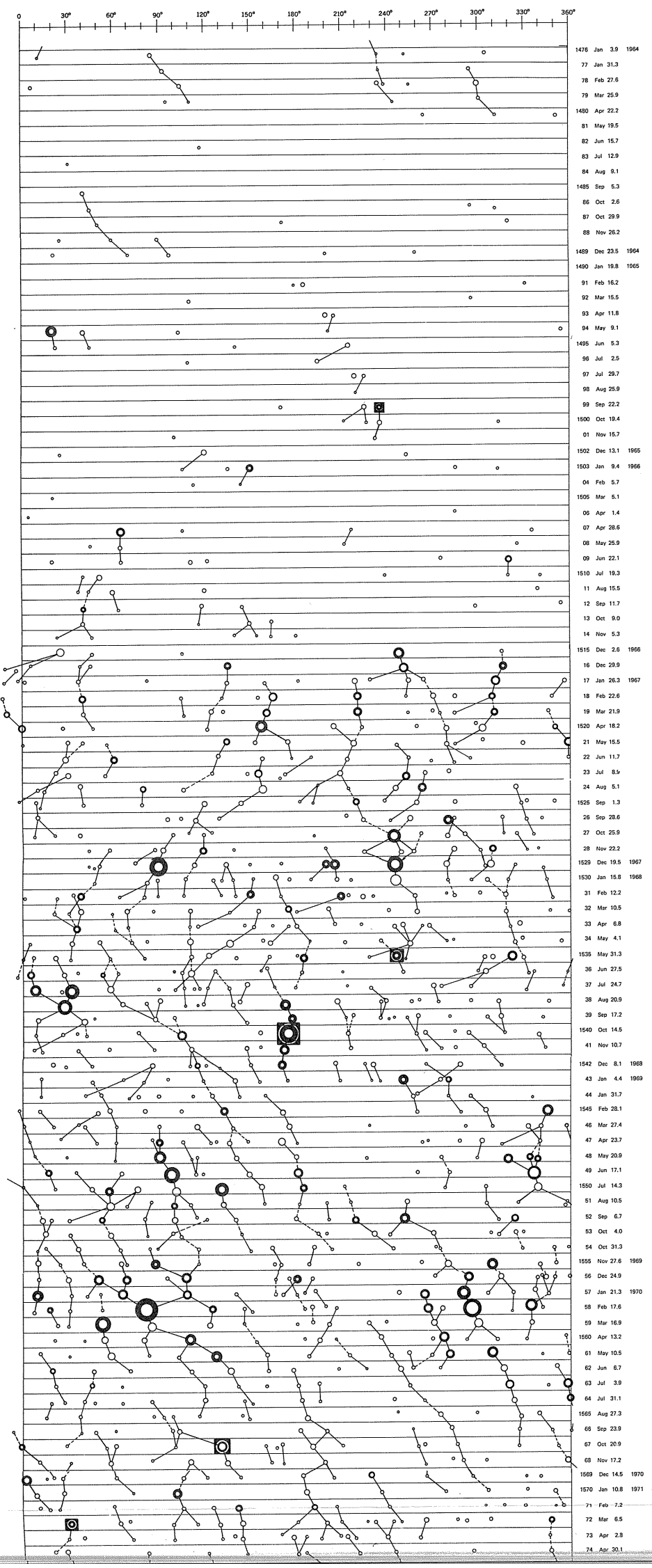

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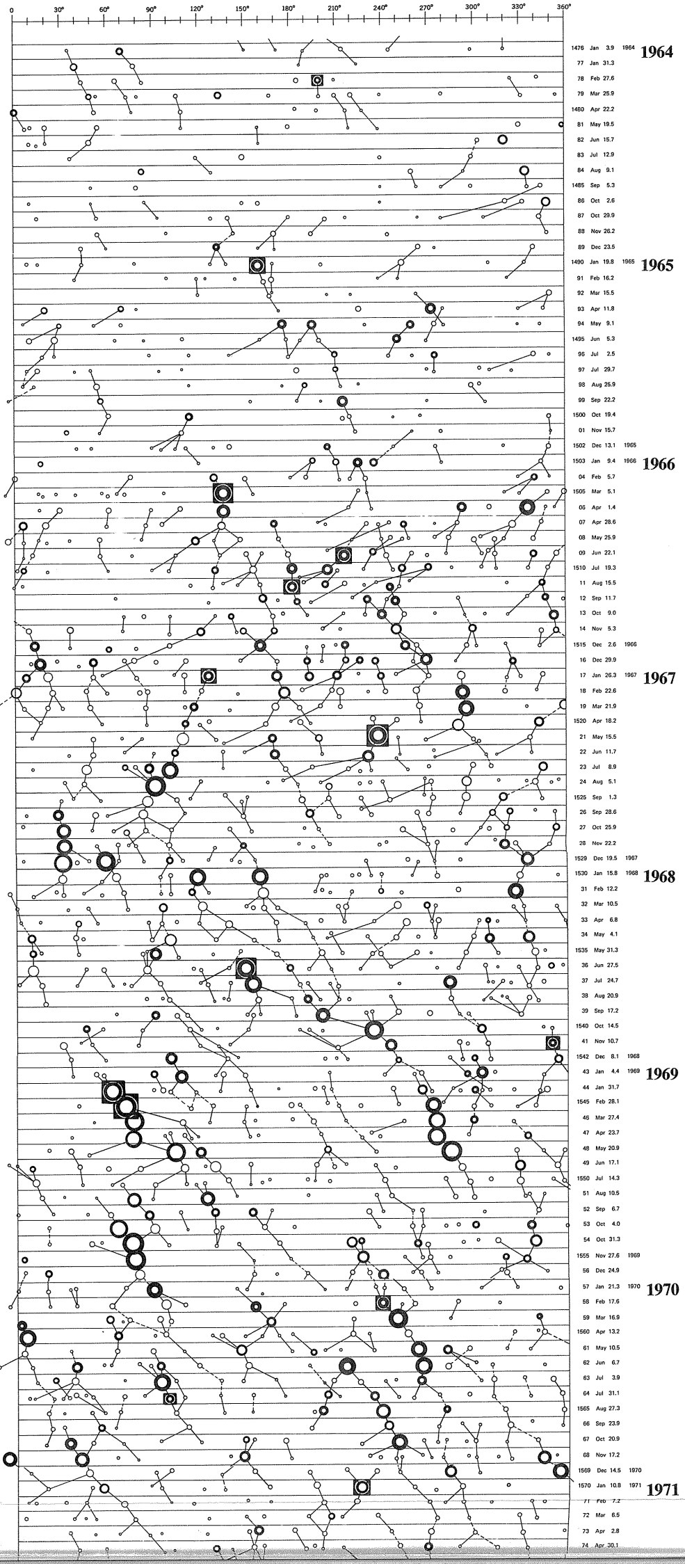

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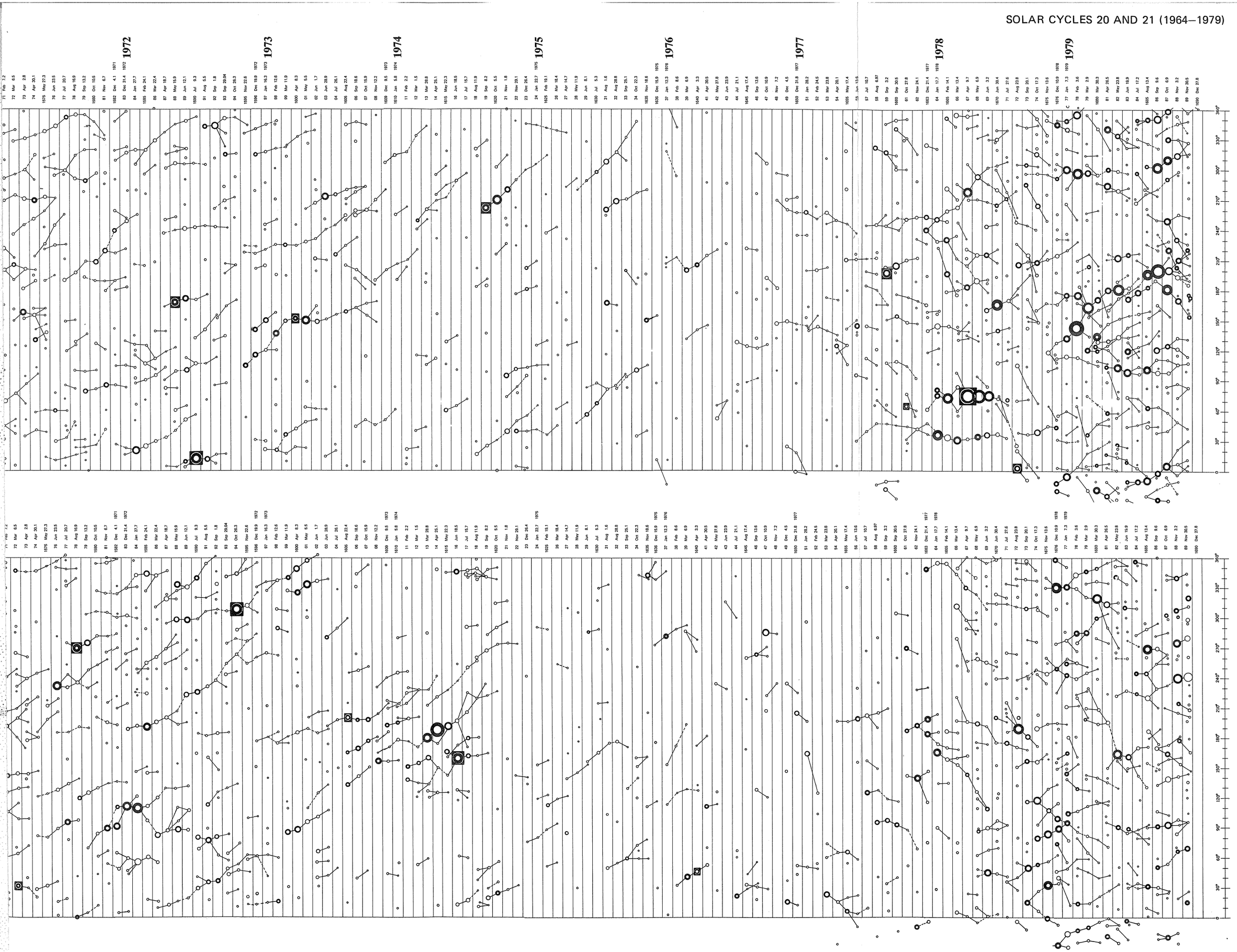

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