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



August 1981

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# REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

| 1. REPORT NUMBER | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
|---|---|---|
| AFGL-TR-82-0145 | AD-A115 527 | |

| 4. TITLE (and Subtitle) | 5. TYPE OF REPORT & PERIOD COVERED |
|---|---|
| EVOLUTIONARY CHARTS OF SOLAR ACTIVITY (CALCIUM PLAGES) AS FUNCTIONS OF HELIOGRAPHIC LONGITUDE AND TIME 1964-1979 | REPRINT |
| | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) | 8. CONTRACT OR GRANT NUMBER(s) |
| E.R. Hedeman, H.W. Dodson, E.C. Roelof. | MIPR FY71218100001 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| The Johns Hopkins University<br>Applied Physics Laboratory<br>Laurel, Maryland 20810 | 61102F<br>2311G1AL |
| 11. CONTROLLING OFFICE NAME AND ADDRESS | 12. REPORT DATE |
| Air Force Geophysics Laboratory<br>Hanscom AFB, Massachusetts 01731<br>Monitor/M.A.Shea/PHG | April, 1982<br>13. NUMBER OF PAGES<br>87 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | 15. SECURITY CLASS. (of this report)<br>Unclassified |
| | 15a. DECLASSIFICATION DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

~~Approved for public release; distribution unlimited~~

For Announcement Only

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

DTIC ELECTE MAY 27 1982 S D A

18. SUPPLEMENTARY NOTES Work performed as Task ZF10 of Contract N00024-78-C-5384, Dept. of the Navy. Continues work previously performed under MIPR FY712179-00011 and FY71218000003. Reprint from UAG-81, August, 1981.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

solar activity
solar cycle
calcium plage

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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 prepared 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. → cont

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Item 20 continued

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. These charts have 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 on the basis of McMath-Hulbert Observatory data and diagrams. These charts organize data relating to practically all calcium plages reported by the McMath-Hurbert 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.

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# Solar-Terrestrial Physics

**REPORT UAG-81**

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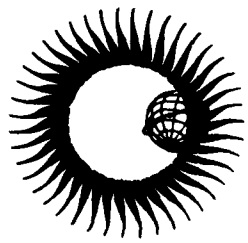
by

E. Ruth Hedeman, Helen W. Dodson and Edmond C. Roelof
The Johns Hopkins University
Applied Physics Laboratory
Laurel, Maryland 20707

August 1981



Published by World Data Center A for
Solar-Terrestrial Physics, NOAA, Boulder, Colorado
and printed by

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ENVIRONMENTAL DATA AND INFORMATION SERVICE
Boulder, Colorado, USA 80303

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E. Ruth Hedeman, Helen W. Dodson and Edmond C. Roelof
The Johns Hopkins University
Applied Physics Laboratory
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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 Hα 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 ± 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 | $\alpha_p$ | 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. | $< \sim 30$ | 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. | $\sim 200$ | 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.

ACKNOWLEDGEMENTS

The authors wish to express their deepest gratitude to Mr. Allan Kundratic of the Applied Physics Laboratory of The Johns Hopkins University for his meticulous preparation of the drawings of the evolutionary charts that are included in this study. The original charts were prepared by Miss E. Ruth Hedeman on the basis of data collected at the former McMath-Hulbert Observatory of the University of Michigan. This effort was supported by NASA through Grant NSG-7055, and by the Air Force Geophysics Laboratory under Task ZF10 via Contract N00024-81-C-5301 between the Department of the Navy and the Johns Hopkins University.

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 $\gamma$ 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 βγ 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 (βγ-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 (βγ).

| 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 $\delta$ 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 $\alpha$ 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 conspicuous. 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 major 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 $\delta$ 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 $\delta$ 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 $\beta_p$ -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 $\delta$ 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 > 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 $\delta$ 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- | > 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 $\delta$ 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 $\delta$ 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 $\beta$-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 $\delta$ 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 $\delta$ 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 $\beta_p$-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 $\beta_p$-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 $\alpha_p$ 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 $\beta_p$-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 $\delta$ 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 > 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 $\beta$-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 $\delta$ 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 $\delta$ 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 $\delta$ 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 $\delta$ 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 $\beta_p$-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 $\delta$ 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 $\delta$ 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 | API |
|---|---|---|---|---|---|---|---|
| 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 $\delta$ 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 $\delta$ 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 $\beta_p$-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 $\beta_p$-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 $\beta_p$-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 $\sigma$ 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 $\alpha$ 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 $\sigma$ 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 $\beta p$ 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 $\gamma$ spot with a $\sigma$ 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 $\sigma$ 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 $\sigma$ 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 $\beta_p$-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 $\beta_p$ 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 $\beta_p$ spot with a $\sigma$ 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 $\alpha$. 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 $\gamma$ 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 $\beta_p$ spot (which occasionally becomes complex), with a $\sigma$ 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 $\beta_p$ spot with a $\sigma$ 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 $\sigma$ 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 $\beta$-type spot which occasionally becomes complex, with a $\sigma$ 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 $\delta$ 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 > 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 $\beta$-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 > 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 $\delta$ 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 $\alpha$ 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 ($\gamma$).

| | | | | | | |
|---|---|---|---|---|---|---|
| 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 βγ). 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 βγ 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 - βγ, 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 > 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

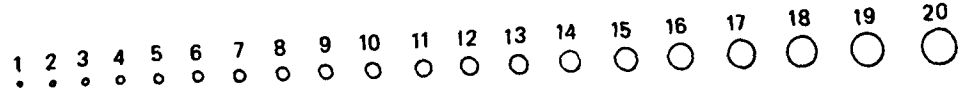
Old and dying plage followed by resurgence of new center of activity in the same location, or, transient plage (duration < 14 days) associated with other, more permanent center of activity

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

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

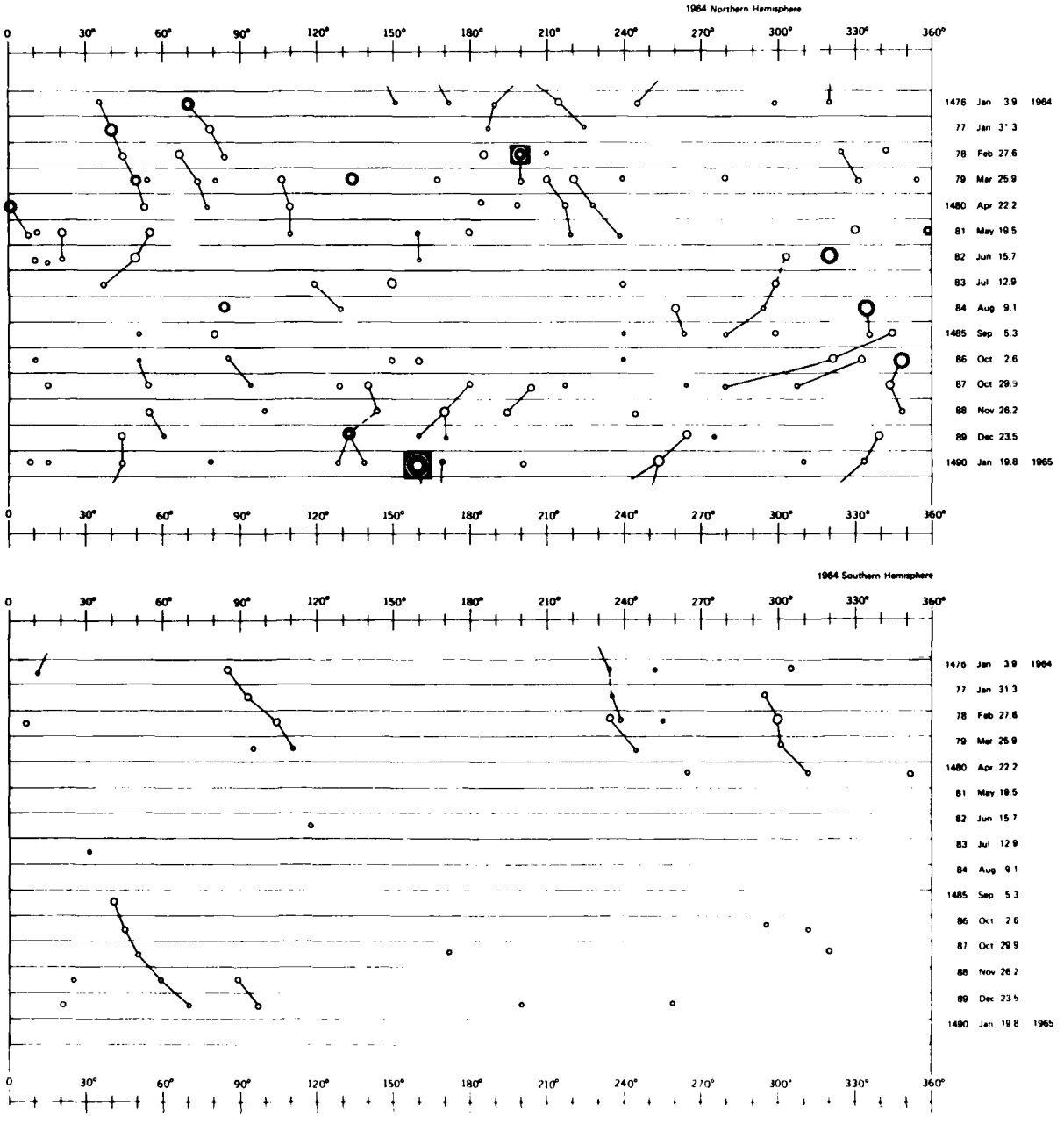
where A = corrected area (in millionths of a solar hemisphere) and I = intensity (1 = faint, 5 = very bright)

k-values (to chart scale)



## 1964

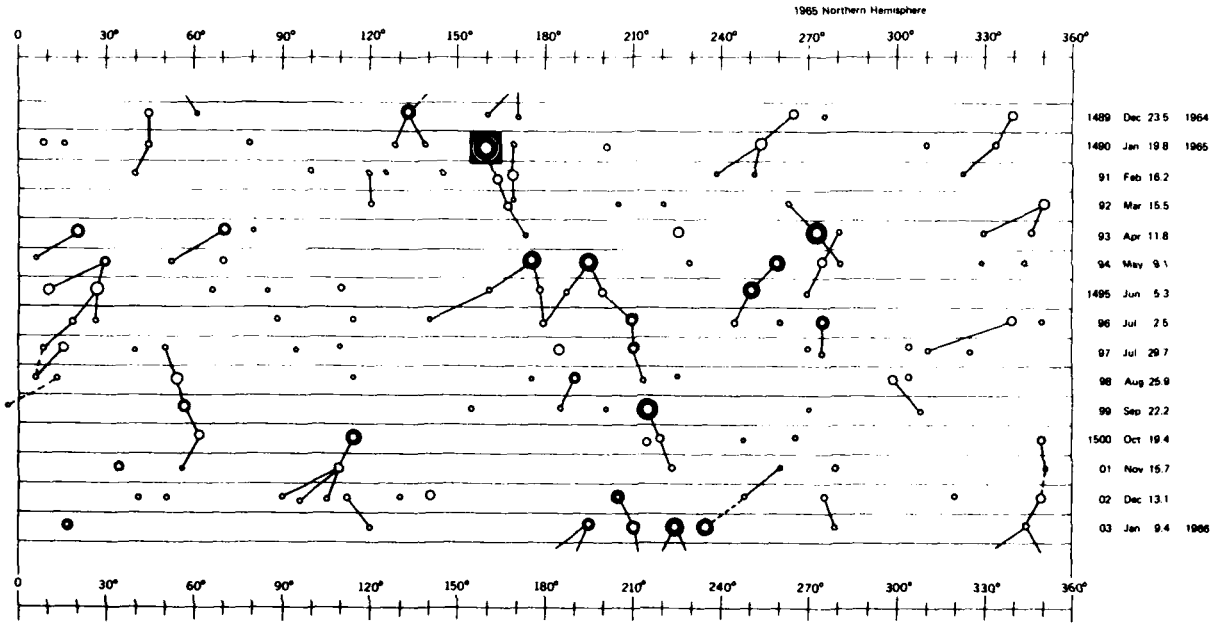
In this year of sun spot minimum, there was only one region of significant activity: Rotation 1478, Plage 7182, CMP March 11; $L_o$ = 200°, Lat N04°. This region, belonging to old Cycle 19, produced a PCA flare on March 16.


1964 Northern Hemisphere
0 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°
1476 Jan 3.9 1964
77 Jan 31.3
78 Feb 27.6
79 Mar 25.9
1480 Apr 22.2
81 May 19.5
82 Jun 15.7
83 Jul 12.9
84 Aug 9.1
1485 Sep 5.3
86 Oct 2.6
87 Oct 29.9
88 Nov 26.2
89 Dec 23.5
1490 Jan 19.8 1965
1964 Southern Hemisphere
0 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°
1476 Jan 3.9 1964
77 Jan 31.3
78 Feb 27.6
79 Mar 25.9
1480 Apr 22.2
81 May 19.5
82 Jun 15.7
83 Jul 12.9
84 Aug 9.1
1485 Sep 5.3
86 Oct 2.6
87 Oct 29.9
88 Nov 26.2
89 Dec 23.5
1490 Jan 19.8 1965

1964

## 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
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
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98 Aug 25.9
99 Sep 22.2
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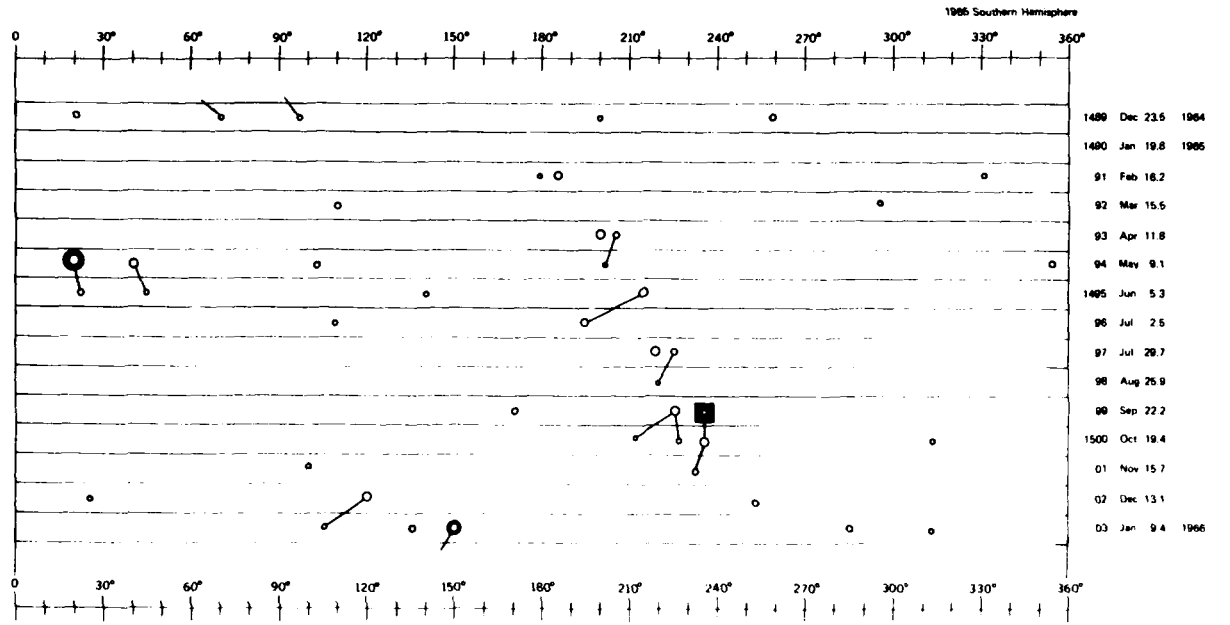
01 Nov 15.7
02 Dec 13.1
03 Jan 9.4 1966


1965 Southern Hemisphere
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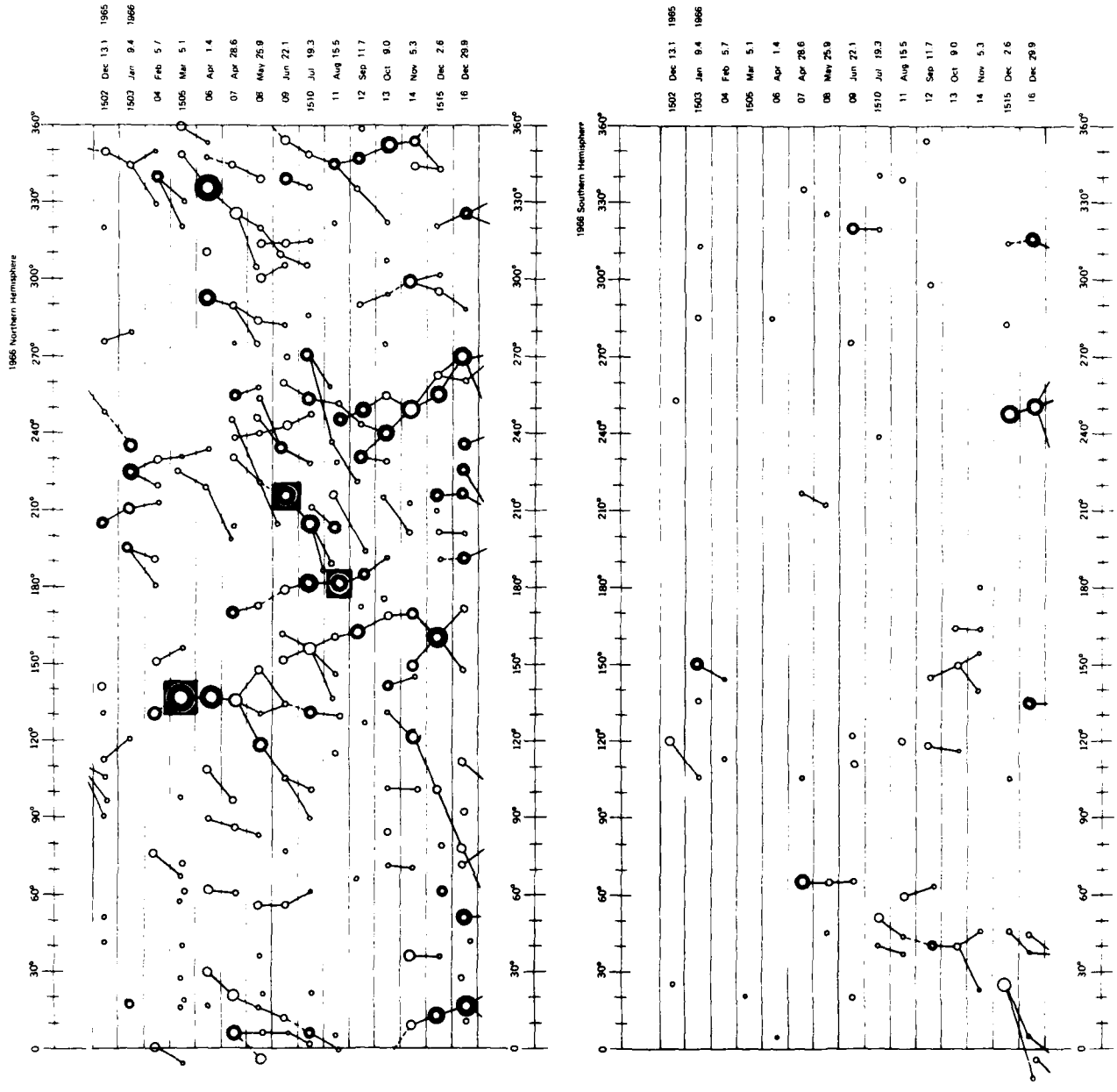
92 Mar 15.5
93 Apr 11.8
94 May 9.1
1495 Jun 5.3
96 Jul 2.5
97 Jul 29.7
98 Aug 25.9
99 Sep 22.2
1500 Oct 19.4
01 Nov 15.7
02 Dec 13.1
03 Jan 9.4 1966

## 1966

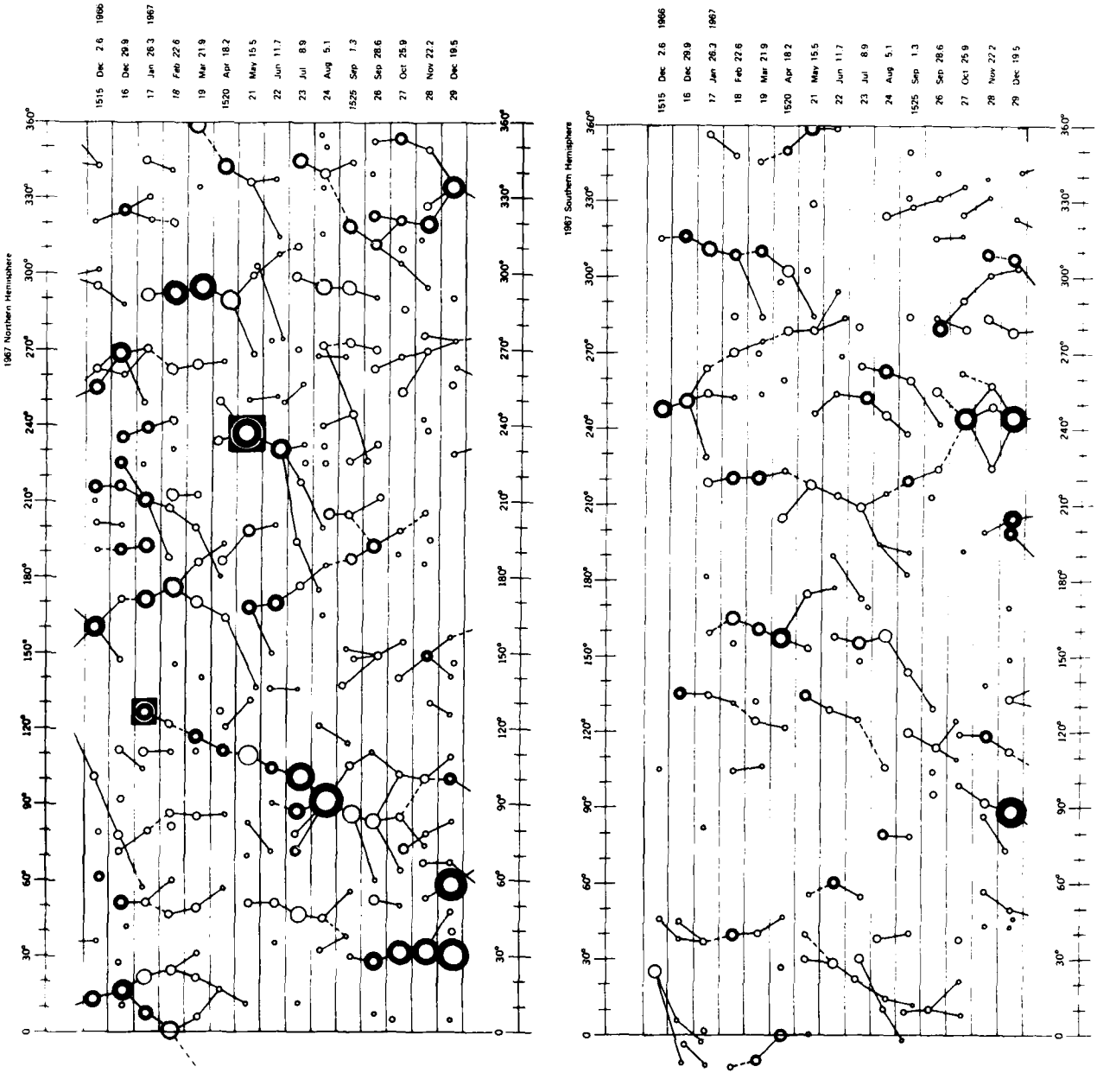
Major activity increased, but continued to be concentrated in the northern hemisphere and in longitude zone 130° to 270°.


1966 Northern Hemisphere
1966 Southern Hemisphere
1502 Dec 13.1 1965
1503 Jan 9.4 1966
04 Feb 5.7
1506 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
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°

## 1967

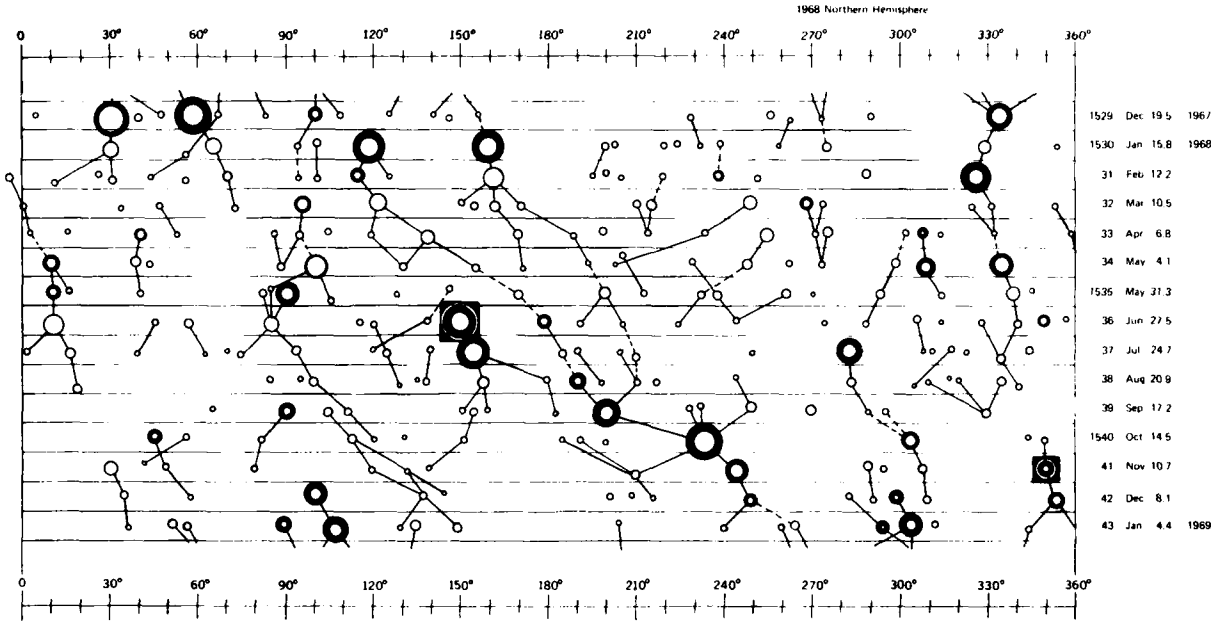
Solar activity increased in both hemispheres and practically all longitudes were represented, although the northern hemisphere still dominated. A long-enduring family of plages began with Region 8687 in Rotation 1517 at longitude 125° and latitude N24 and can be traced for at least 12 rotations. It had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

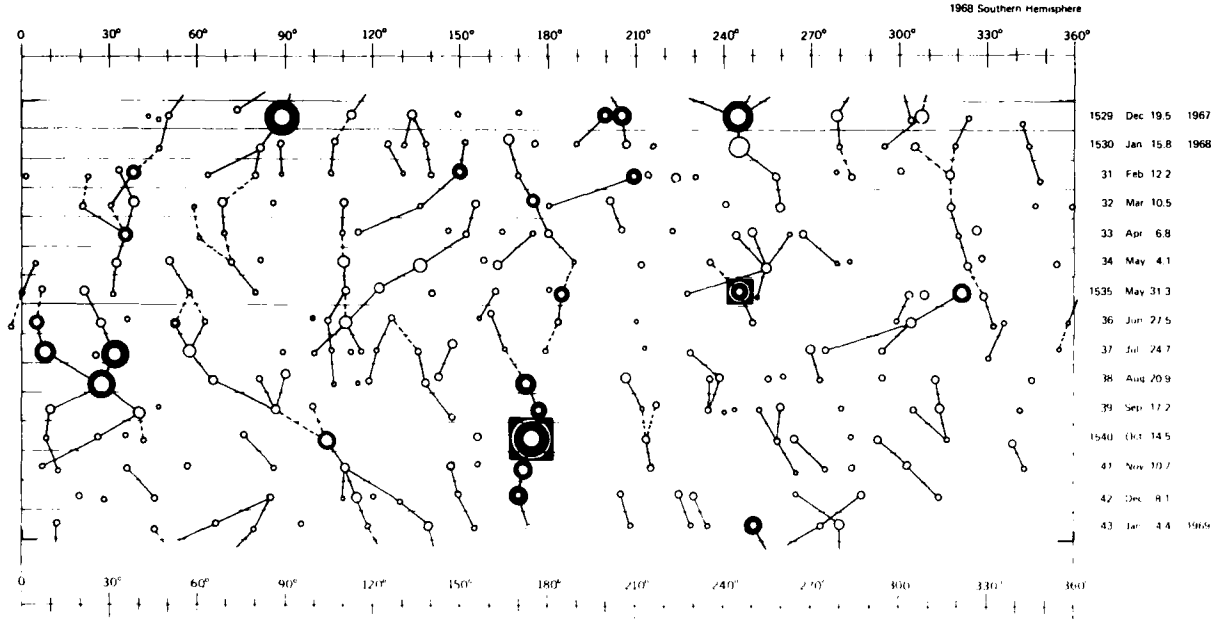
# 1967


1967 Northern Hemisphere
1967 Southern Hemisphere
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
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°

## 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 Northern Hemisphere
0 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°
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


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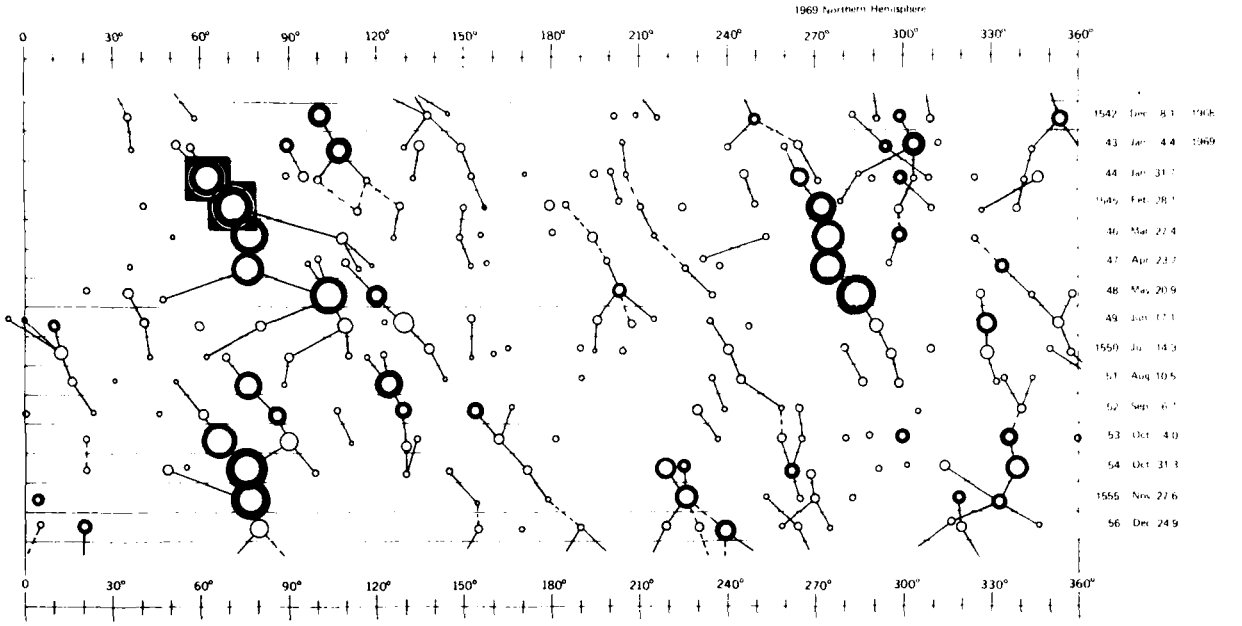
31 Feb 12.2
32 Mar 10.5
33 Apr 6.8
34 May 4.1
1535 May 31.3
36 Jun 27.5
37 Jul 24.7
38 Aug 20.9
39 Sep 17.2
1540 Oct 14.5
41 Nov 10.7
42 Dec 8.1
43 Jan 4.4 1969

## 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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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
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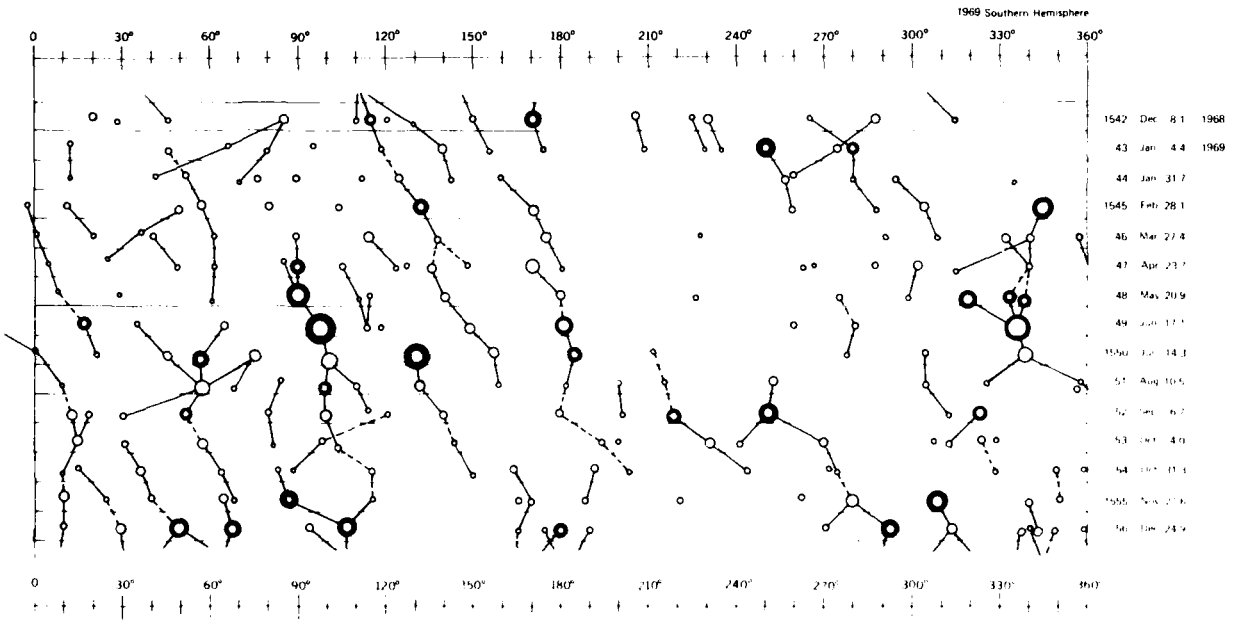
53 Oct 4.0
54 Oct 31.3
1555 Nov 27.6
56 Dec 24.9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44 Jan 31.7
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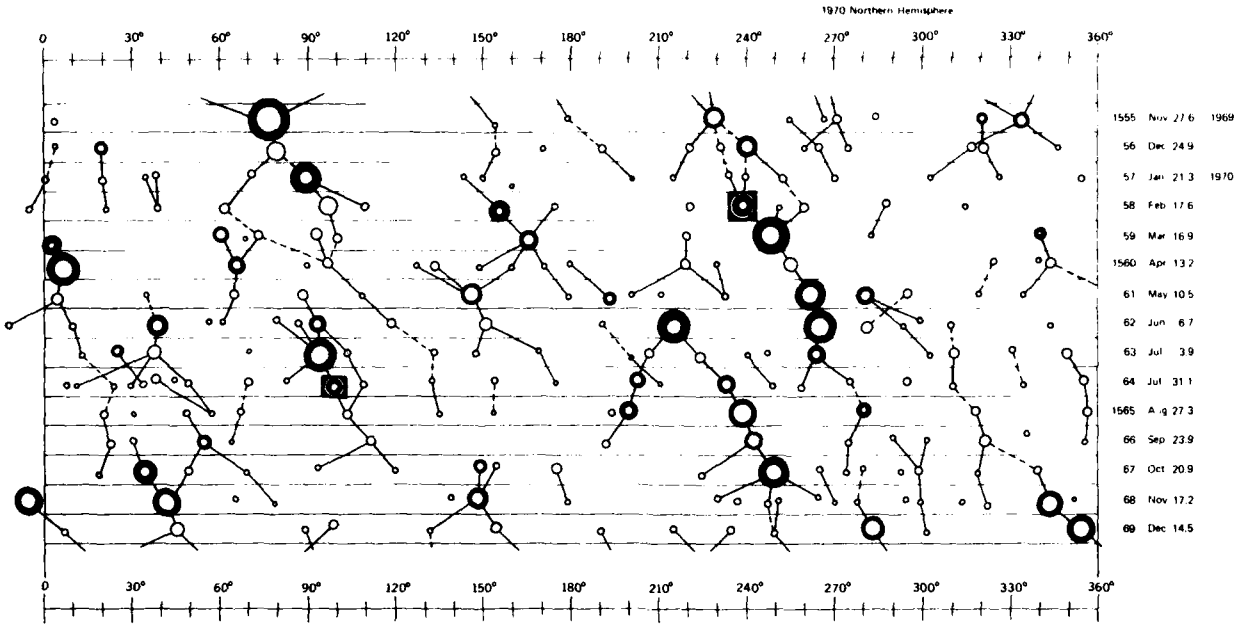
46 Mar 27.4
47 Apr 23.7
48 May 20.9
49 Jun 17.1
1550 Jul 14.3
51 Aug 10.5
52 Sep 6.7
53 Oct 4.0
54 Oct 31.3
1555 Nov 27.6
56 Dec 24.9

## 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
0 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°
1555 Nov 27.6 1969
56 Dec 24.9
57 Jan 21.3 1970
58 Feb 17.6
59 Mar 16.9
1560 Apr 13.2
61 May 10.5
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64 Jul 31.1
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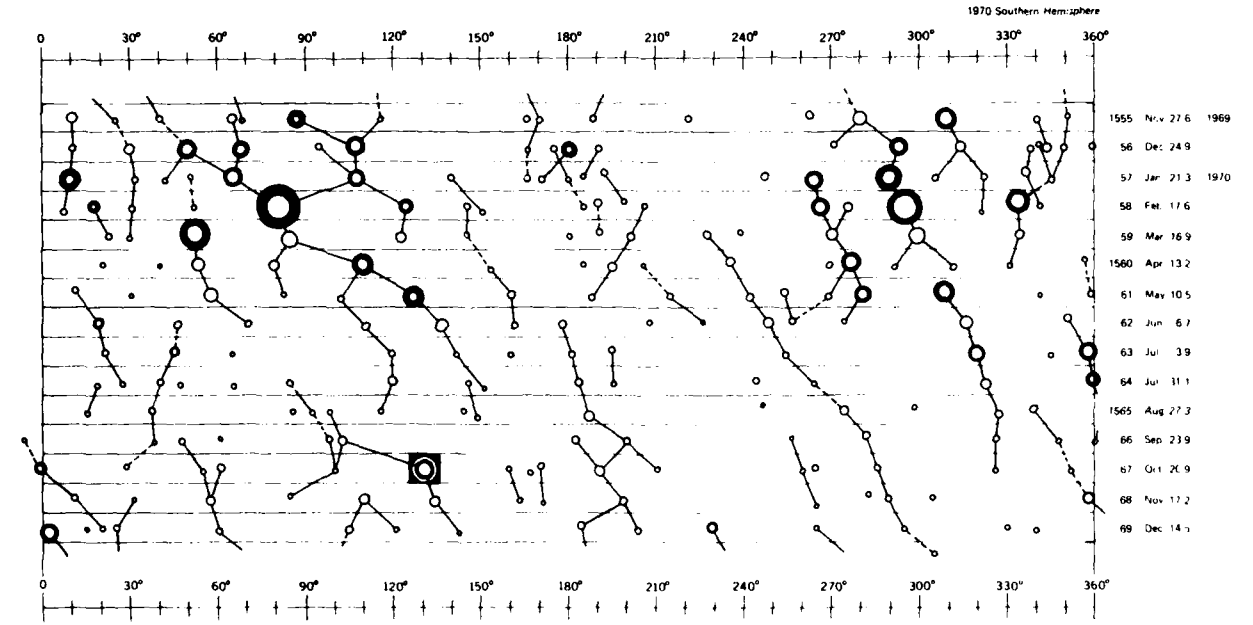
66 Sep 23.9
67 Oct 20.9
68 Nov 17.2
69 Dec 14.5


1970 Southern Hemisphere
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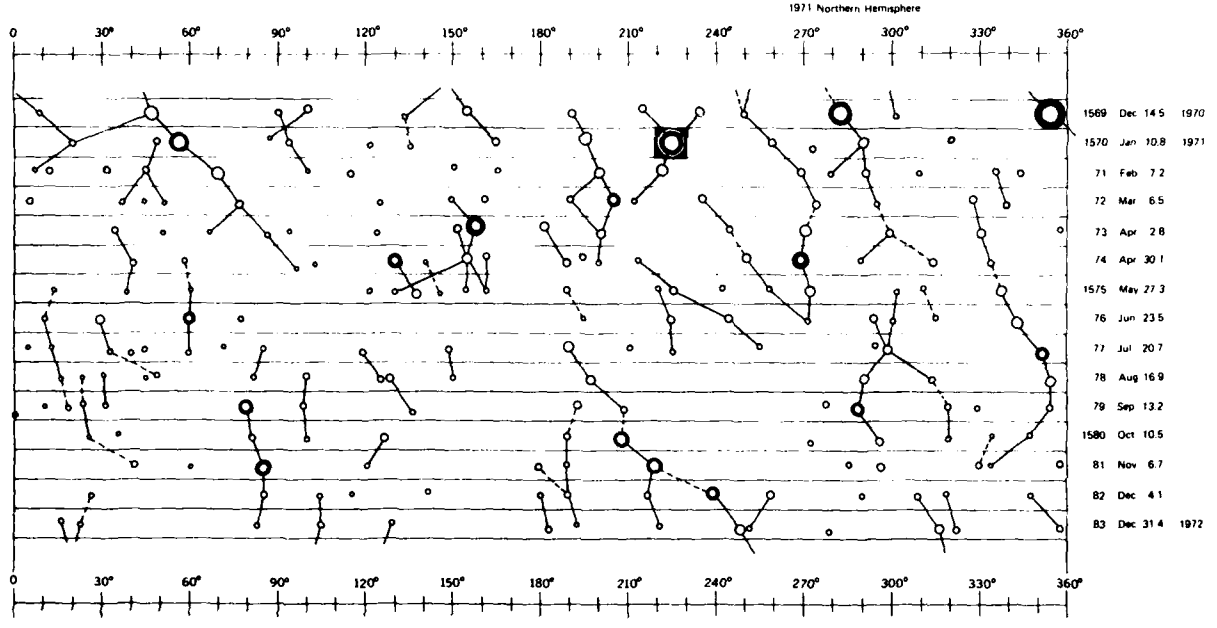
57 Jan 21.3 1970
58 Feb 17.6
59 Mar 16.9
1560 Apr 13.2
61 May 10.5
62 Jun 6.7
63 Jul 3.9
64 Jul 31.1
1565 Aug 27.3
66 Sep 23.9
67 Oct 20.9
68 Nov 17.2
69 Dec 14.5

## 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°
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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
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77 Jul 20.7
78 Aug 16.9
79 Sep 13.2
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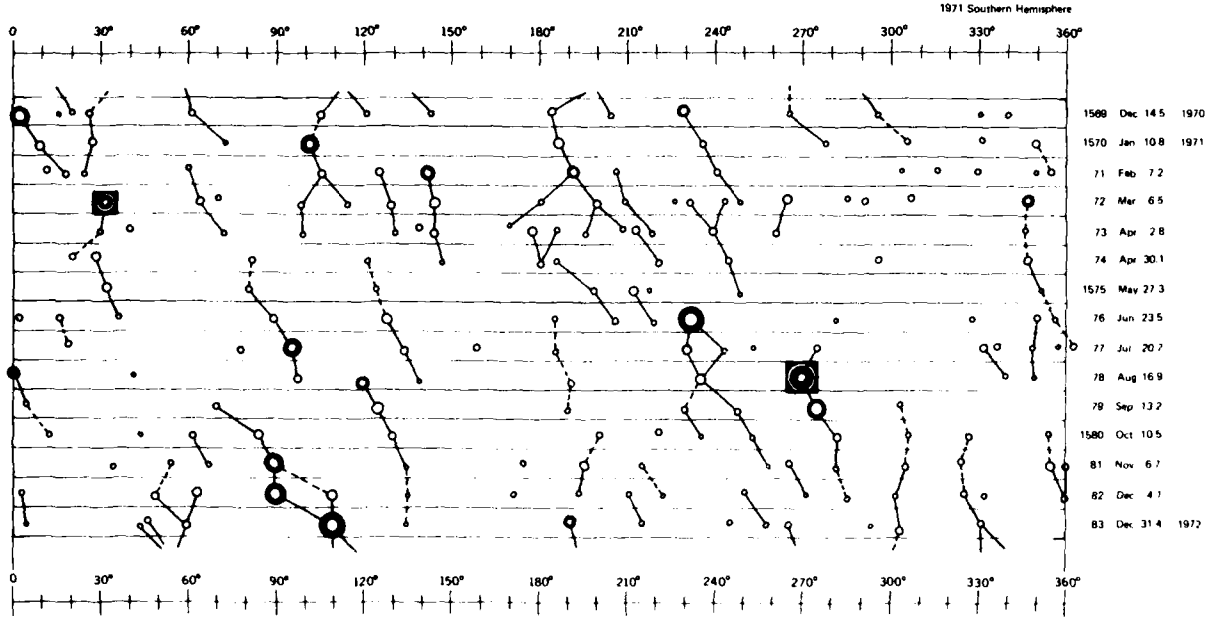
82 Dec 4.1
83 Dec 31.4 1972


1971 Southern Hemisphere
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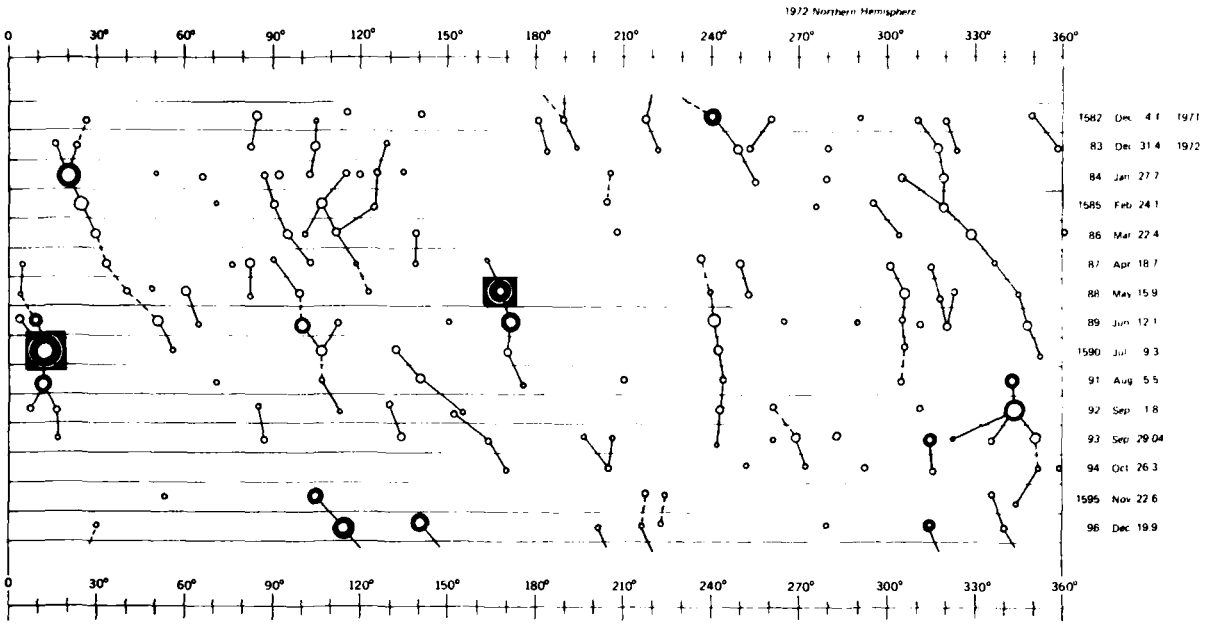
1570 Jan 10.8 1971
71 Feb 7.2
72 Mar 6.5
73 Apr 2.8
74 Apr 30.1
1575 May 27.3
76 Jun 23.5
77 Jul 20.7
78 Aug 16.9
79 Sep 13.2
1580 Oct 10.5
81 Nov 6.7
82 Dec 4.1
83 Dec 31.4 1972

## 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 Northern 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
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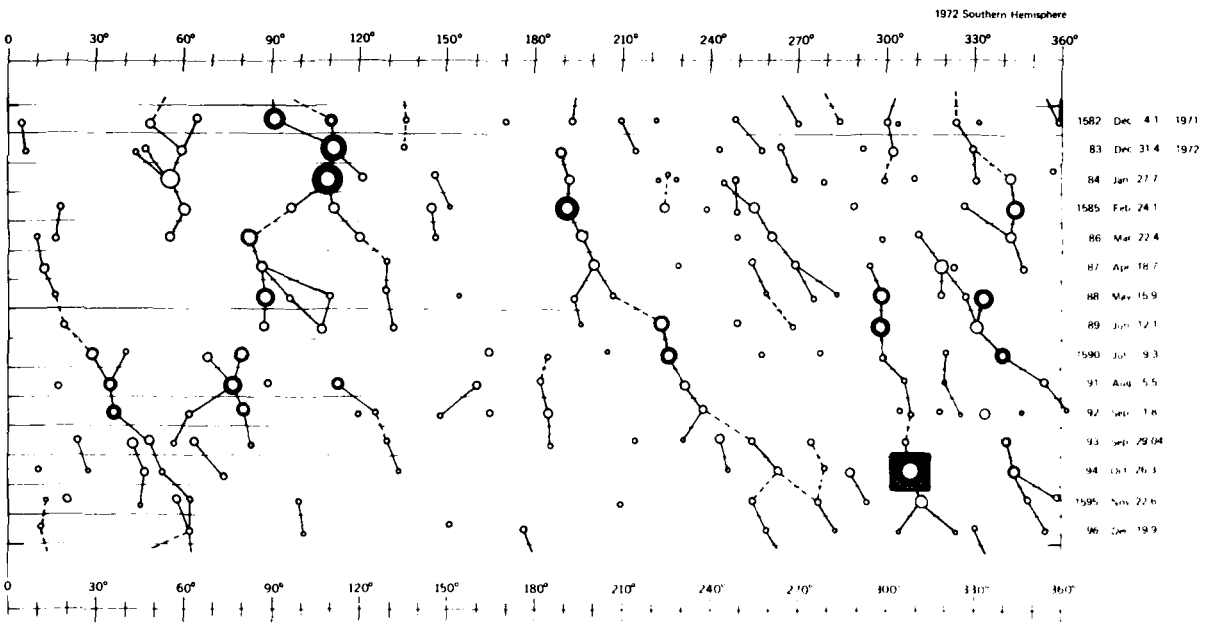
89 Jun 12 1
1590 Jul 9 3
91 Aug 5 5
92 Sep 1 8
93 Sep 29 04
94 Oct 26 3
1595 Nov 22 6
96 Dec 19 9


1972 Southern Hemisphere
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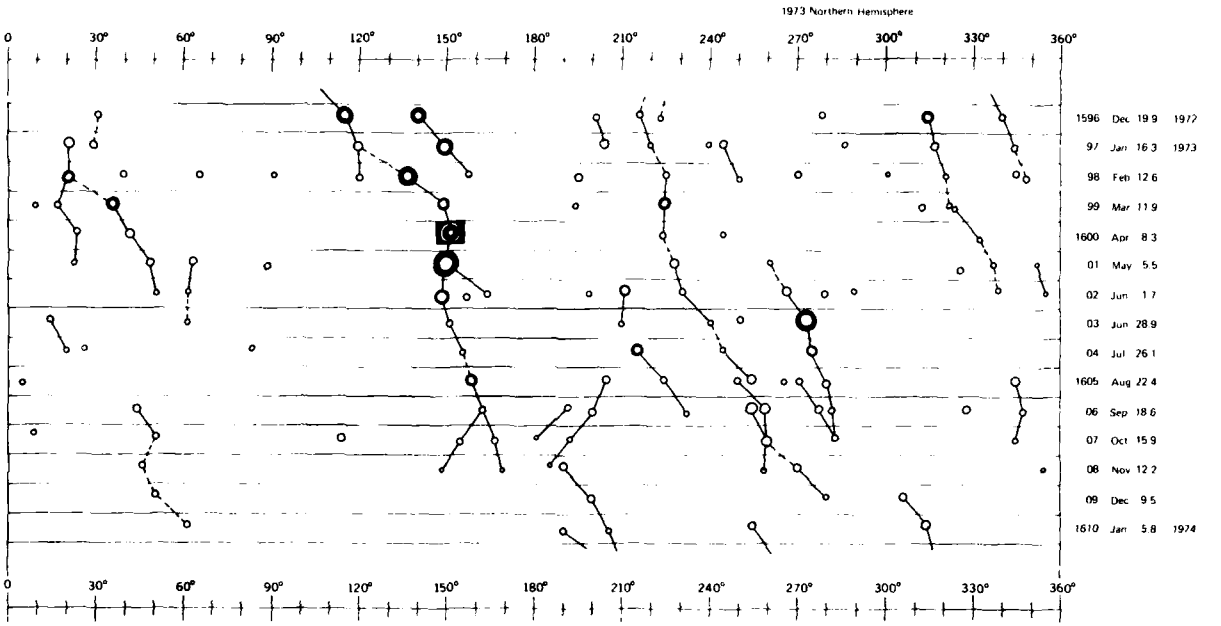
83 Dec 31 4 1972
84 Jan 27 7
1585 Feb 24 1
86 Mar 22 4
87 Apr 18 7
88 May 15 9
89 Jun 12 1
1590 Jul 9 3
91 Aug 5 5
92 Sep 1 8
93 Sep 29 04
94 Oct 26 3
1595 Nov 22 6
96 Dec 19 9

## 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.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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
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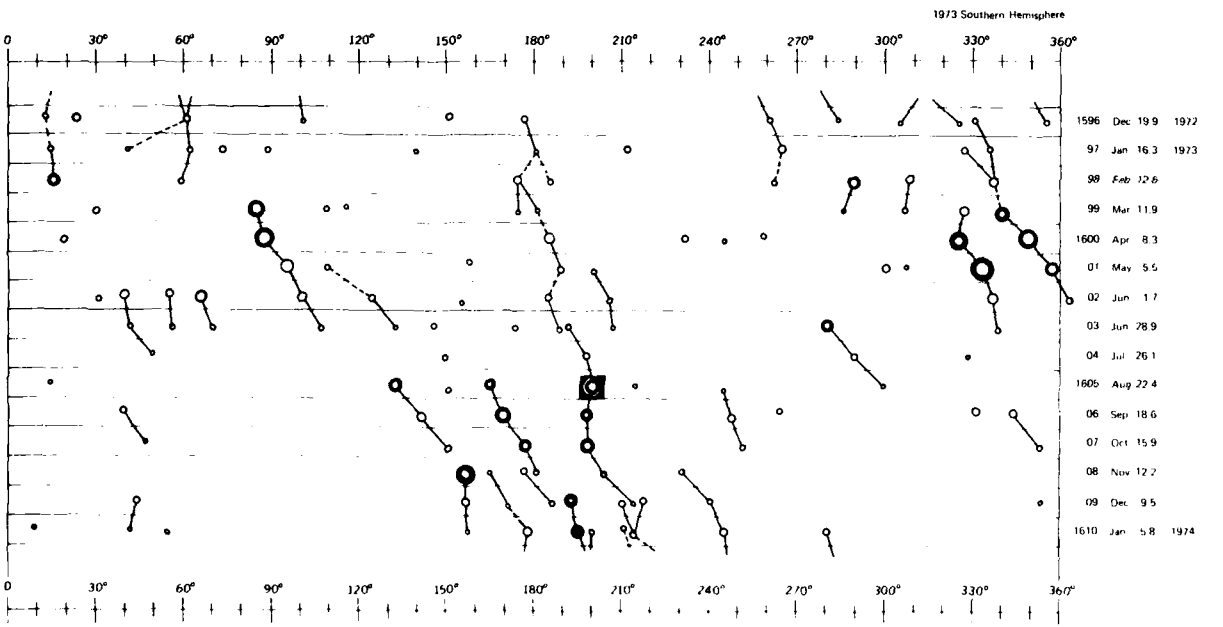
08 Nov 12.2
09 Dec 9.5
1610 Jan 5.8 1974


1973 Southern Hemisphere
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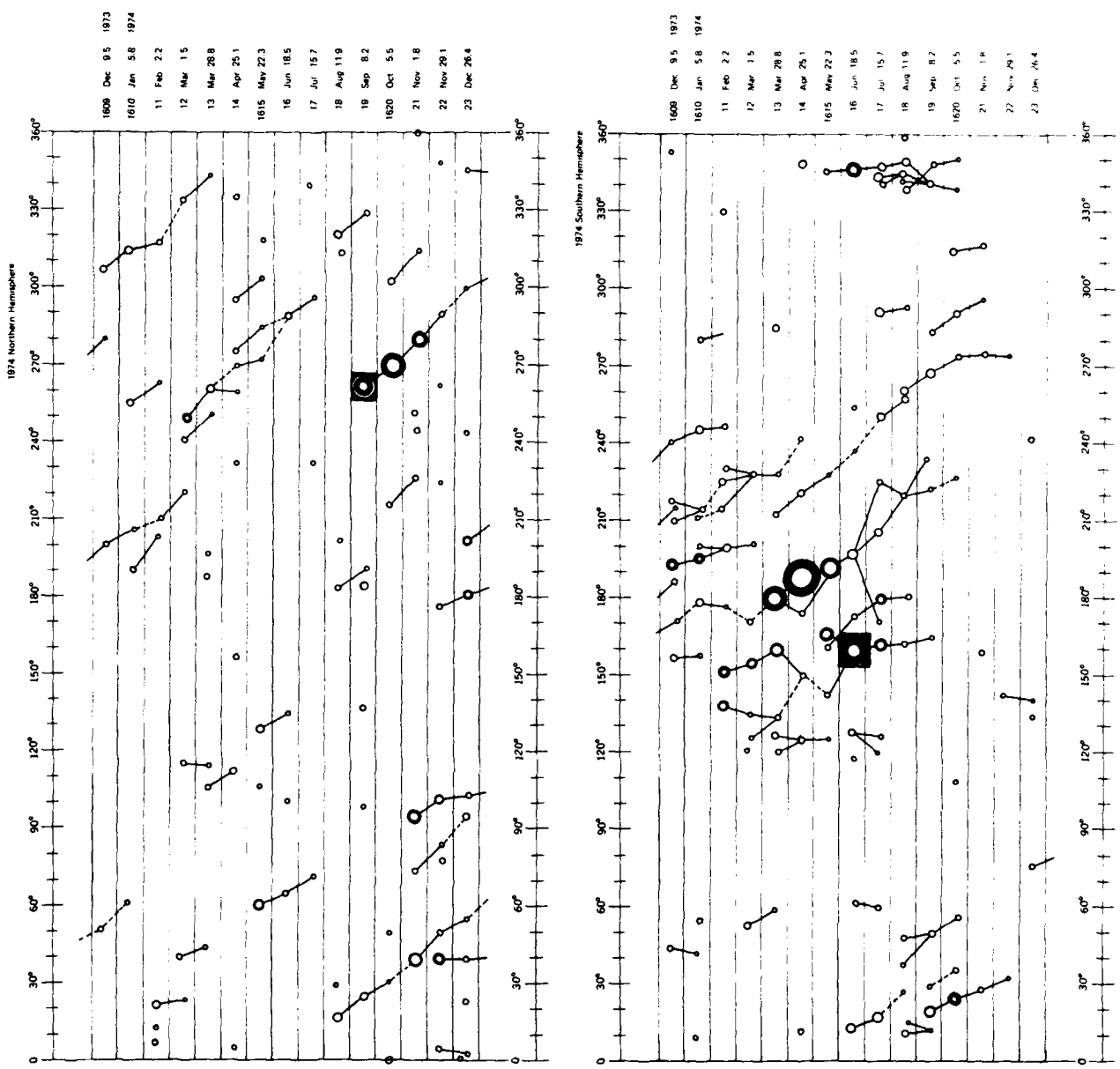
98 Feb 12.6
99 Mar 11.9
1600 Apr 8.3
01 May 5.5
02 Jun 1.7
03 Jun 28.9
04 Jul 26.1
1605 Aug 22.4
06 Sep 18.6
07 Oct 15.9
08 Nov 12.2
09 Dec 9.5
1610 Jan 5.8 1974

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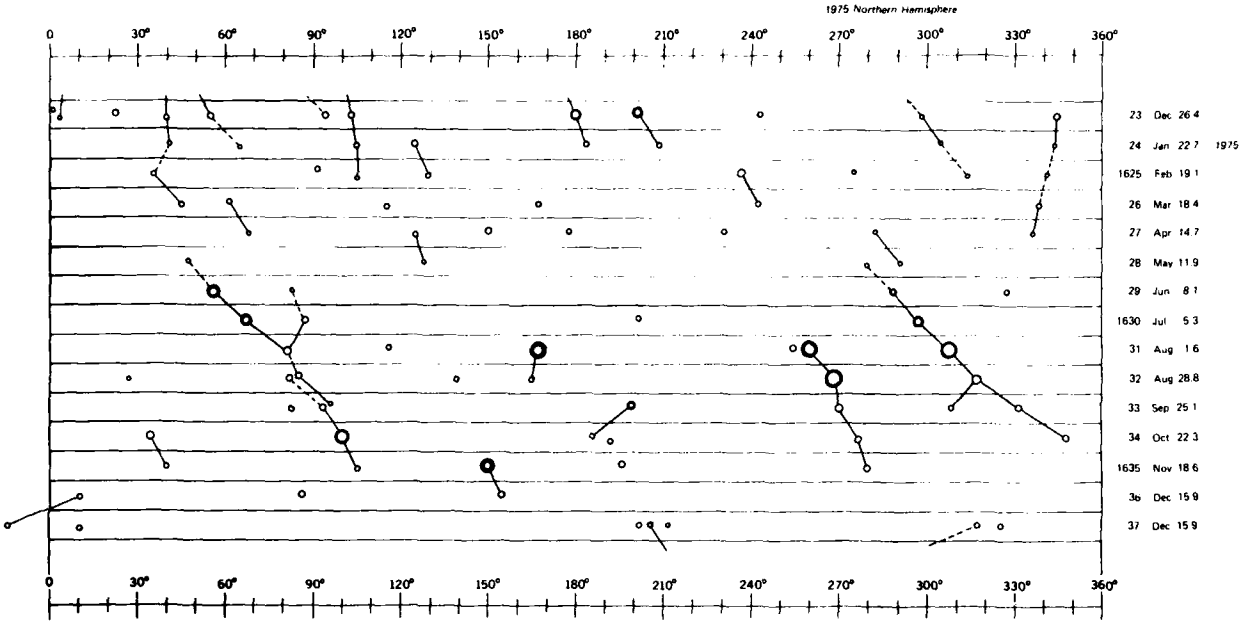
11 Feb 2.2
12 Mar 1.5
13 Mar 28.8
14 Apr 25.1
1615 May 22.3
16 Jun 18.5
17 Jul 15.7
18 Aug 11.9
19 Sep 8.2
1620 Oct 5.5
21 Nov 1.8
22 Nov 29.1
23 Dec 26.4
0
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
360°

## 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 Northern Hemisphere
0 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°
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
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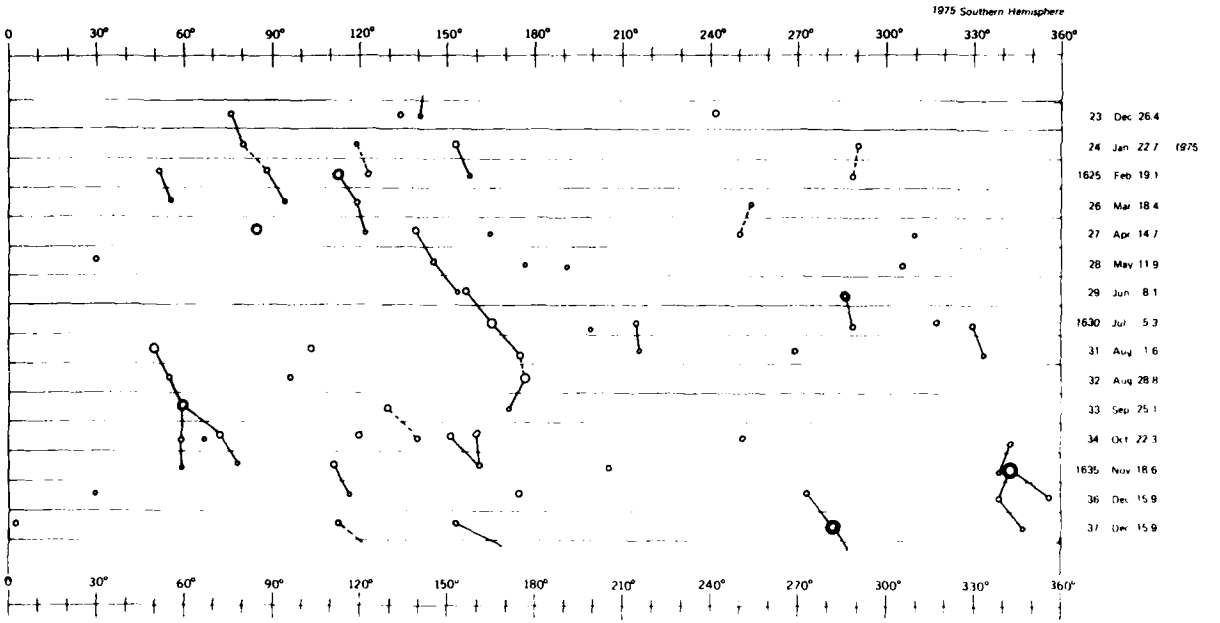
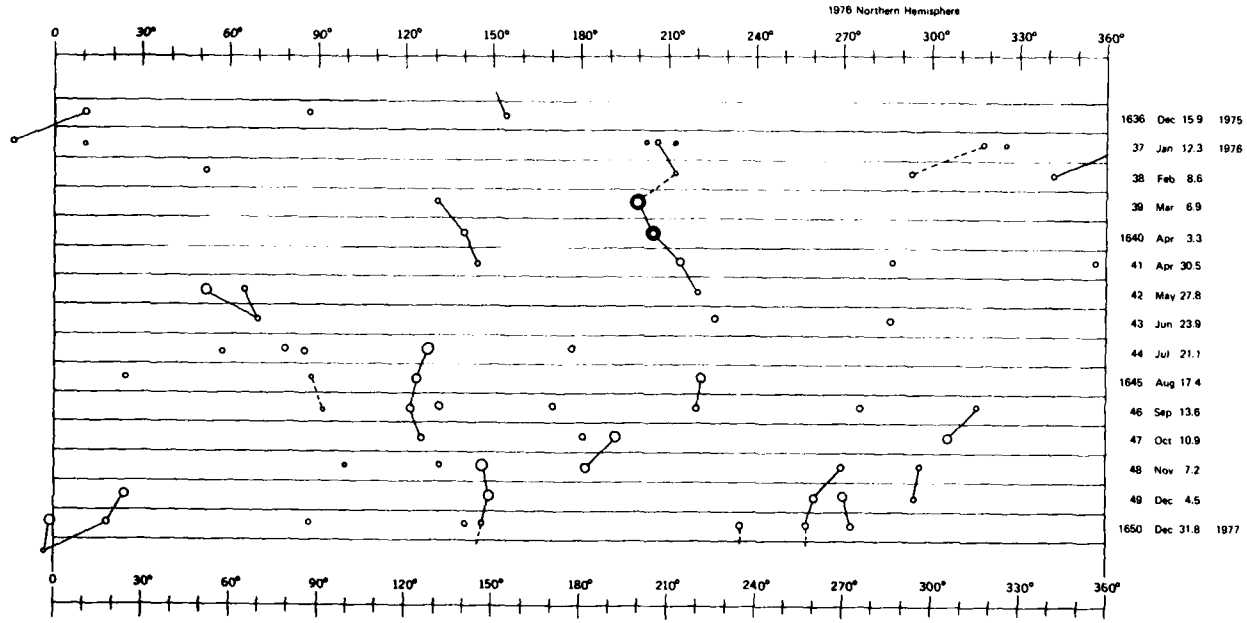
34 Oct 22.3
1635 Nov 18.6
36 Dec 15.9
37 Dec 15.9


1975 Southern Hemisphere
0 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°
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

## 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 Northern Hemisphere
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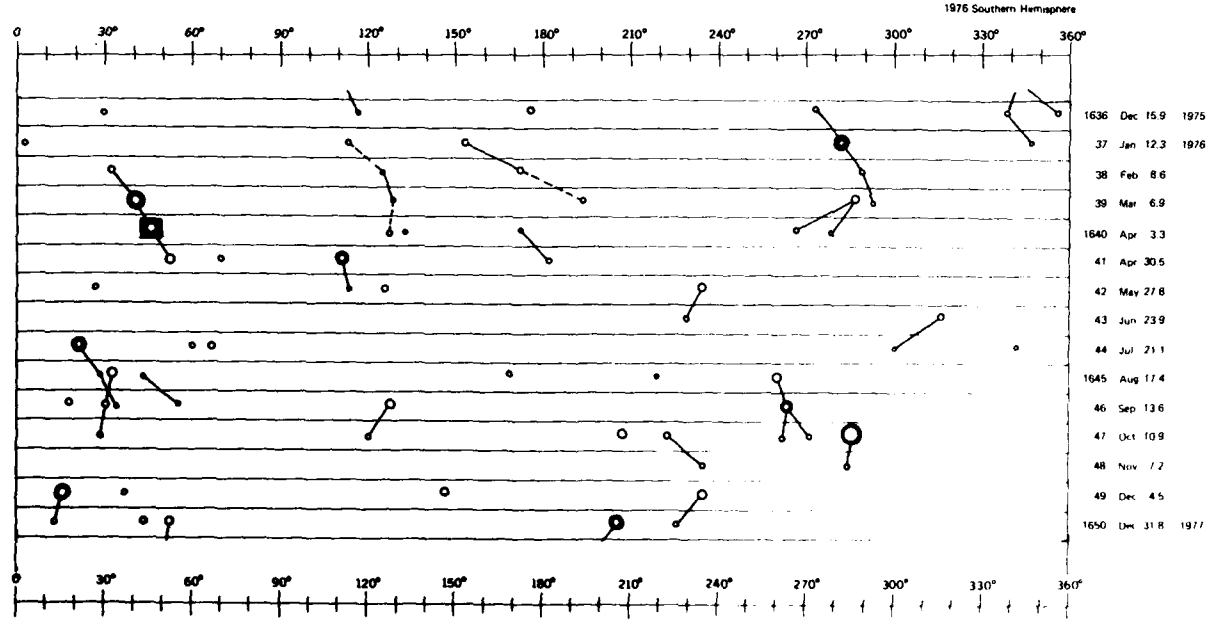
1636 Dec 15.9 1975
37 Jan 12.3 1976
38 Feb 8.6
39 Mar 6.9
1640 Apr 3.3
41 Apr 30.5
42 May 27.8
43 Jun 23.9
44 Jul 21.1
1645 Aug 17.4
46 Sep 13.6
47 Oct 10.9
48 Nov 7.2
49 Dec 4.5
1650 Dec 31.8 1977


1976 Southern Hemisphere
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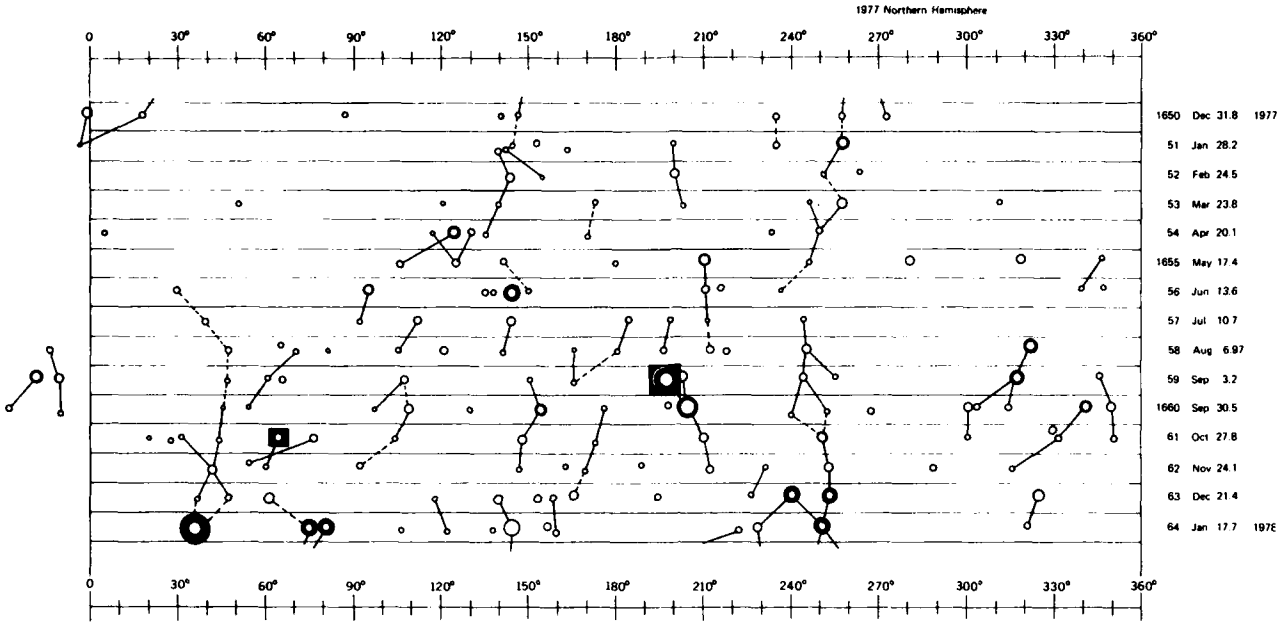
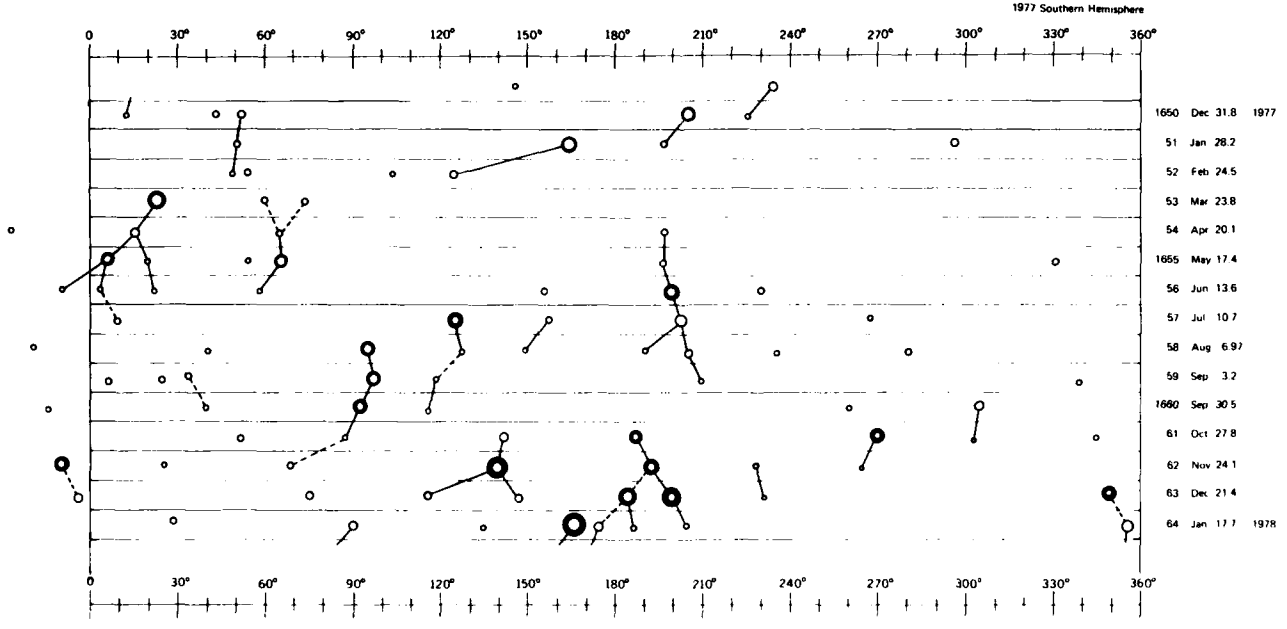
37 Jan 12.3 1976
38 Feb 8.6
39 Mar 6.9
1640 Apr 3.3
41 Apr 30.5
42 May 27.8
43 Jun 23.9
44 Jul 21.1
1645 Aug 17.4
46 Sep 13.6
47 Oct 10.9
48 Nov 7.2
49 Dec 4.5
1650 Dec 31.8 1977

## 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 Northern Hemisphere
0 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 360°
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


1977 Southern Hemisphere
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1650 Dec 31.8 1977
51 Jan 28.2
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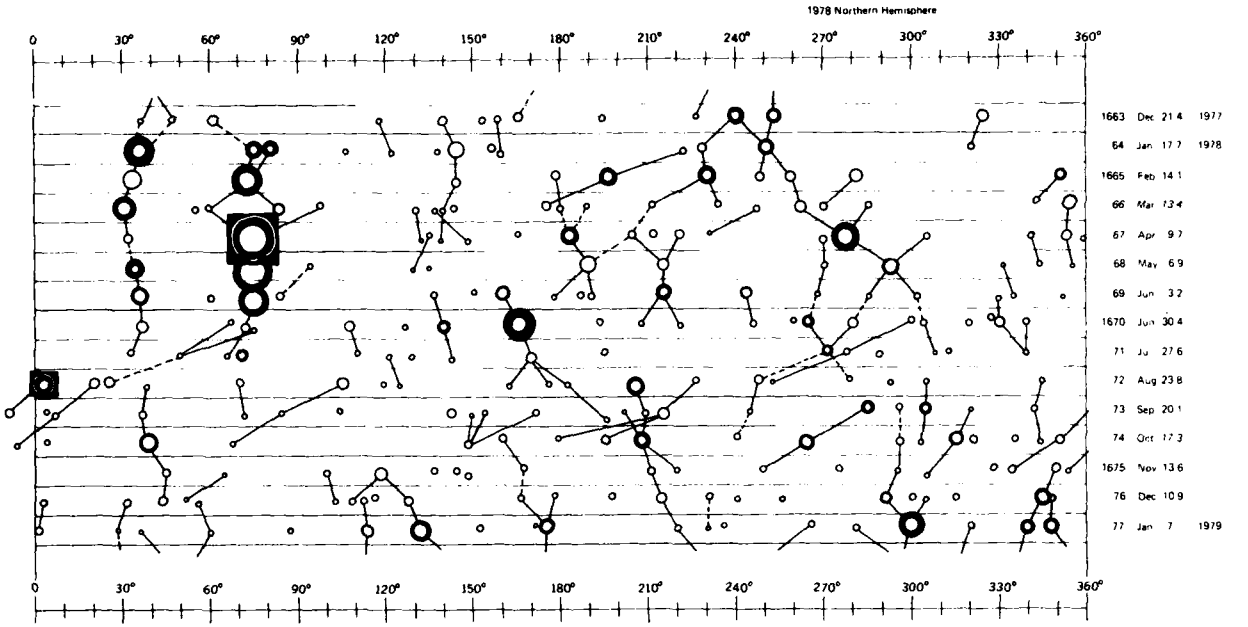
53 Mar 23.8
54 Apr 20.1
1655 May 17.4
56 Jun 13.6
57 Jul 10.7
58 Aug 6.97
59 Sep 3.2
1660 Sep 30.5
61 Oct 27.8
62 Nov 24.1
63 Dec 21.4
64 Jan 17.7 1978

## 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.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66 Mar 13.4
67 Apr 9.7
68 May 6.9
69 Jun 3.2
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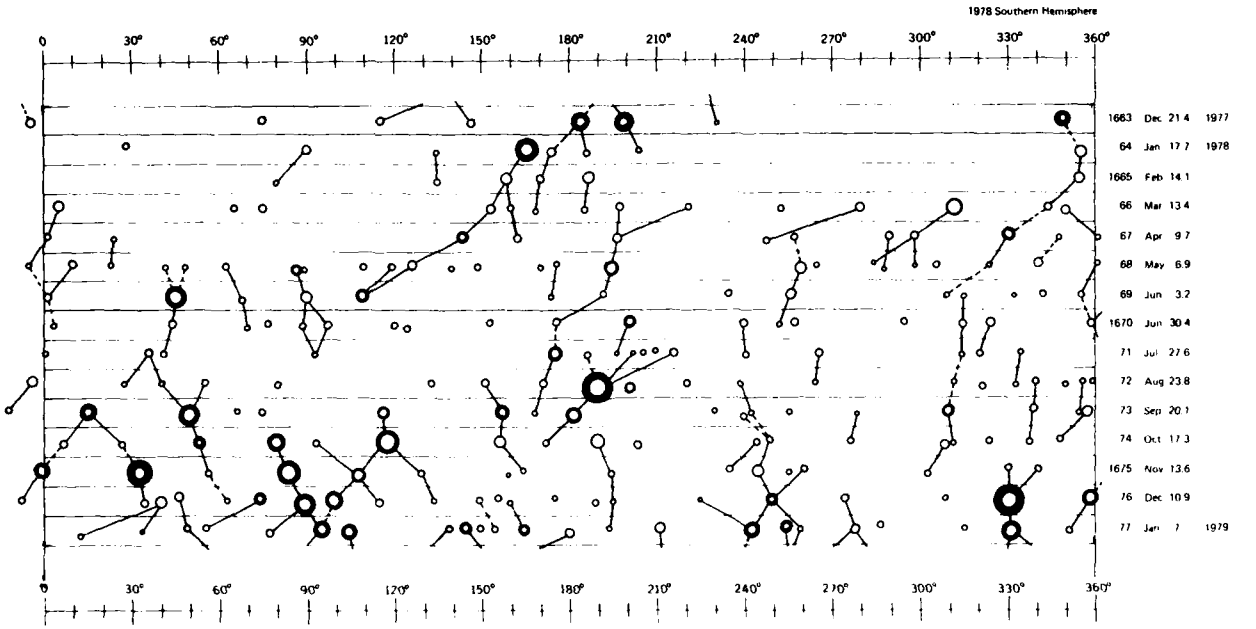
74 Oct 17.3
1675 Nov 13.6
76 Dec 10.9
77 Jan 7 1979


1978 Southern Hemisphere
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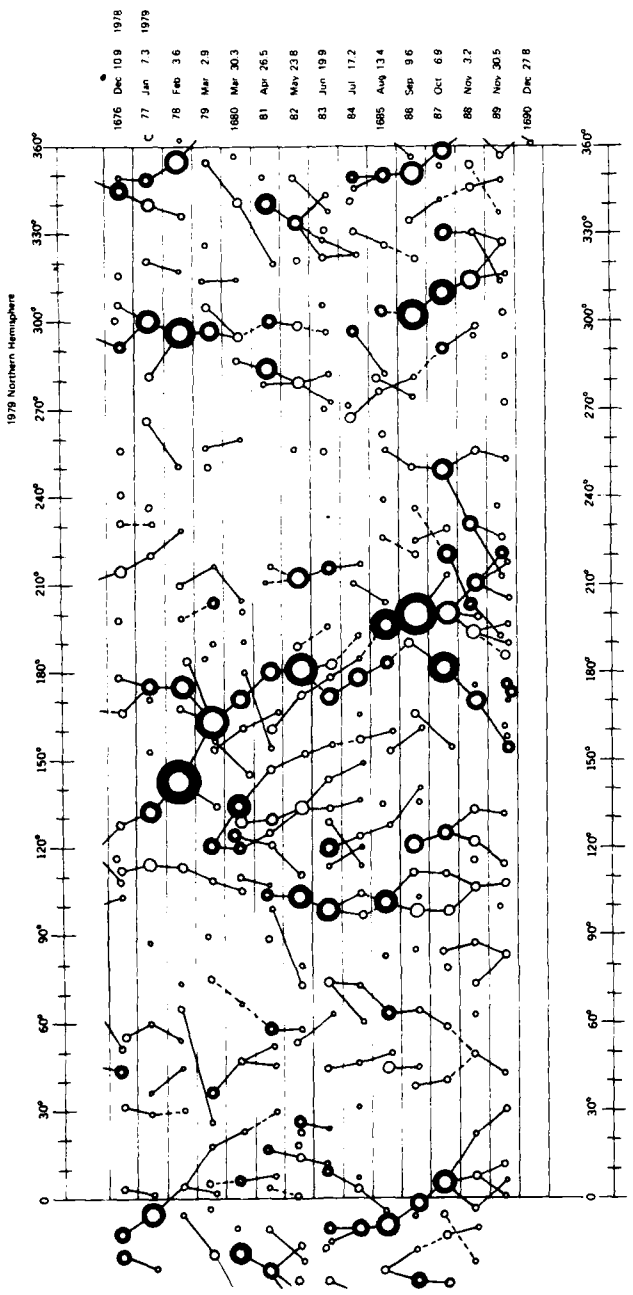
68 May 6.9
69 Jun 3.2
1670 Jun 30.4
71 Jul 27.6
72 Aug 23.8
73 Sep 20.1
74 Oct 17.3
1675 Nov 13.6
76 Dec 10.9
77 Jan 7 1979

## 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).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79 Mar 2.9
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83 Jun 19.9
84 Jul 17.2
1685 Aug 13.4
86 Sep 9.6
87 Oct 6.9
88 Nov 3.2
89 Nov 30.5
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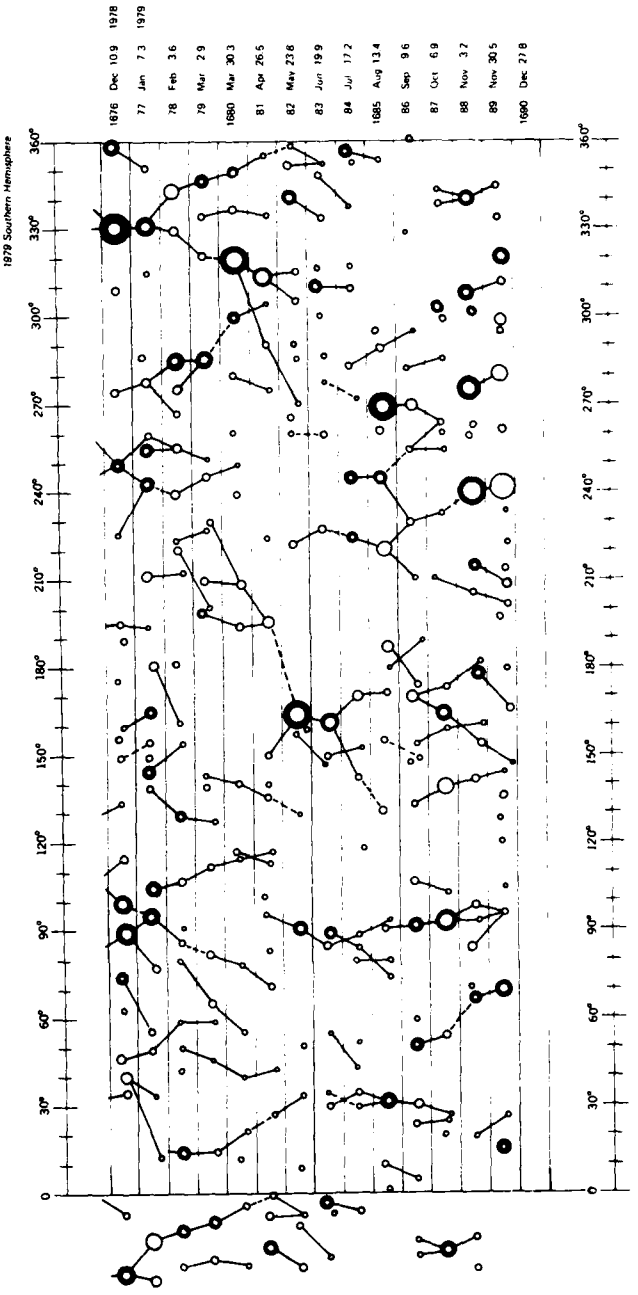
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84 Jul 17.2
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86 Sep. 9.6
87 Oct 6.9
88 Nov 3.2
89 Nov 30.5
1690 Dec 27.8
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## IV. Evolutionary Charts of Solar Activity 1964–1979; Northern and Southern 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

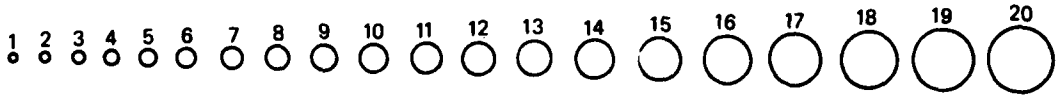
Old and dying plage followed by resurgence of new center of activity in the same location, or, transient plage (duration < 14 days) associated with other, more permanent center of activity

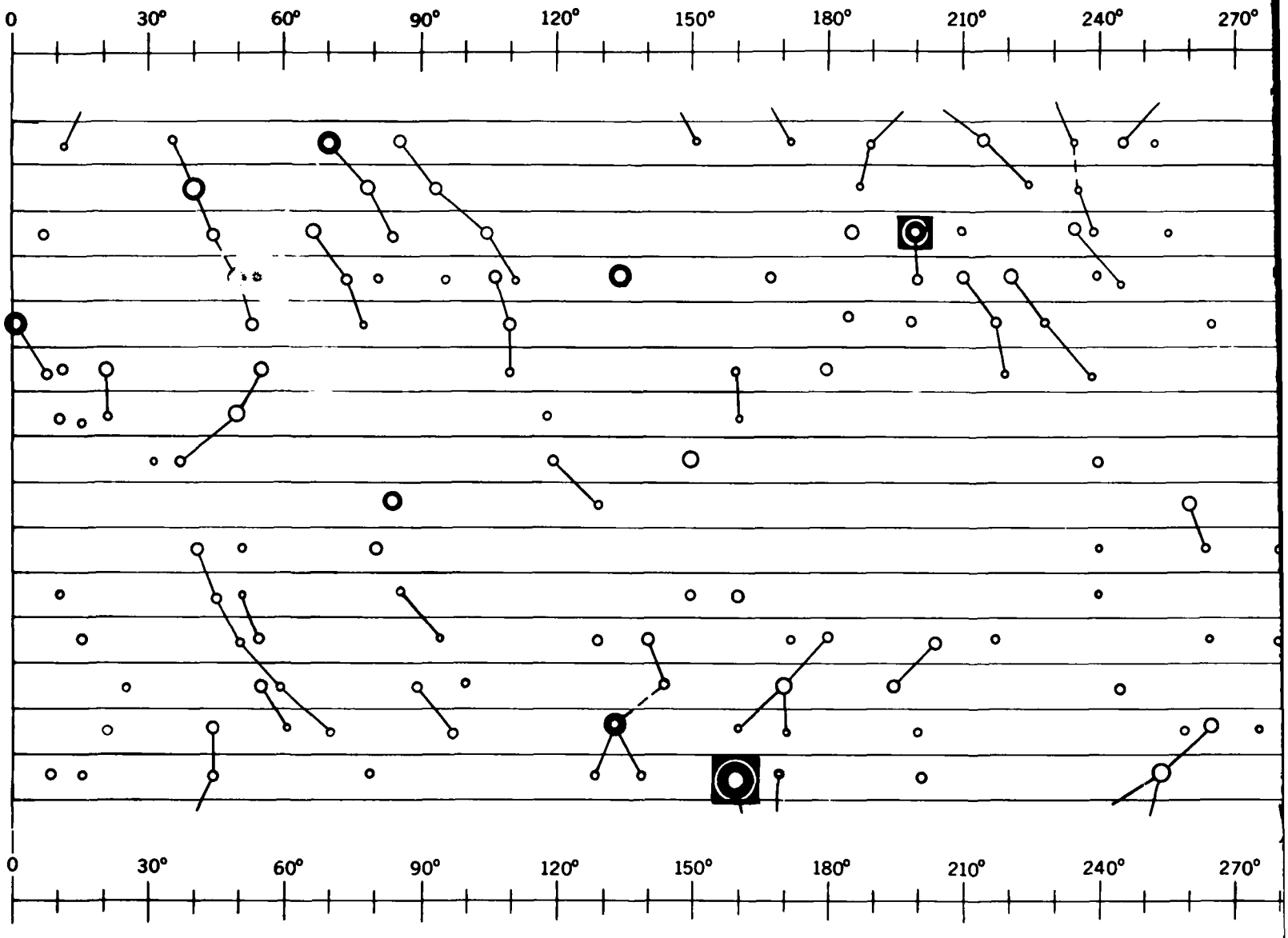
Representative disc-transit CaK plage area-intensity measure based on daily values reported by McMath-Hulbert Observatory

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

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

k-values (to chart scale)

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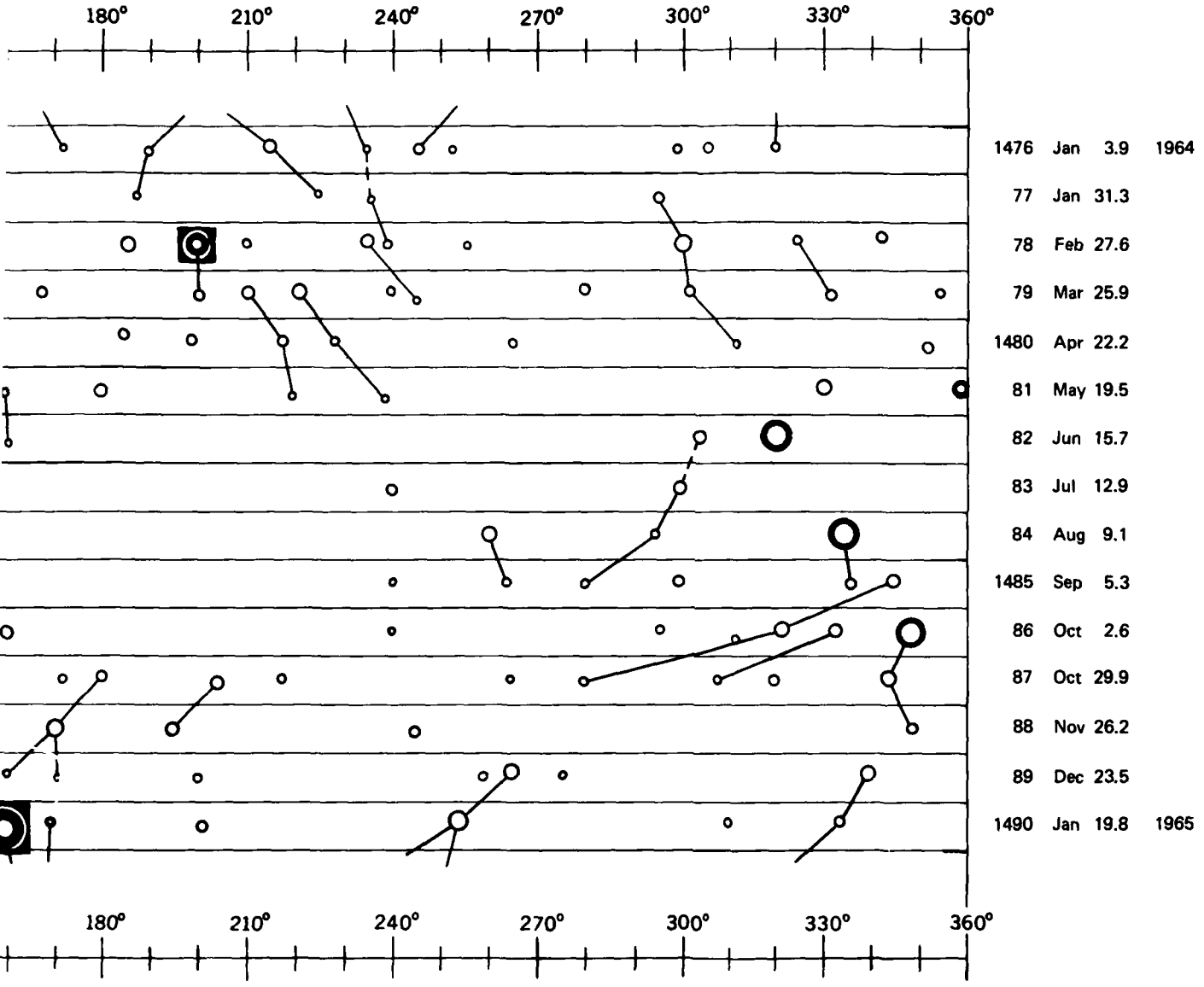
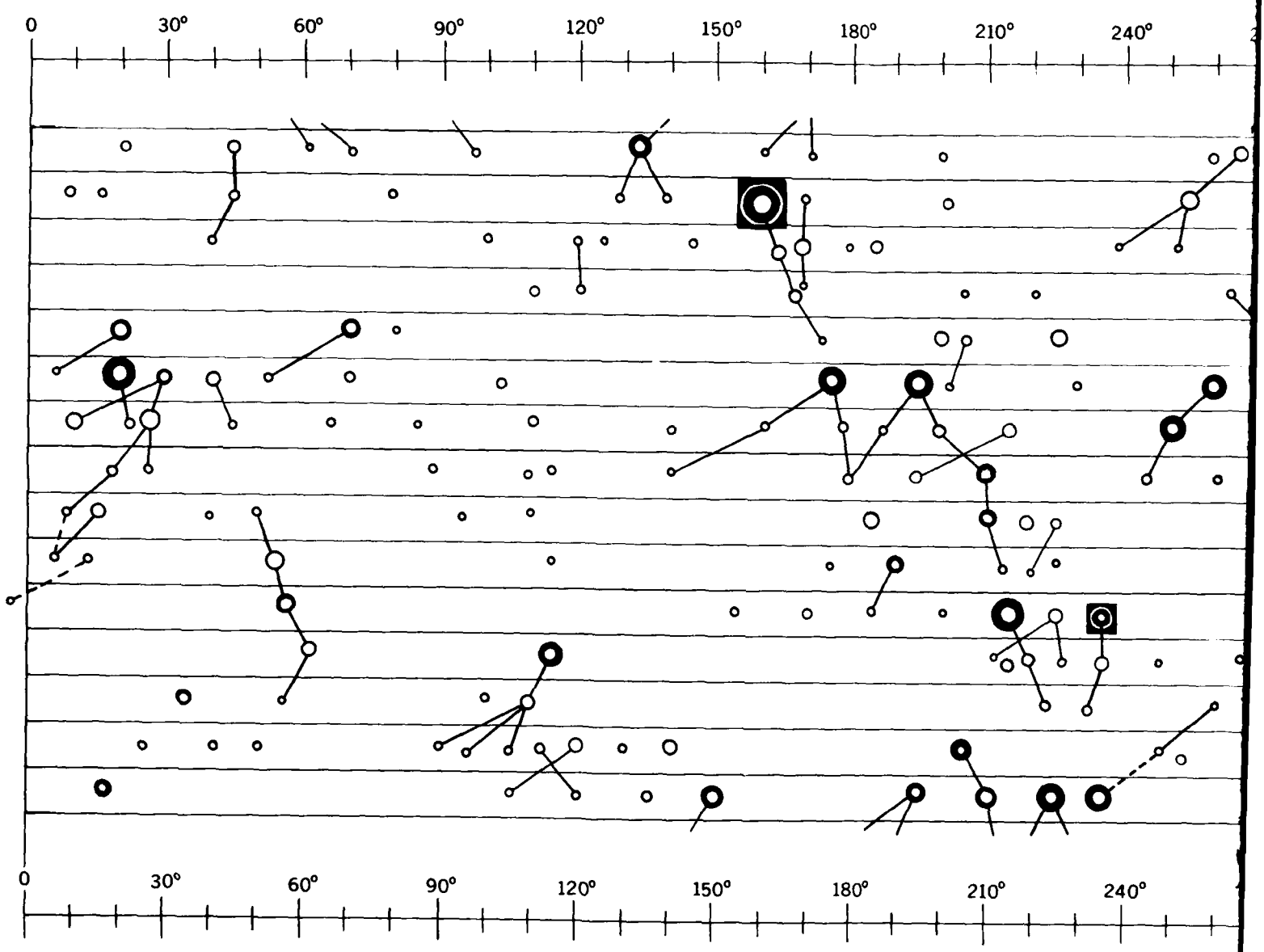
1964 Northern Hemisphere 1964 Southern Hemisphere

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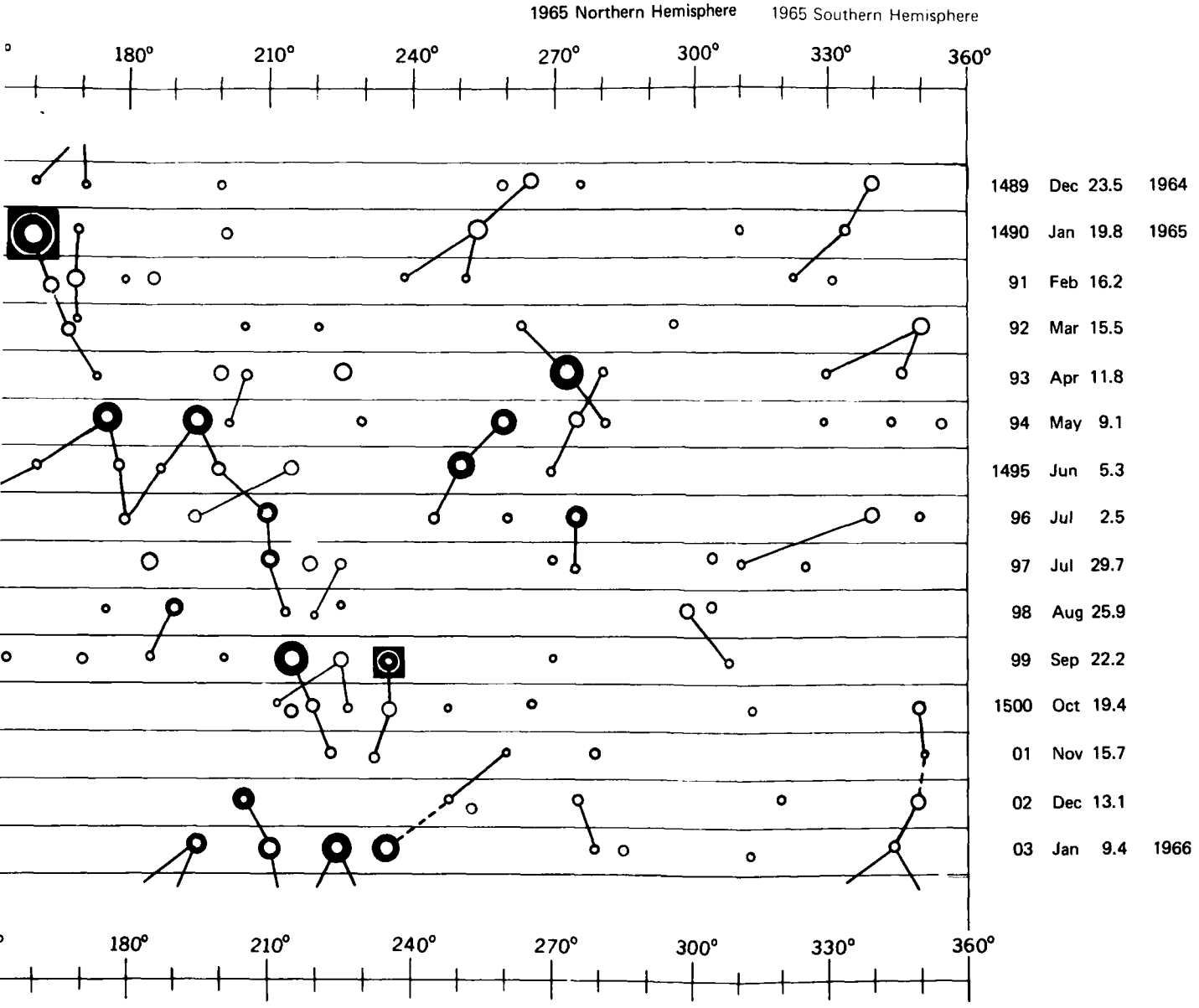
1965 Northern Hemisphere
1965 Southern Hemisphere
180°
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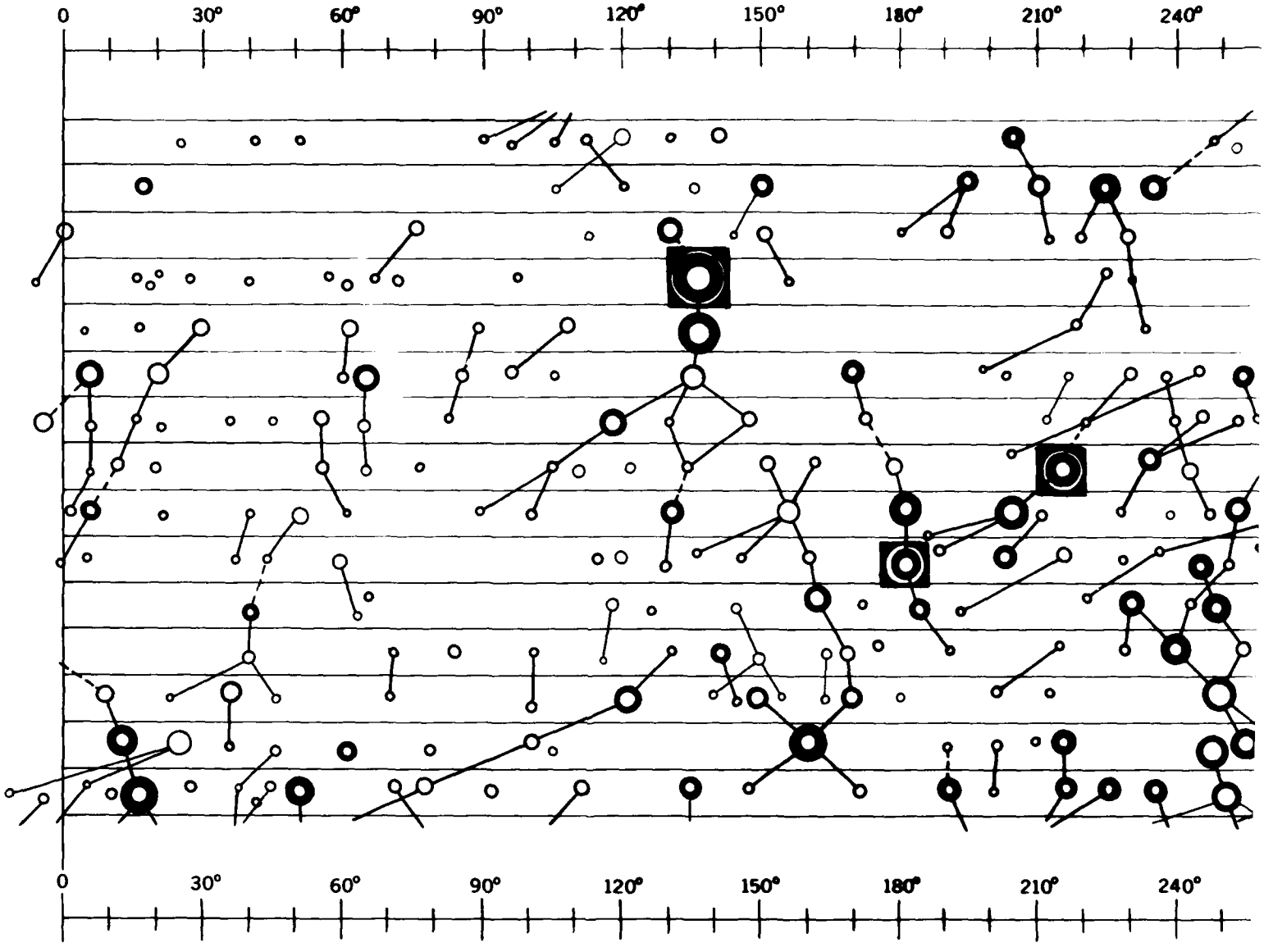
1490 Jan 19.8 1965
91 Feb 16.2
92 Mar 15.5
93 Apr 11.8
94 May 9.1
1495 Jun 5.3
96 Jul 2.5
97 Jul 29.7
98 Aug 25.9
99 Sep 22.2
1500 Oct 19.4
01 Nov 15.7
02 Dec 13.1
03 Jan 9.4 1966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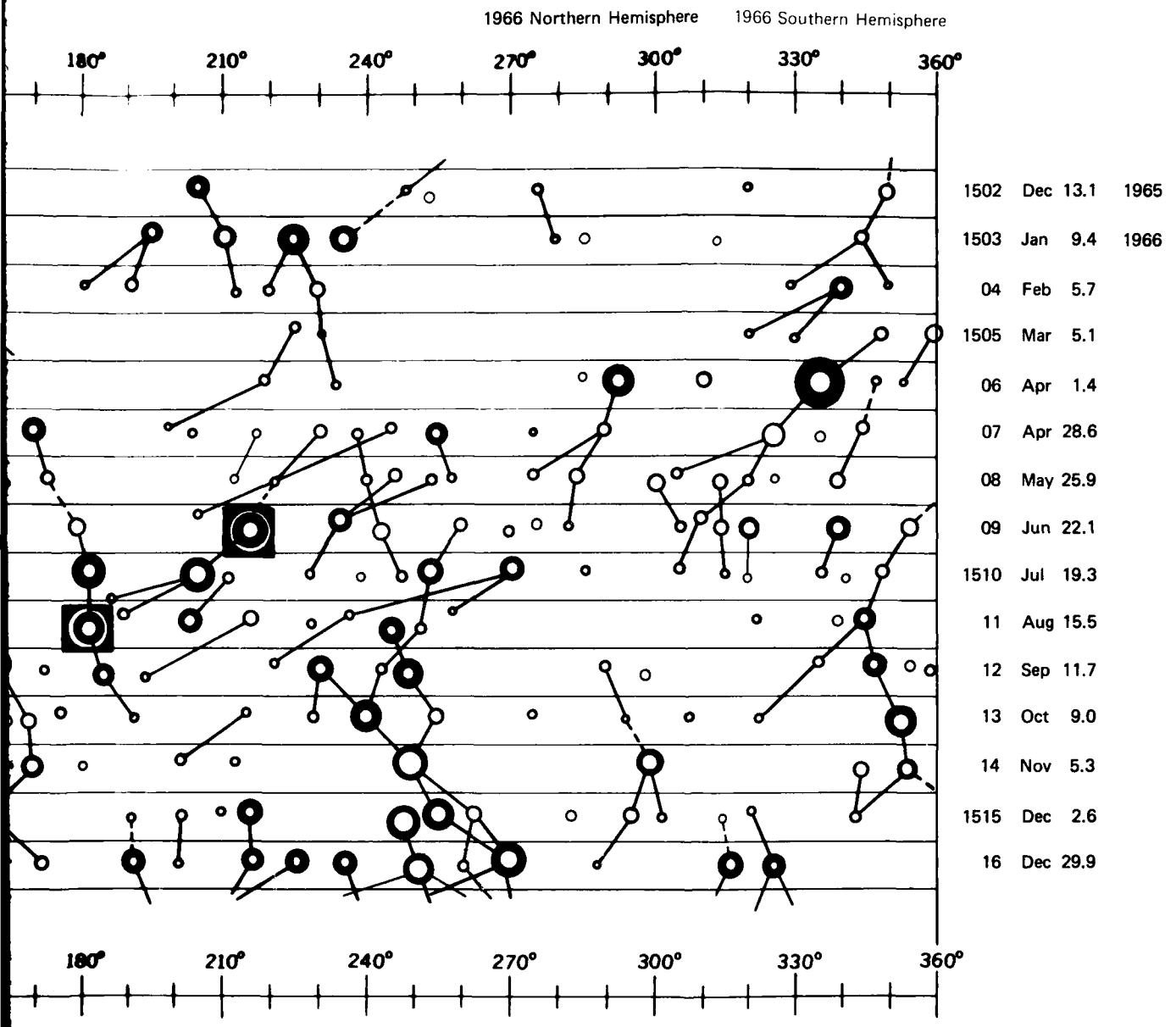
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1966 Southern Hemisphere
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04 Feb 5.7
1505 Mar 5.1
06 Apr 1.4
07 Apr 28.6
08 May 25.9
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14 Nov 5.3
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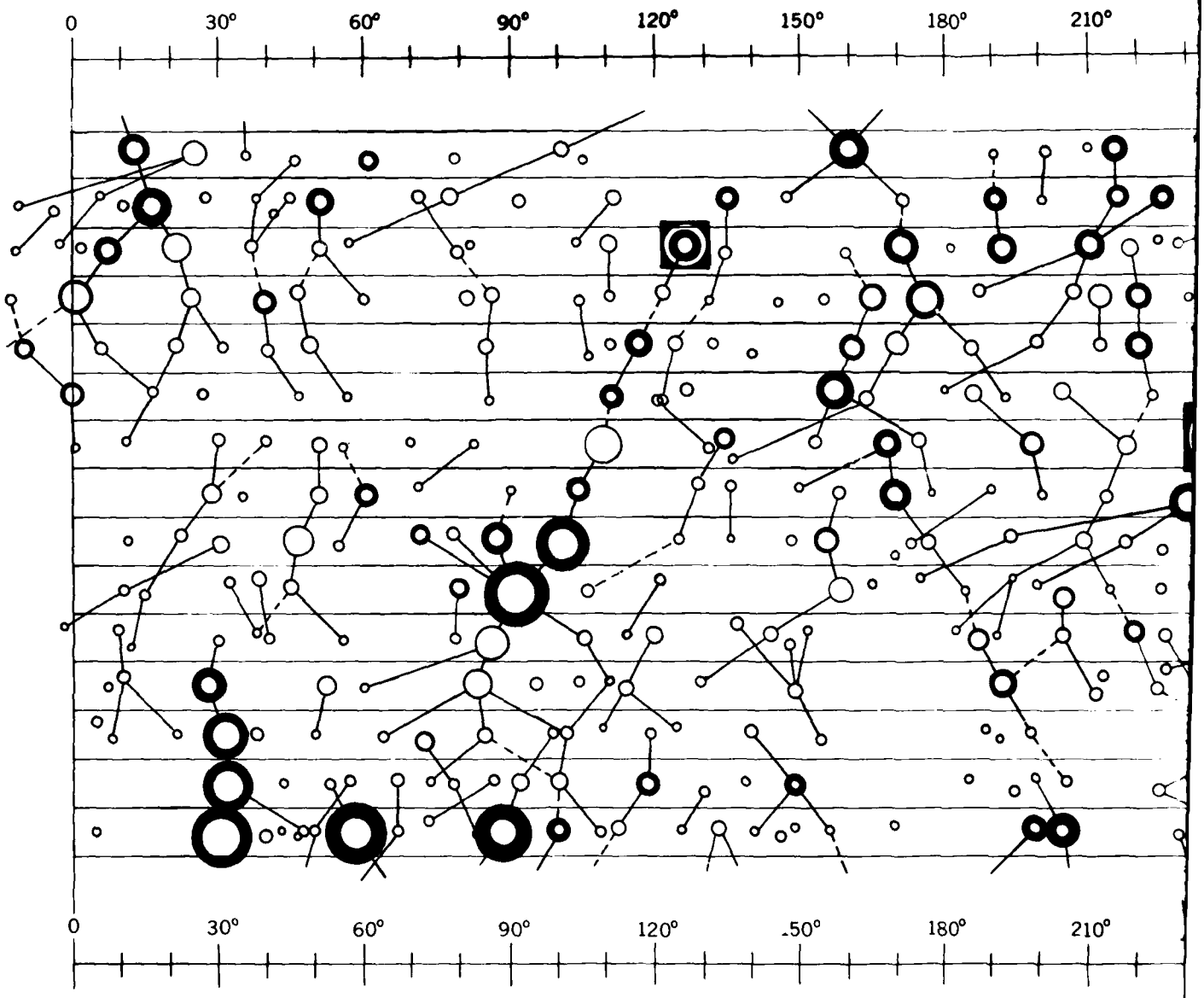
16 Dec 29.9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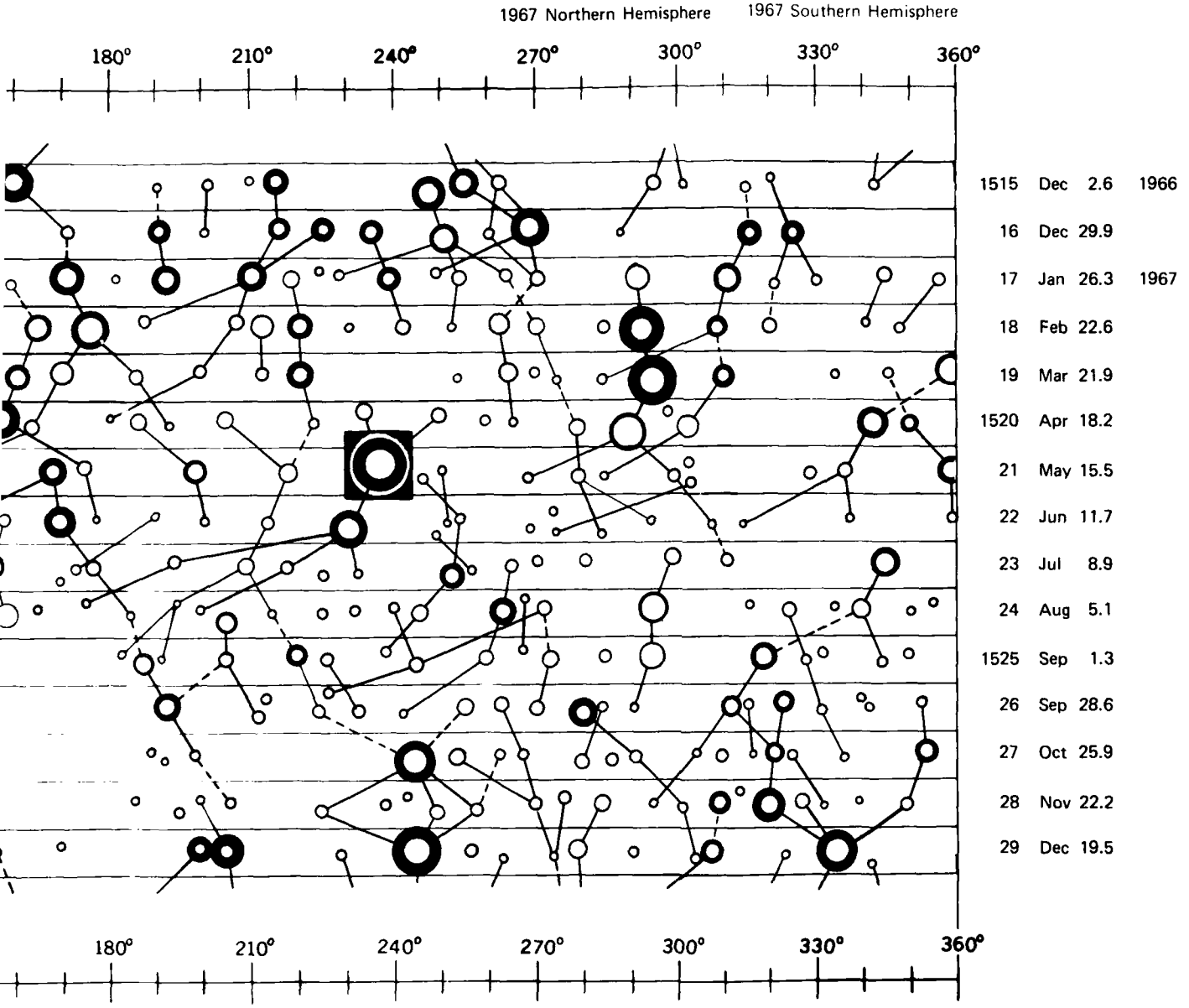
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1967 Southern Hemisphere
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16 Dec 29.9
17 Jan 26.3 1967
18 Feb 22.6
19 Mar 21.9
1520 Apr 18.2
21 May 15.5
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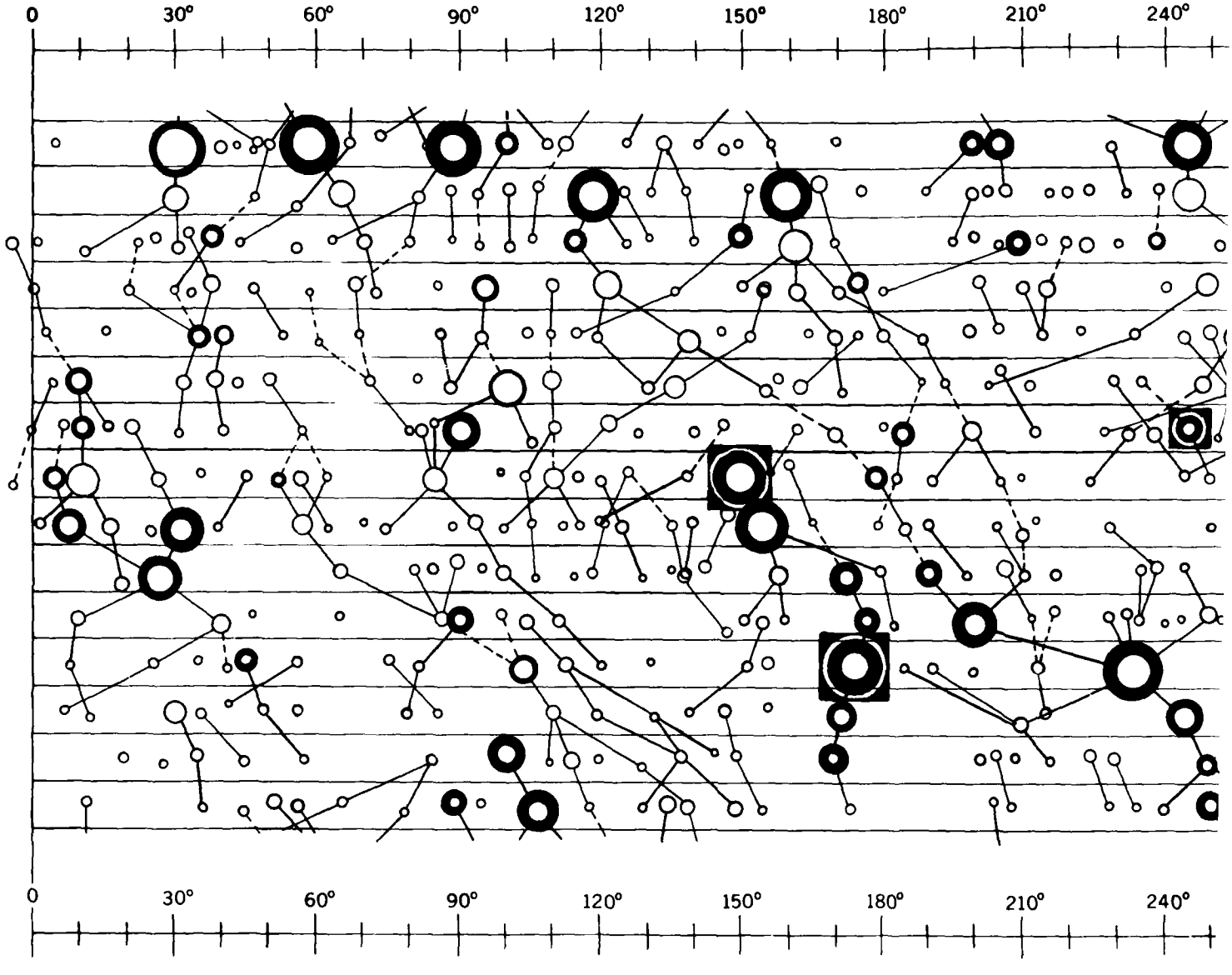
28 Nov 22.2
29 Dec 19.5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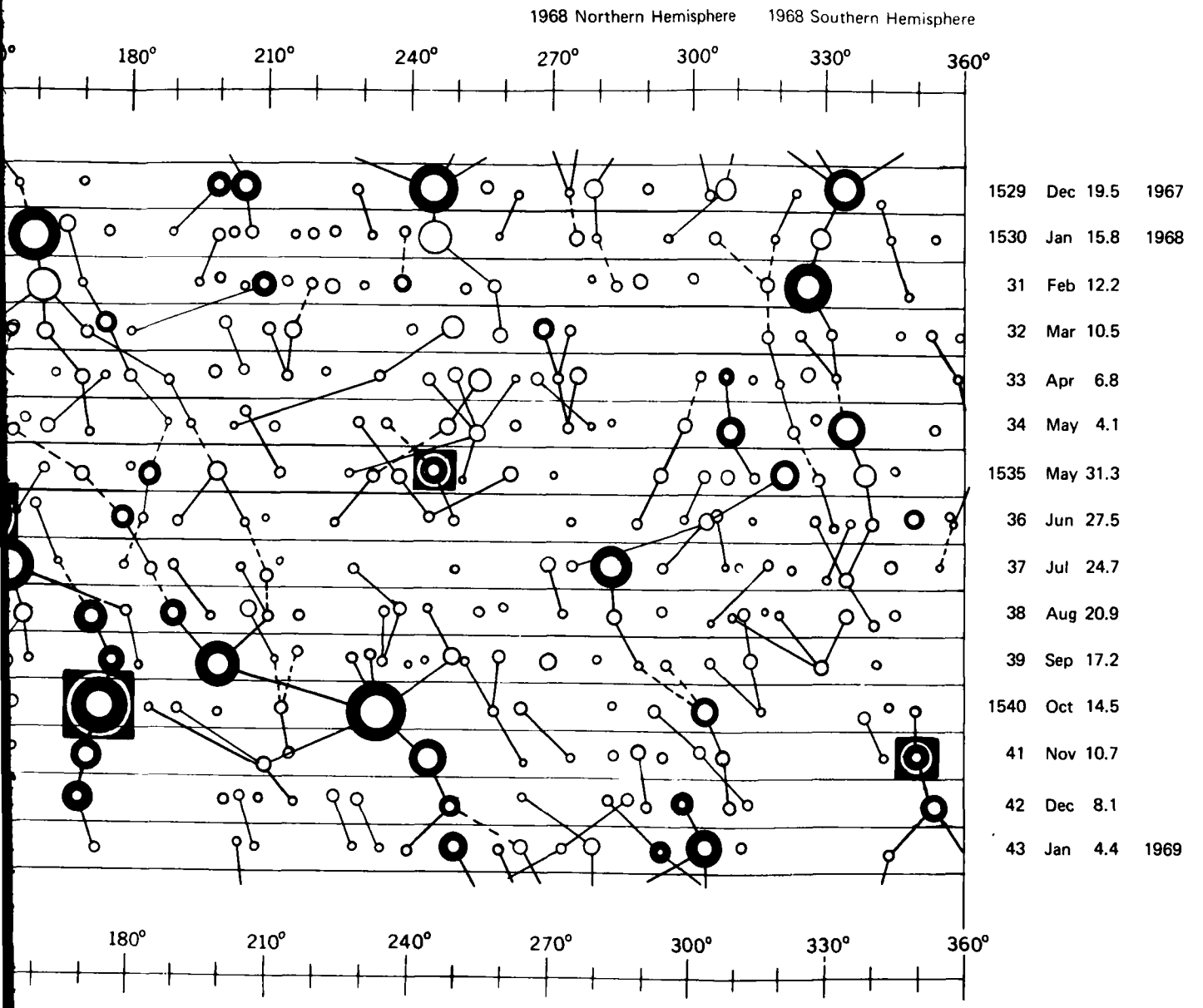
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31 Feb 12.2
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33 Apr 6.8
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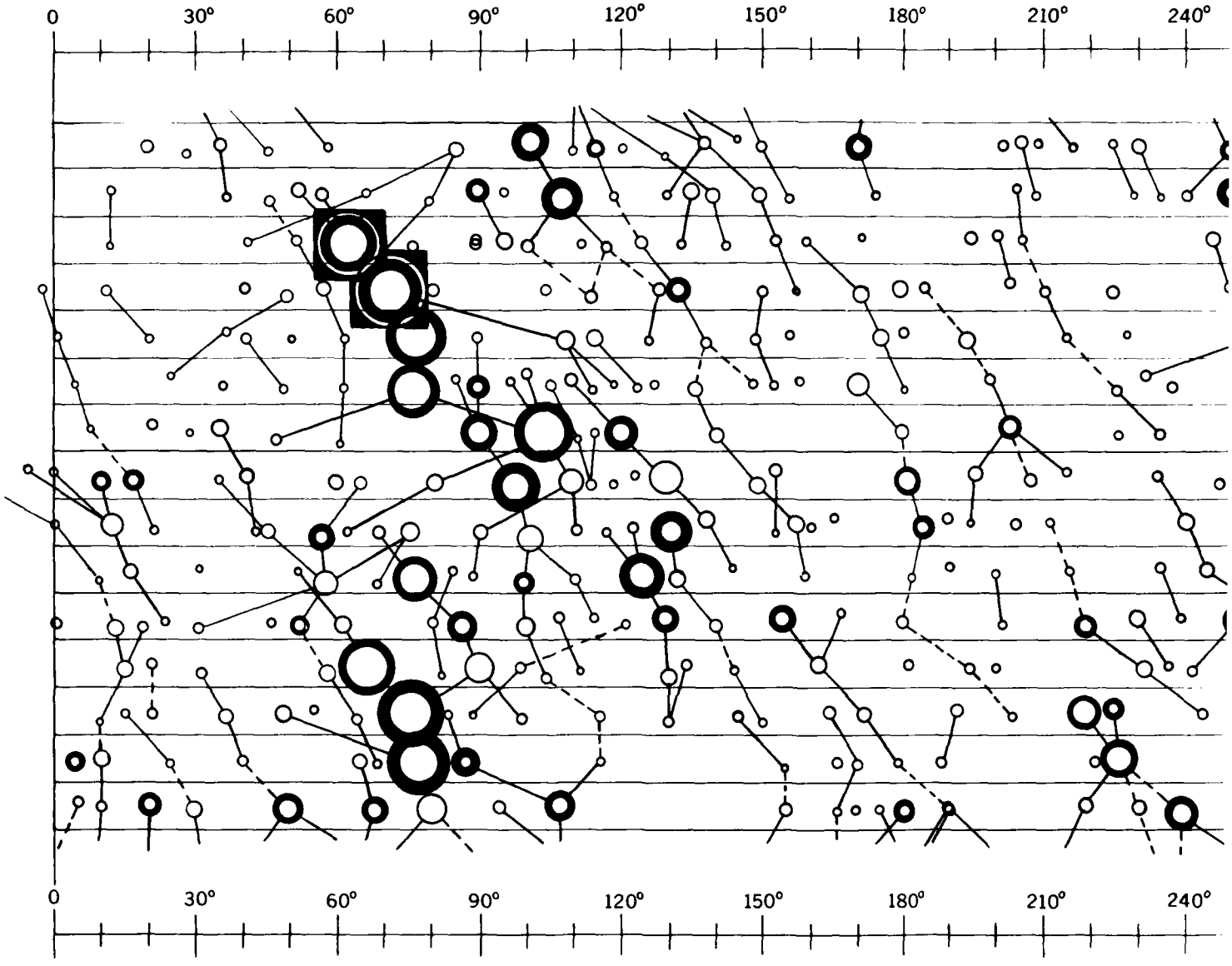
42 Dec 8.1
43 Jan 4.4 1969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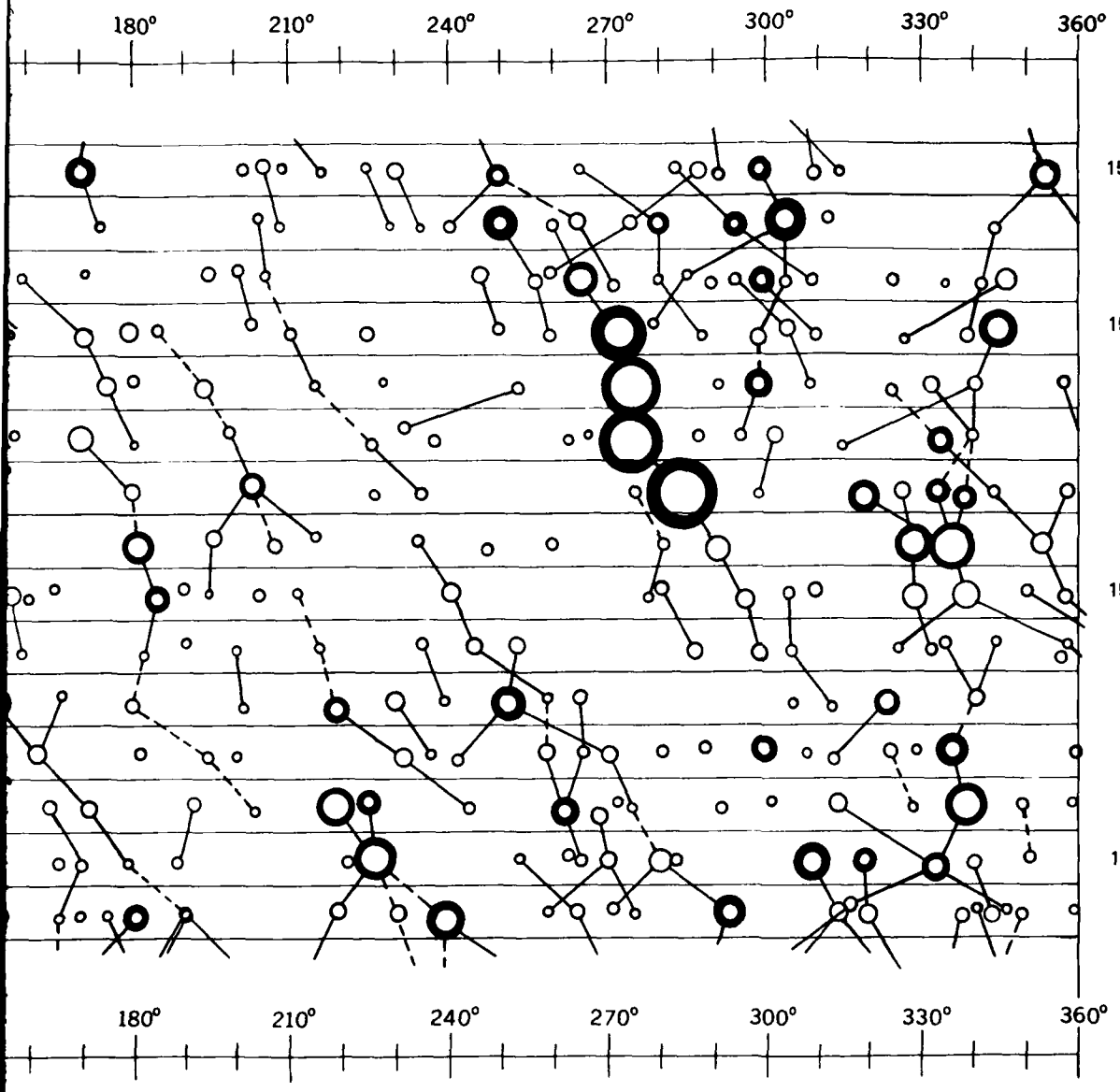
1969 Northern Hemisphere 1969 Southern Hemisphere

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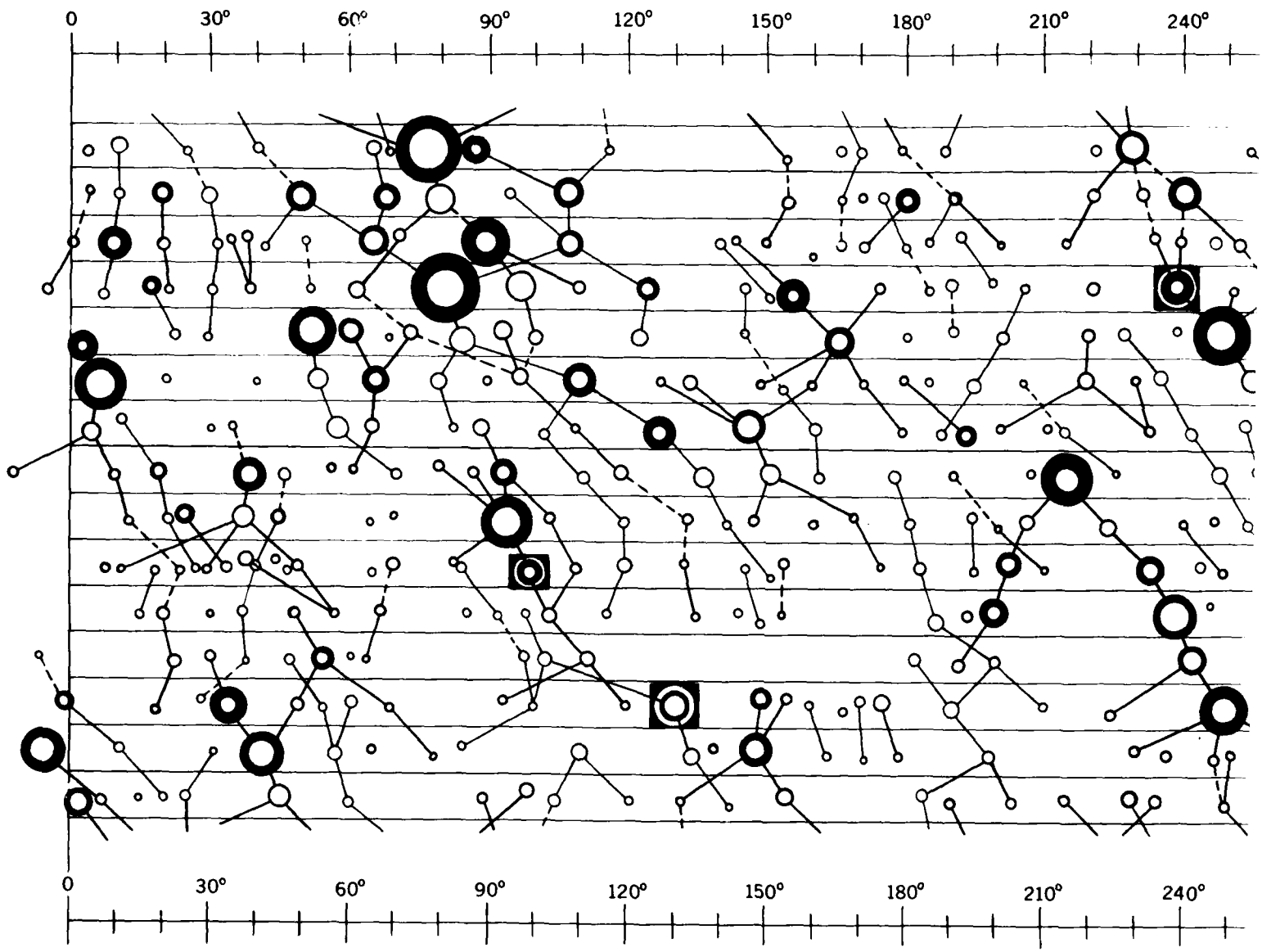
| 46 | Mar | 27.4 | |
| 47 | Apr | 23.7 | |
| 48 | May | 20.9 | |
| 49 | Jun | 17.1 | |
| 1550 | Jul | 14.3 | |
| 51 | Aug | 10.5 | |
| 52 | Sep | 6.7 | |
| 53 | Oct | 4.0 | |
| 54 | Oct | 31.3 | |
| 1555 | Nov | 27.6 | |
| 56 | Dec | 24.9 | |

180° 210° 240° 270° 300° 330° 360°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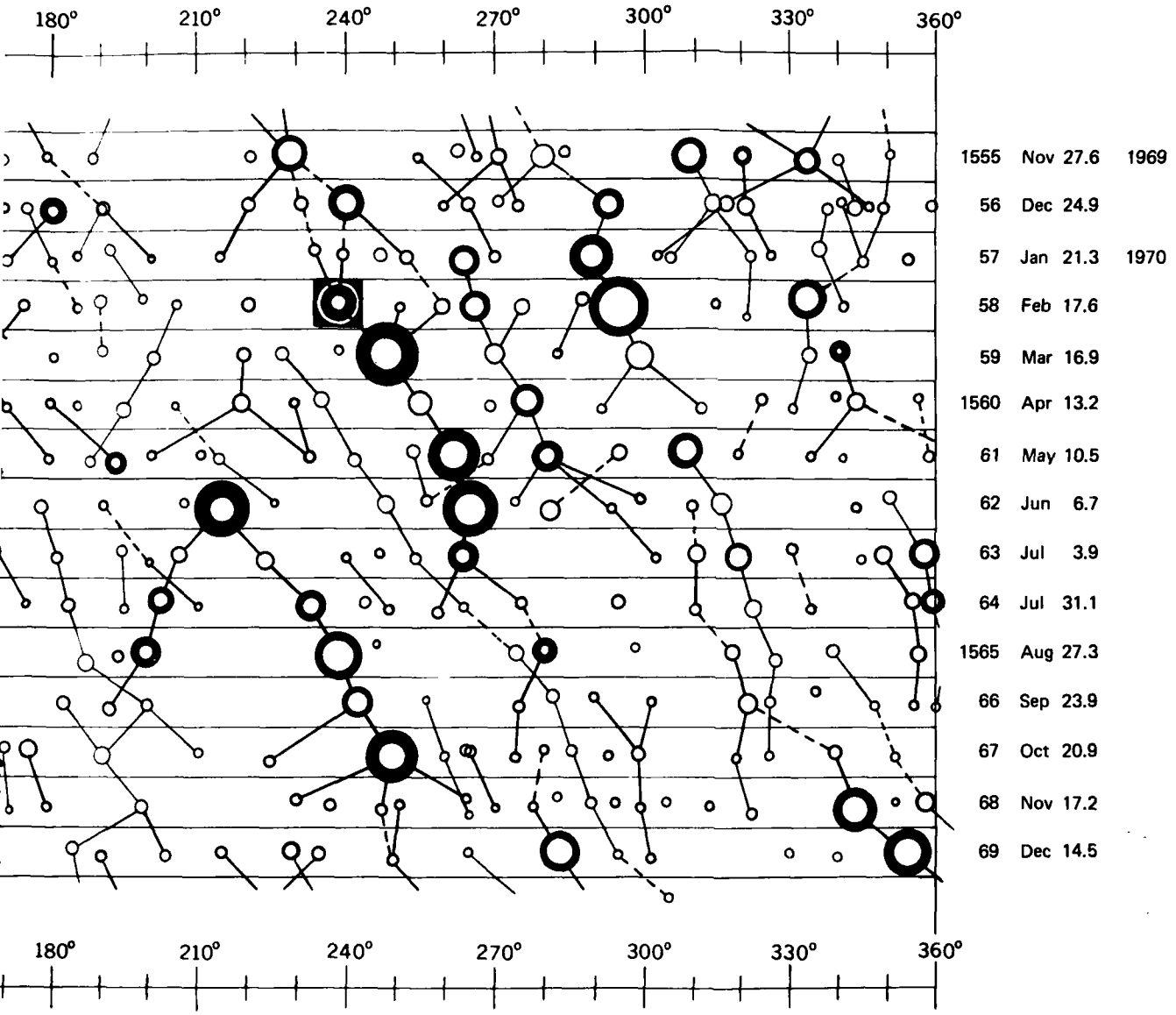
1970 Northern Hemisphere 1970 Southern Hemisphere

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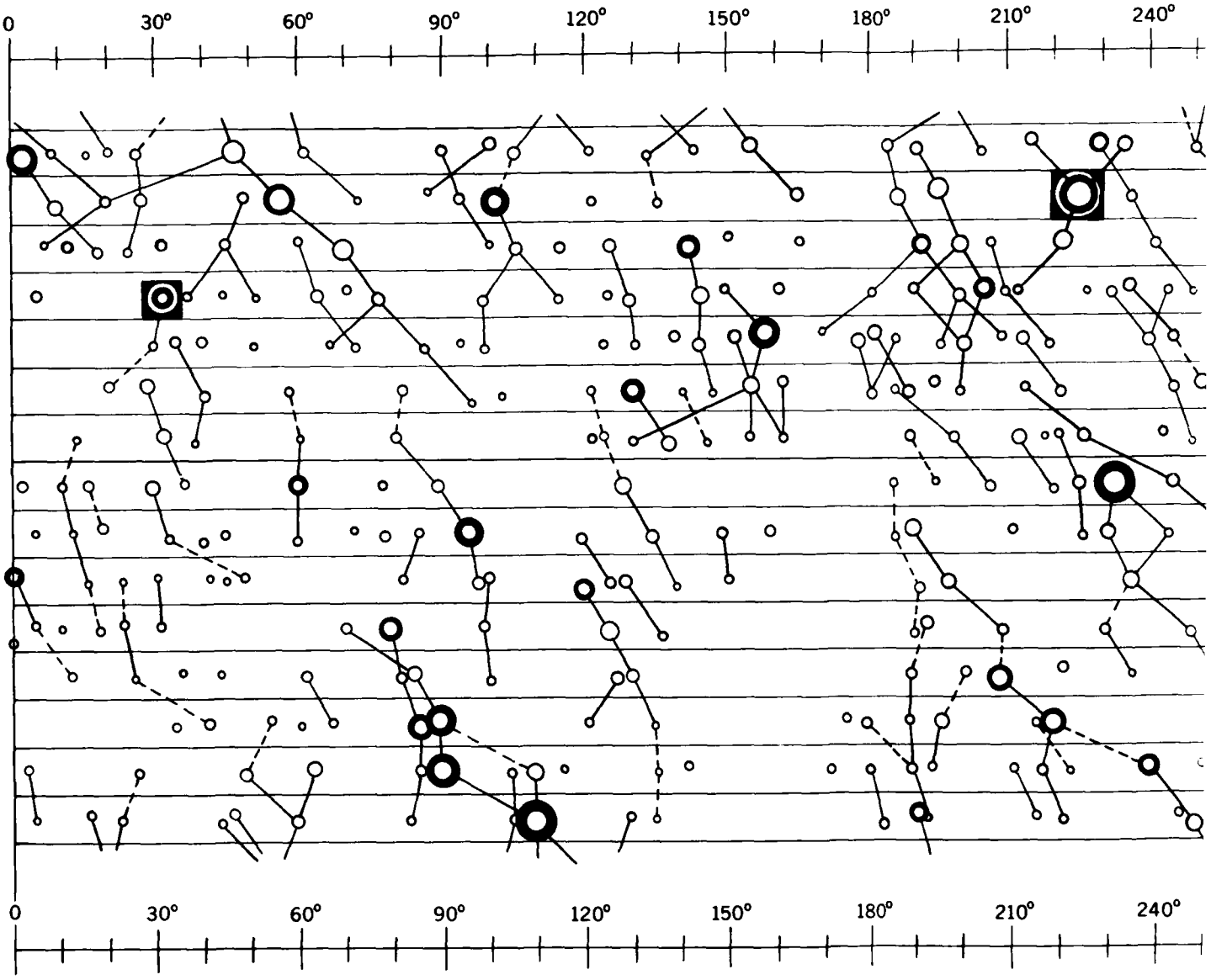
| 57 | Jan | 21.3 | 1970 |
| 58 | Feb | 17.6 | |
| 59 | Mar | 16.9 | |
| 1560 | Apr | 13.2 | |
| 61 | May | 10.5 | |
| 62 | Jun | 6.7 | |
| 63 | Jul | 3.9 | |
| 64 | Jul | 31.1 | |
| 1565 | Aug | 27.3 | |
| 66 | Sep | 23.9 | |
| 67 | Oct | 20.9 | |
| 68 | Nov | 17.2 | |
| 69 | Dec | 14.5 | |

2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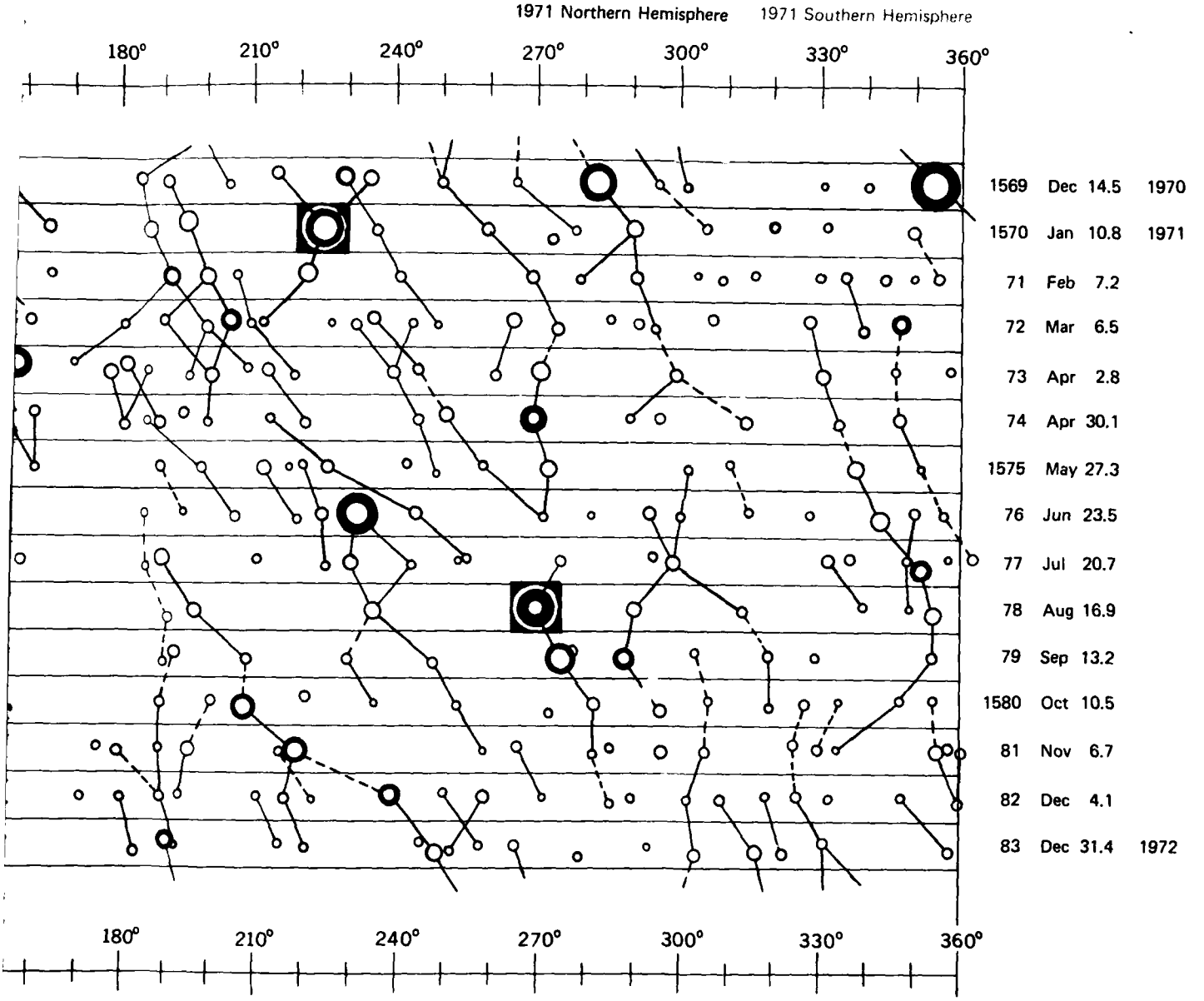
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72 Mar 6.5
73 Apr 2.8
74 Apr 30.1
1575 May 27.3
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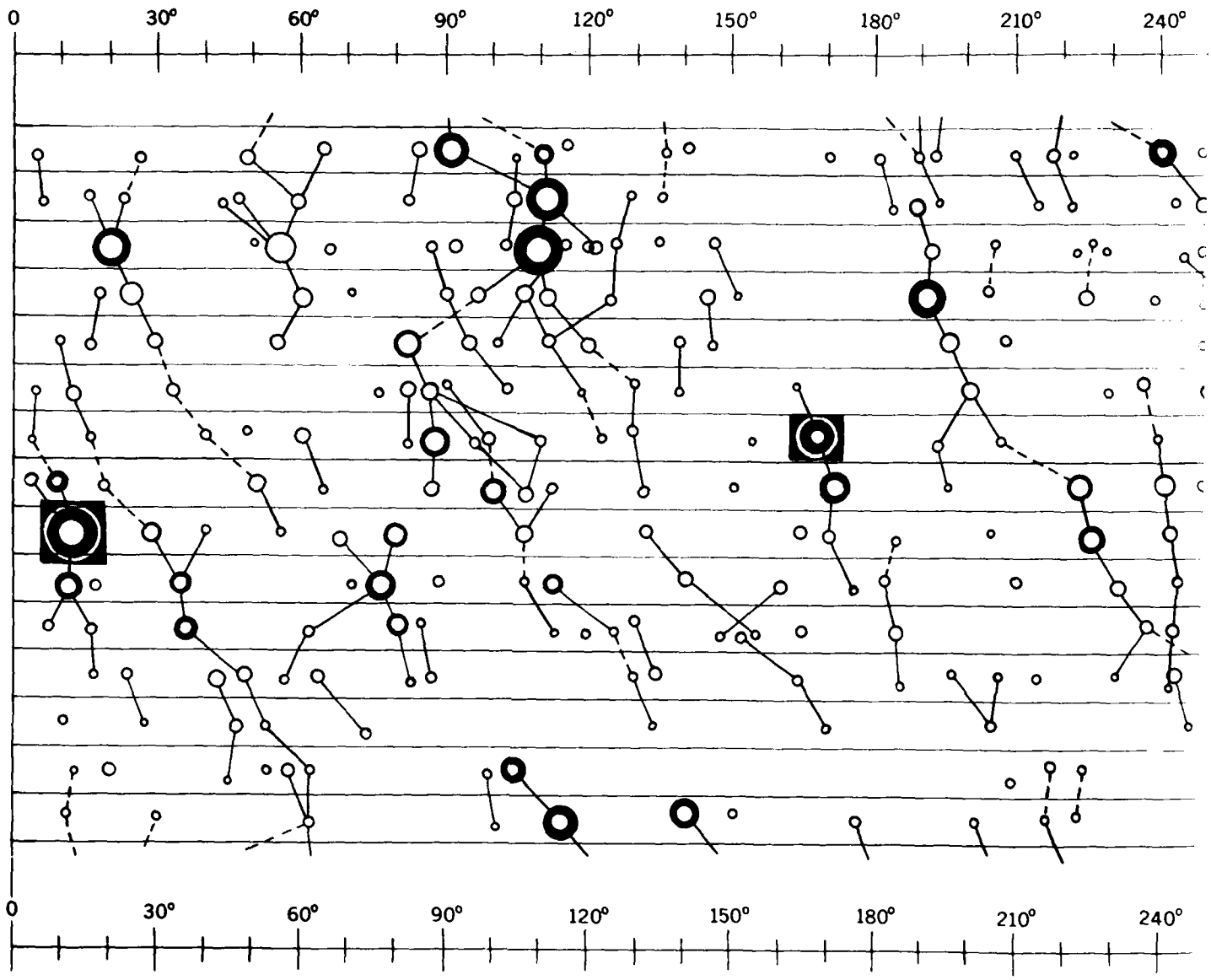
83 Dec 31.4 1972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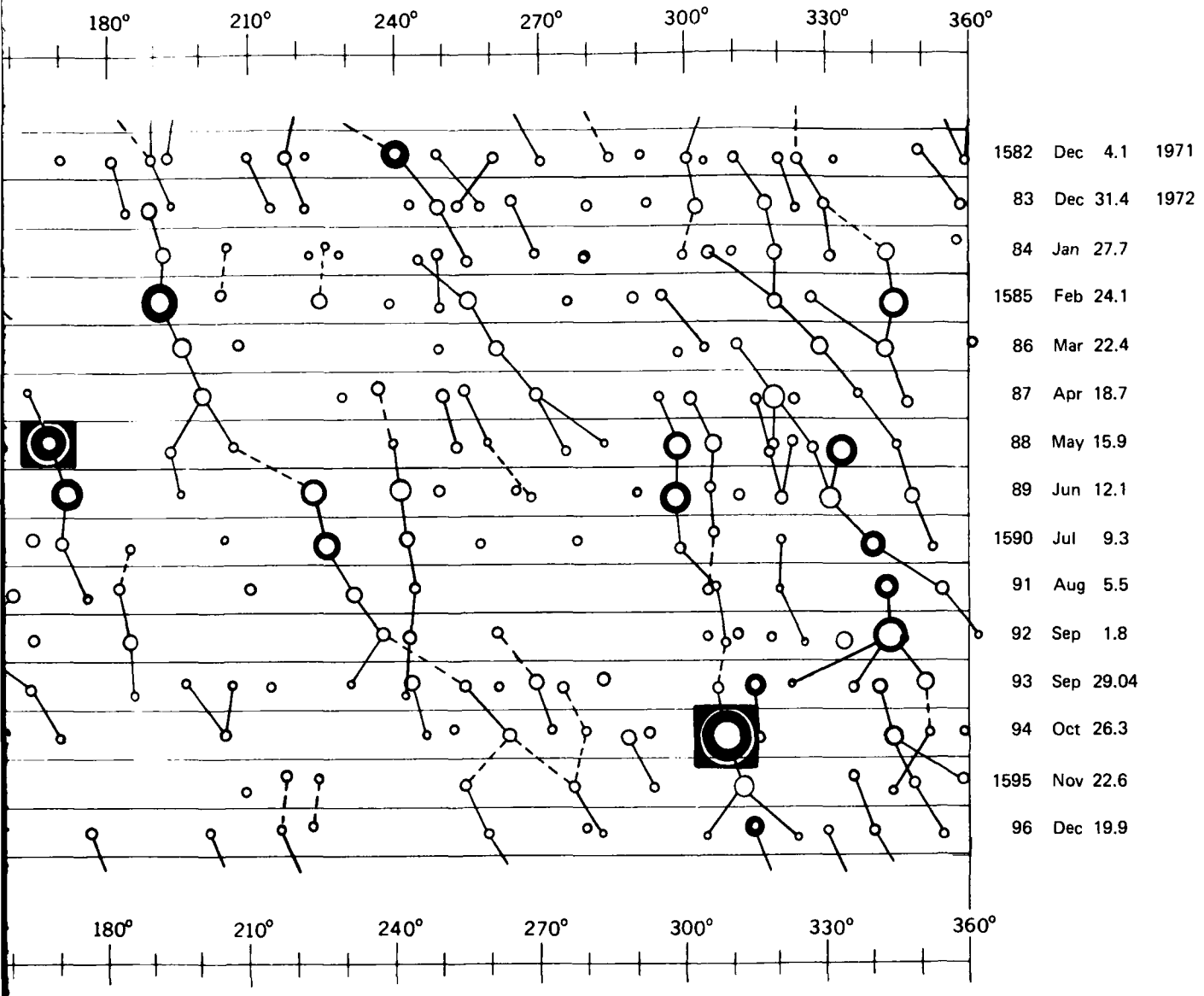
1972 Northern Hemisphere 1972 Southern Hemisphere

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| 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 | |
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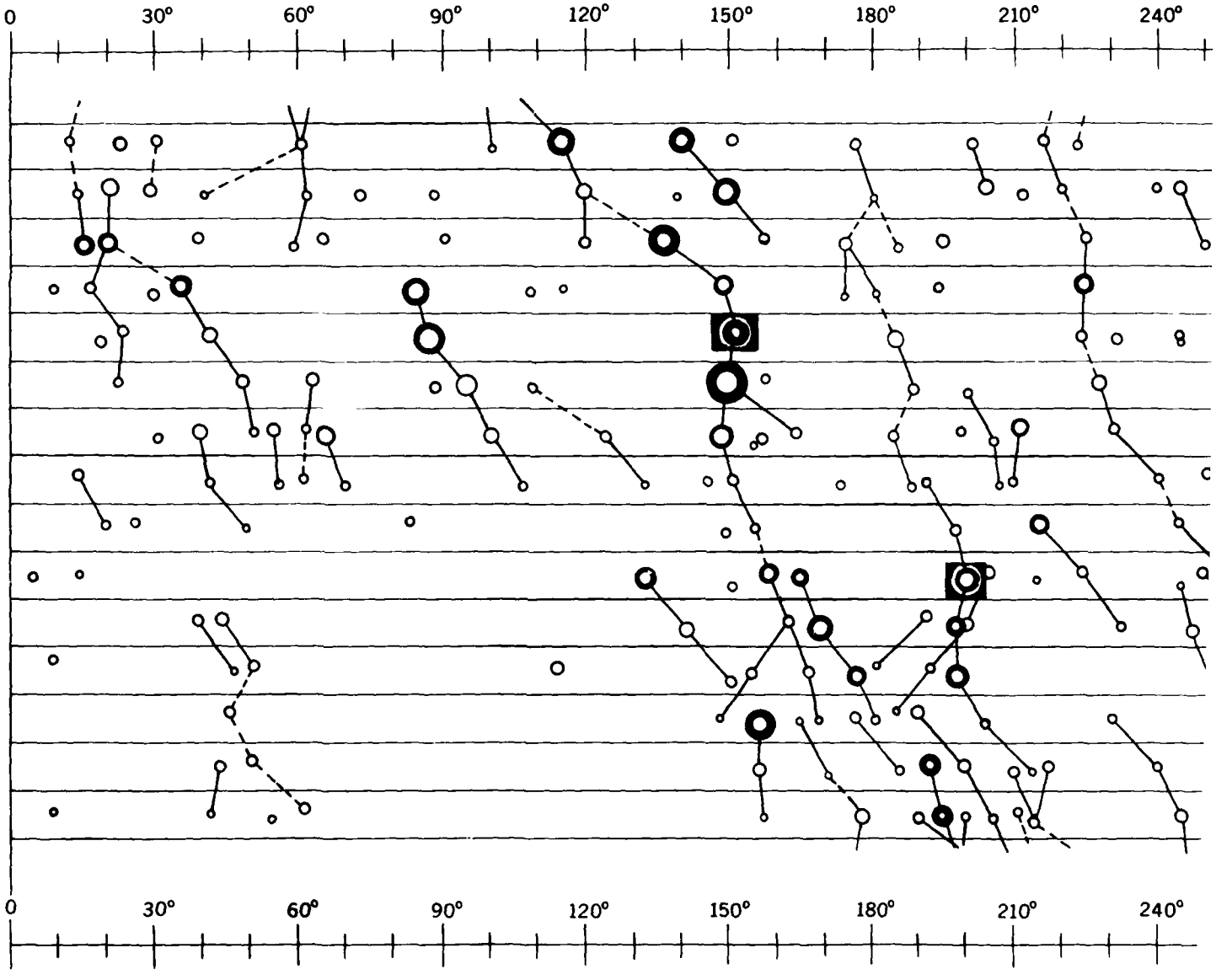
| 1595 | Nov | 22.6 | |
| 96 | Dec | 19.9 | |

2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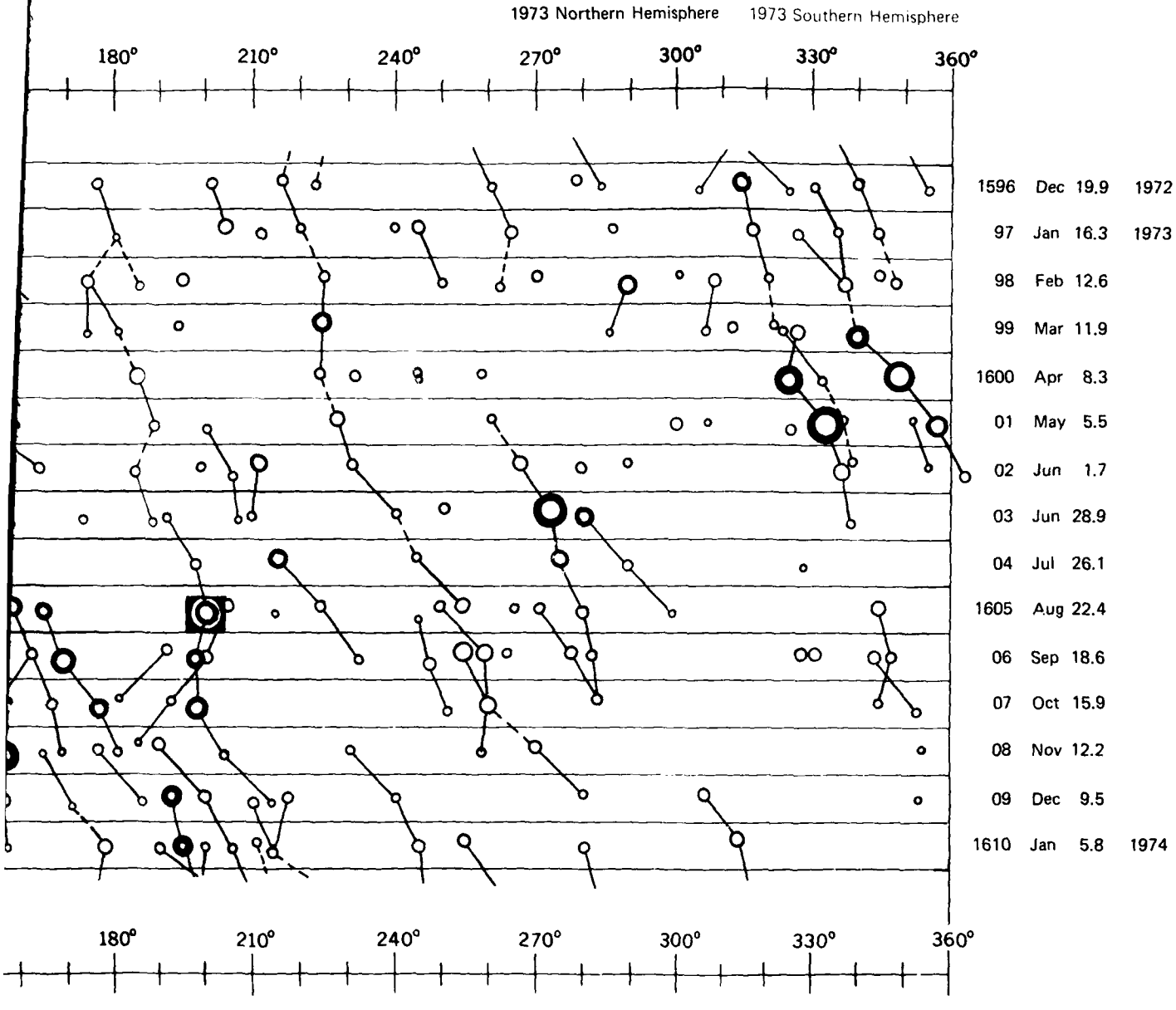
1973 Northern Hemisphere
1973 Southern Hemisphere
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210°
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97 Jan 16.3 1973
98 Feb 12.6
99 Mar 11.9
1600 Apr 8.3
01 May 5.5
02 Jun 1.7
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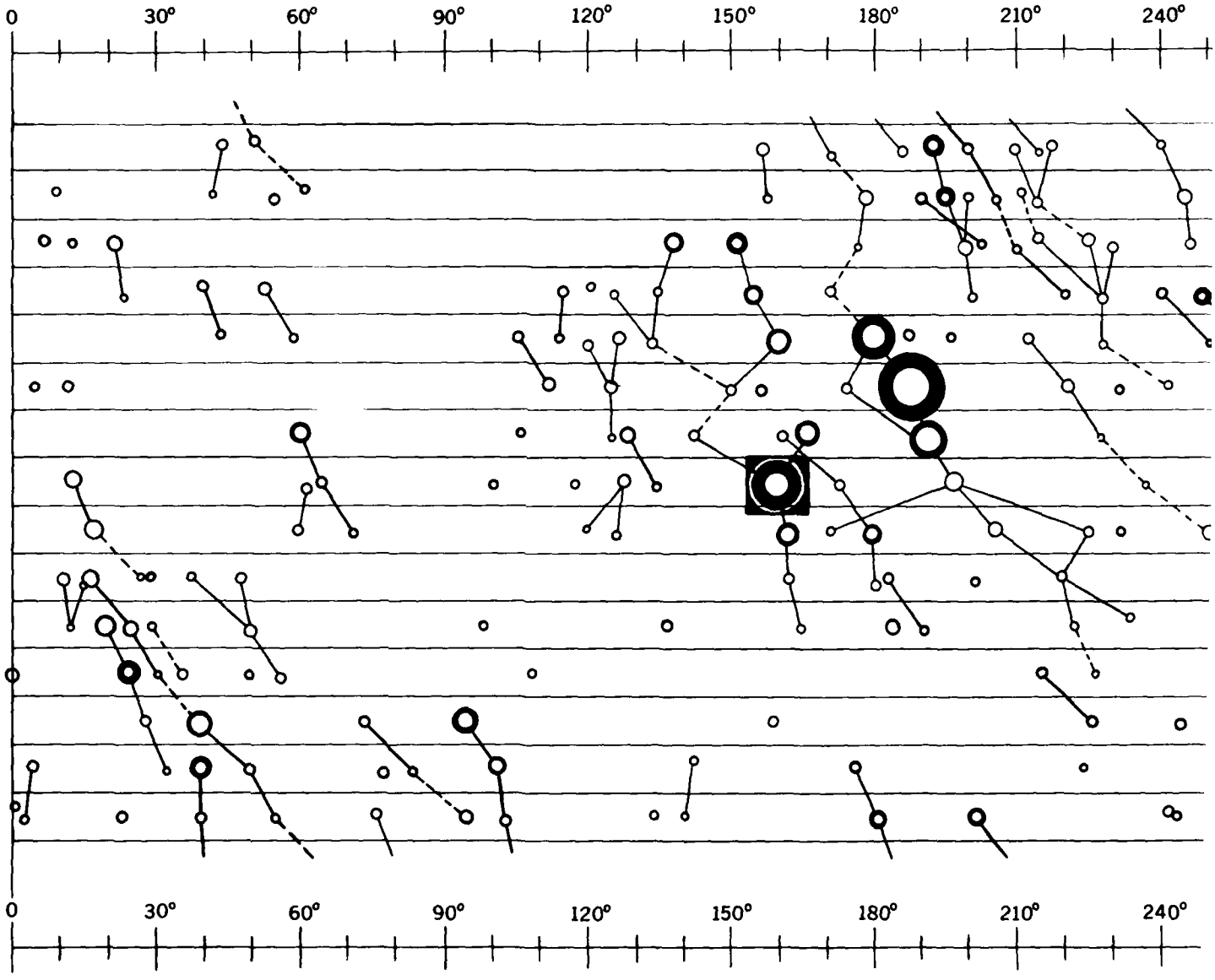
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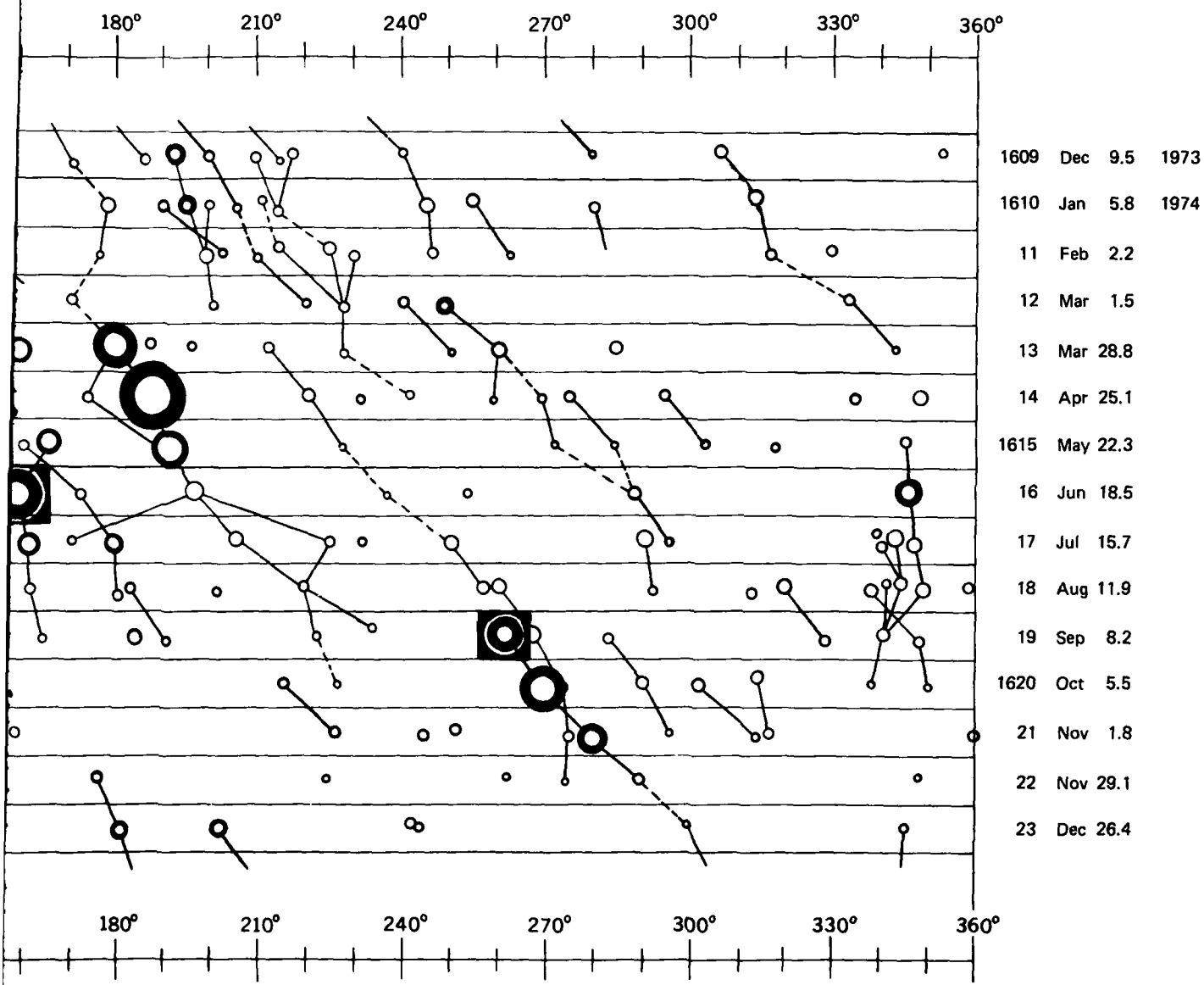
**1974 Northern Hemisphere** 1974 Southern Hemisphere




| | | | |
|---|---|---|---|
| 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 | |
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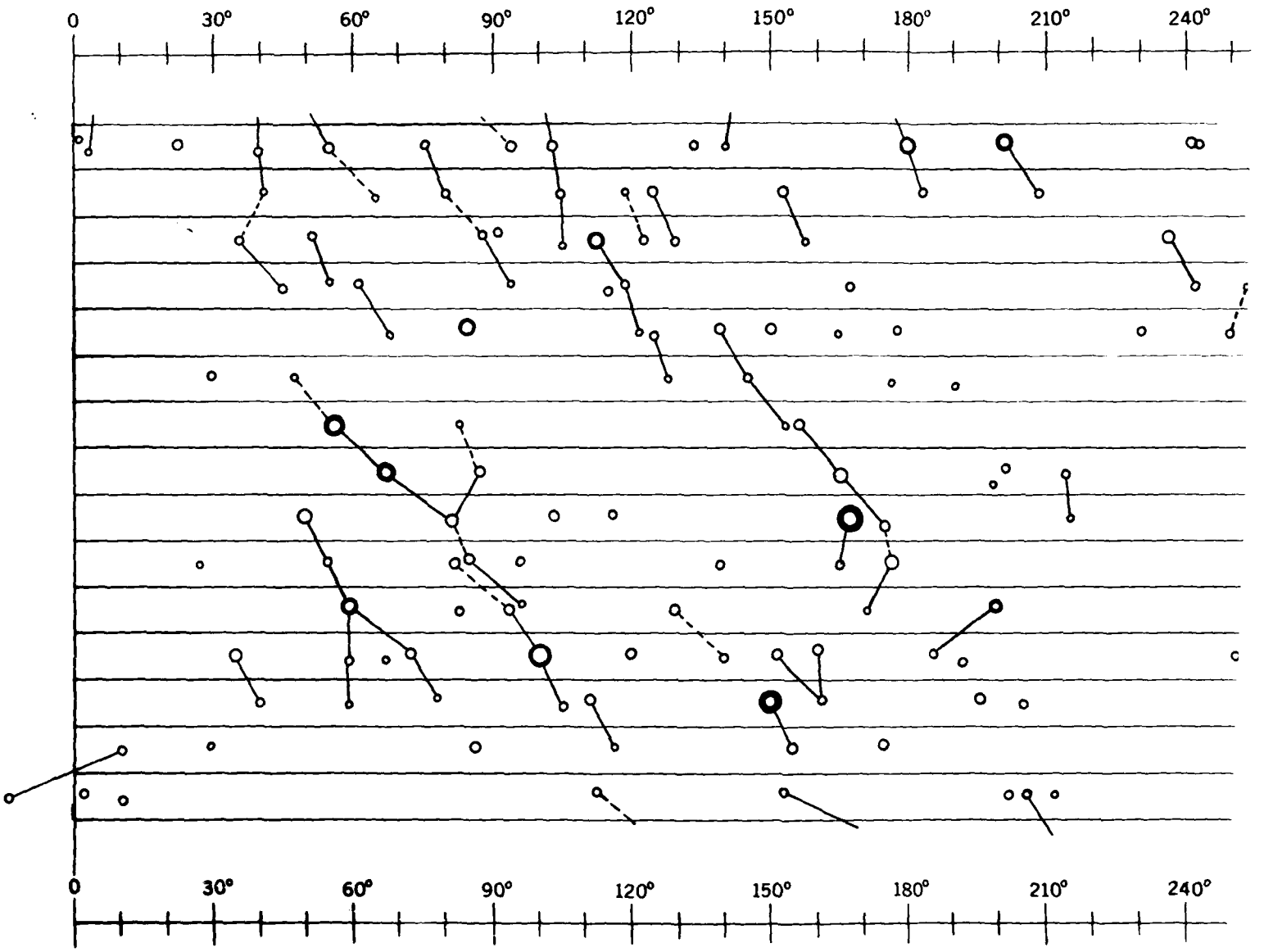
| 22 | Nov | 29.1 | |
| 23 | Dec | 26.4 | |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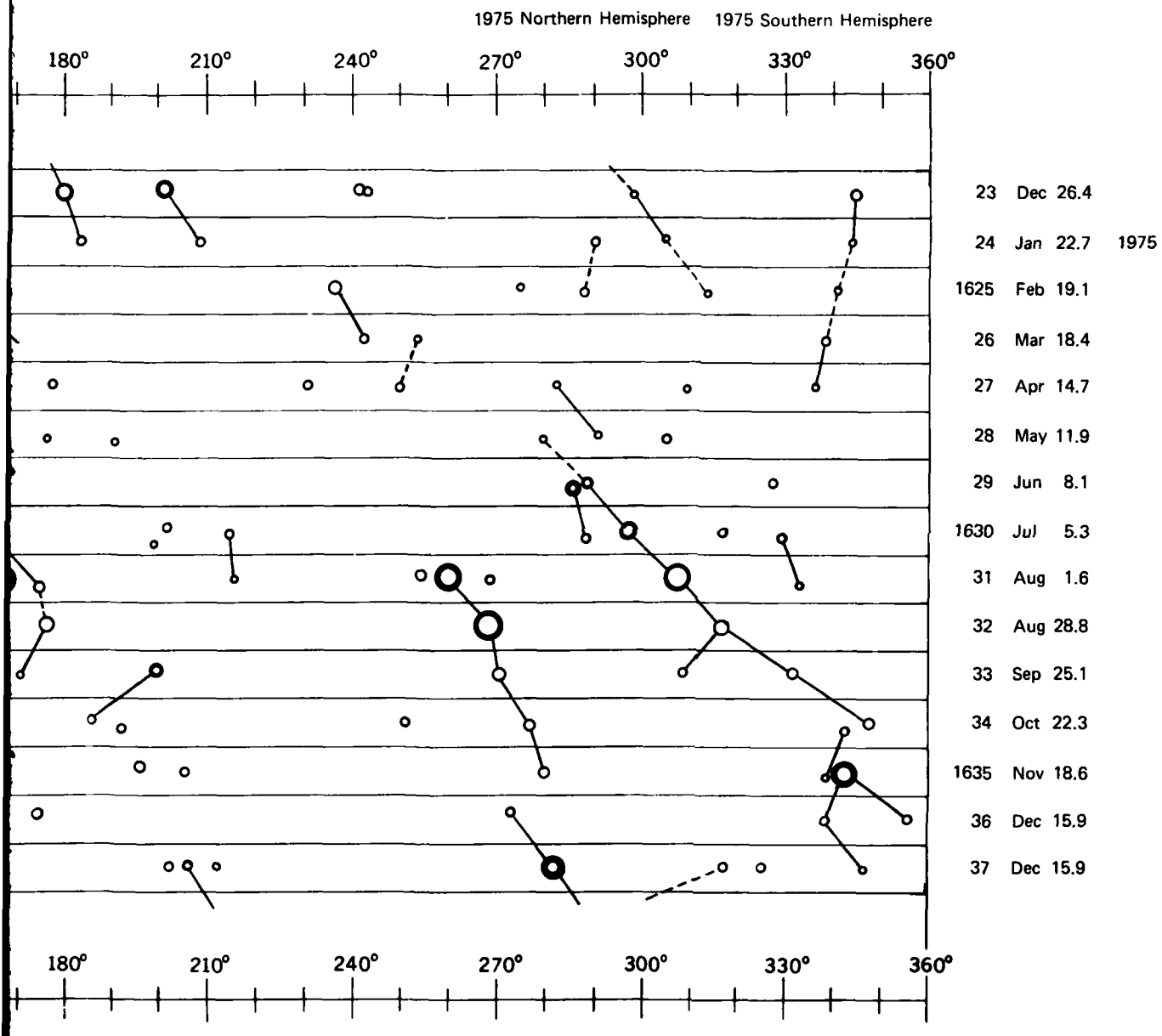
1975 Northern Hemisphere
1975 Southern Hemisphere
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330°
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23 Dec 26.4
24 Jan 22.7 1975
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26 Mar 18.4
27 Apr 14.7
28 May 11.9
29 Jun 8.1
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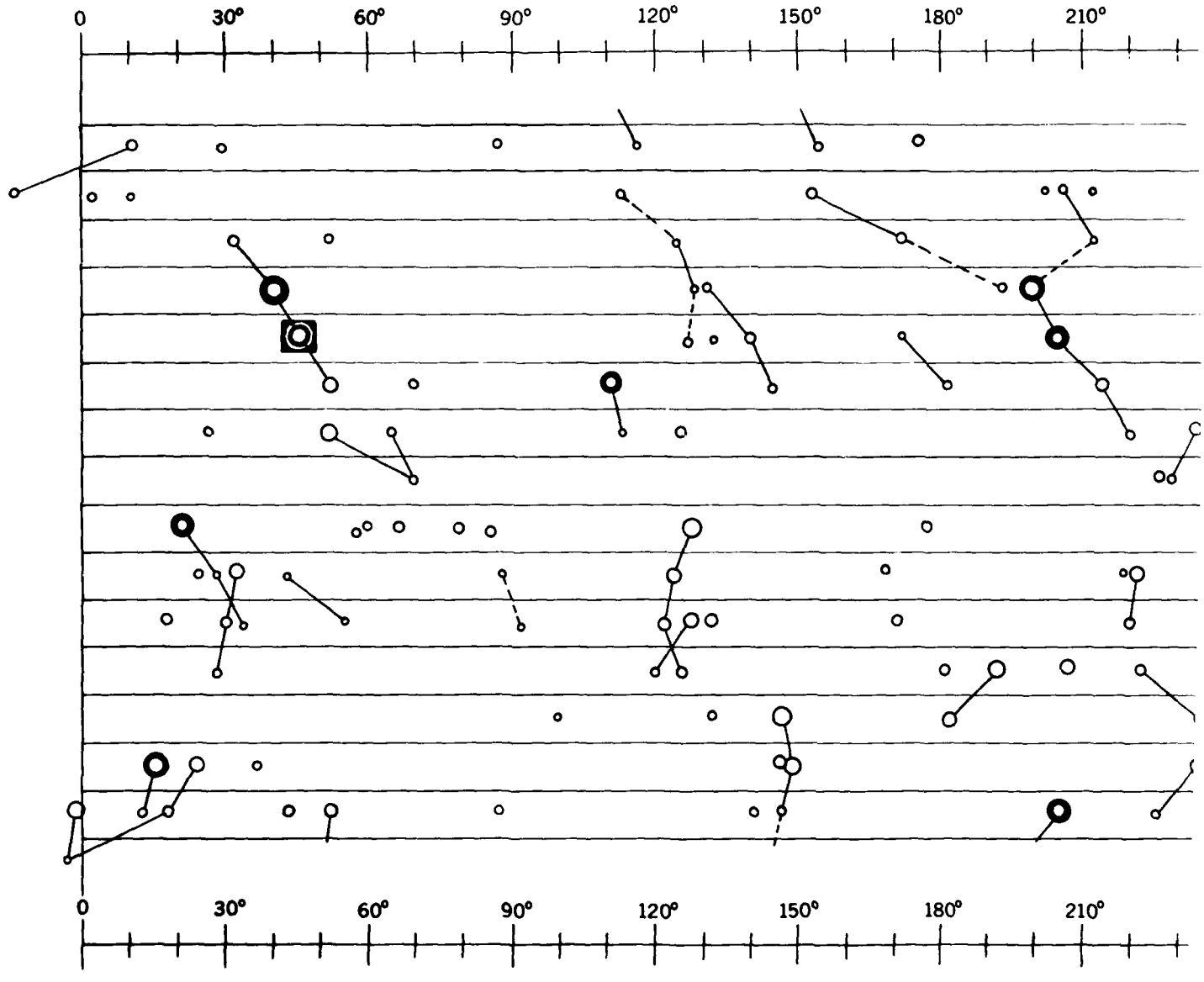
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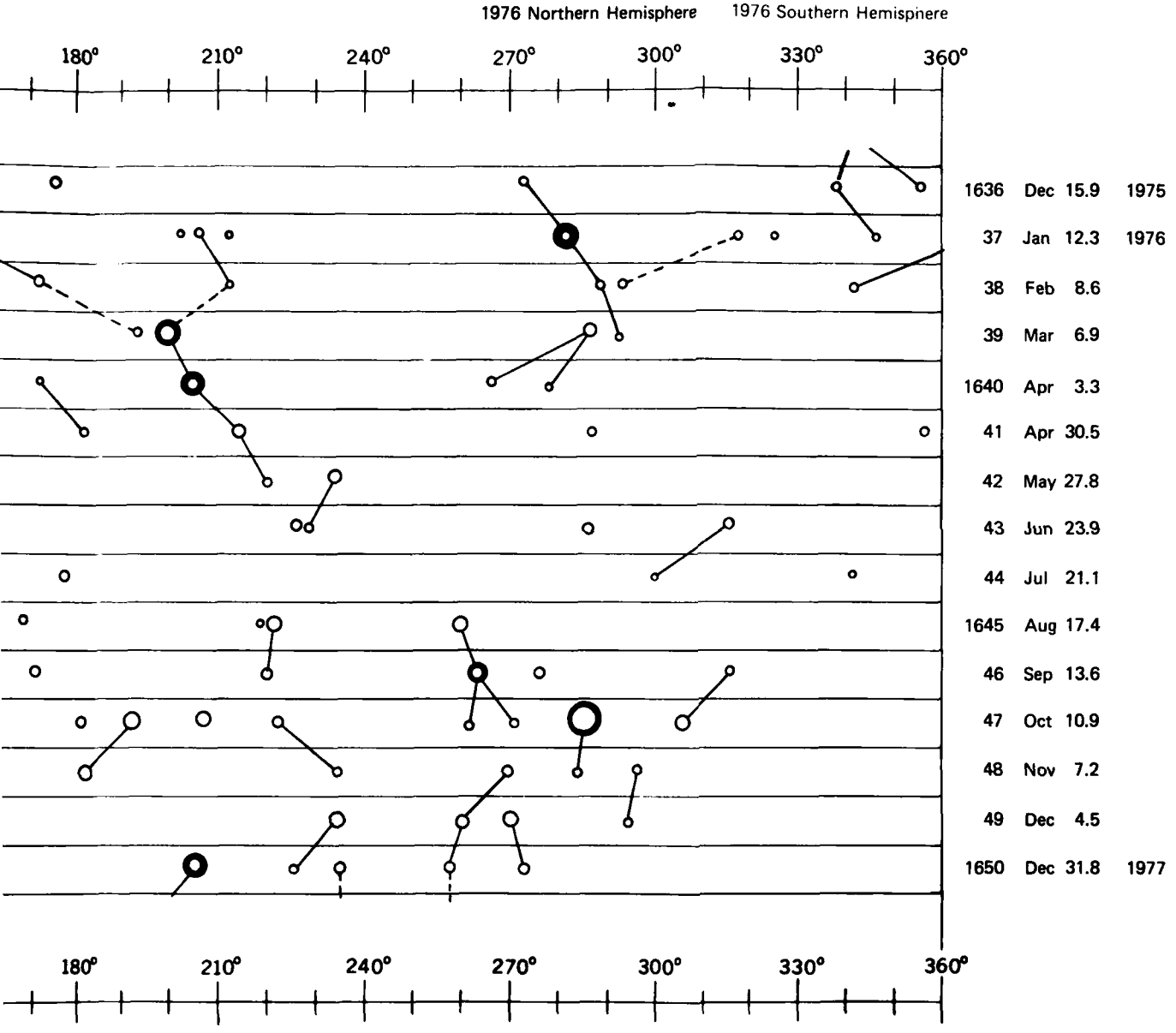
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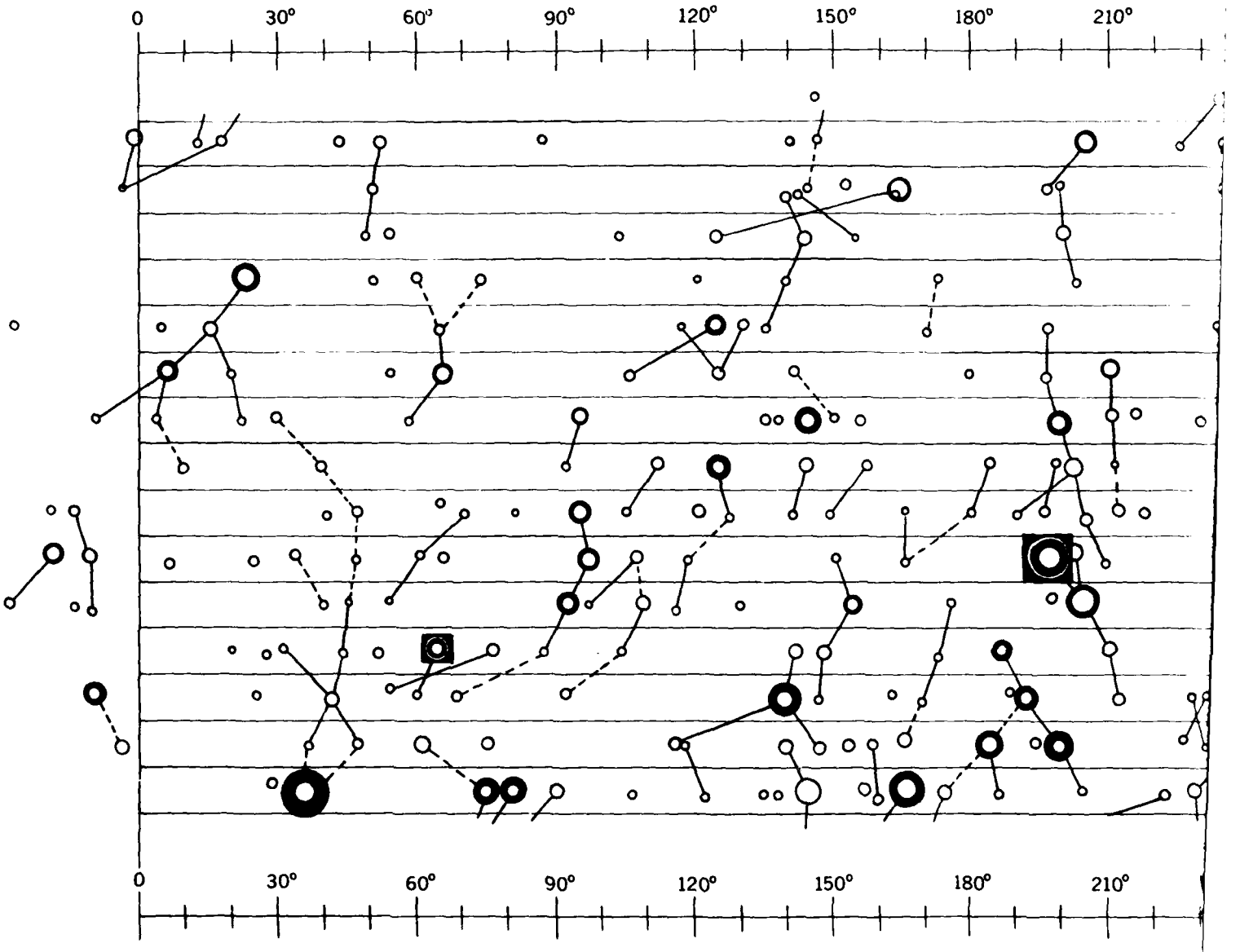
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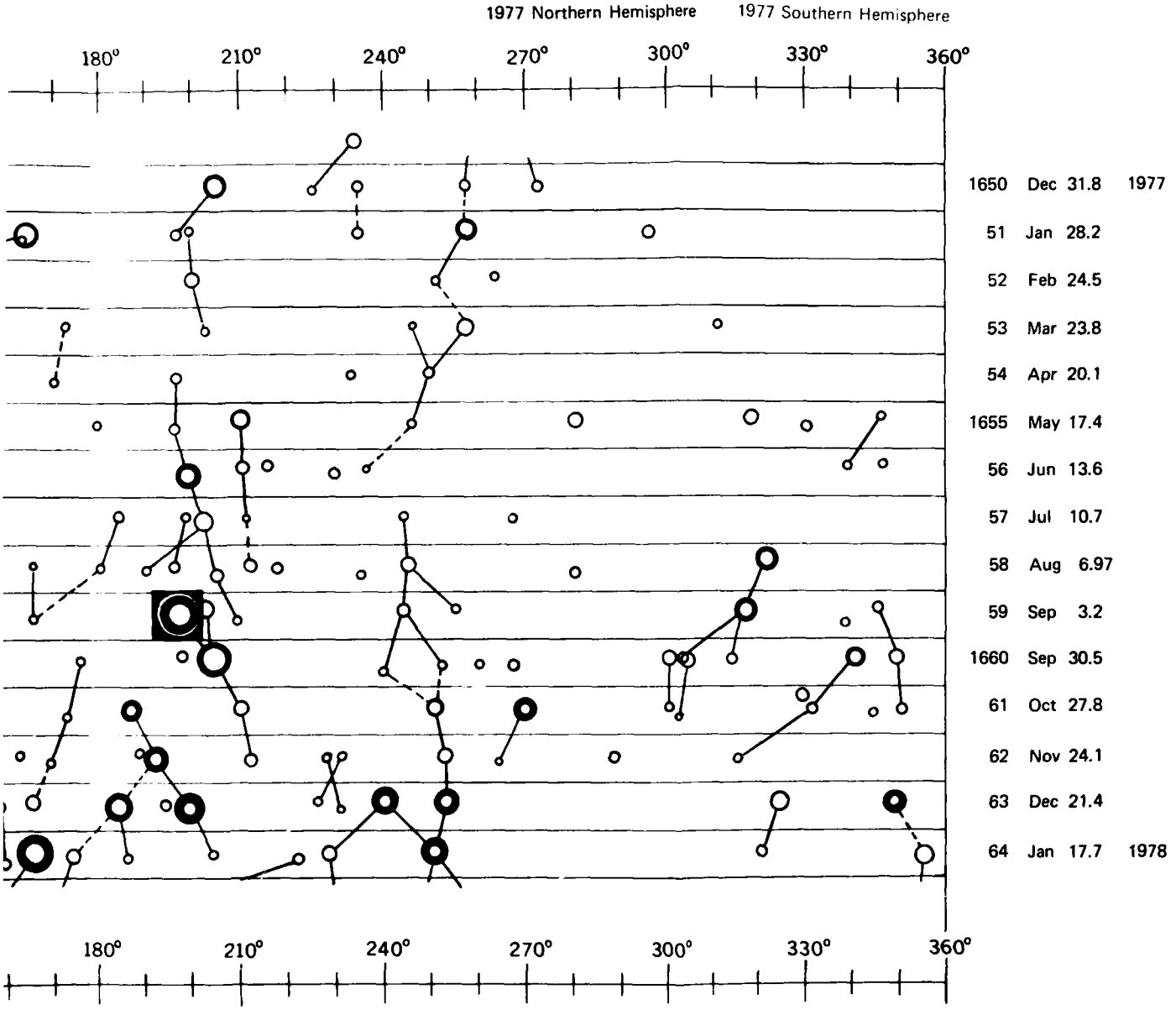
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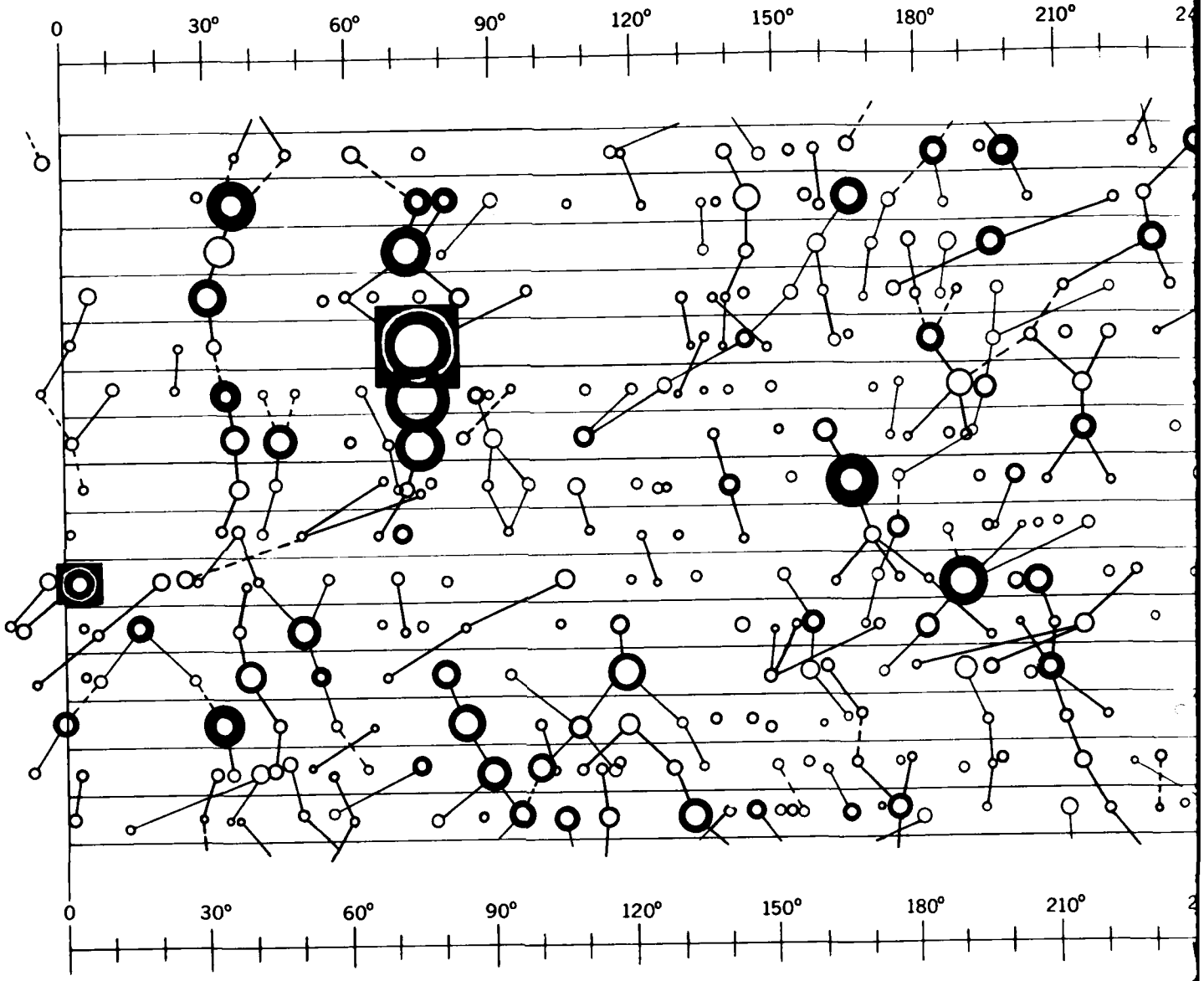
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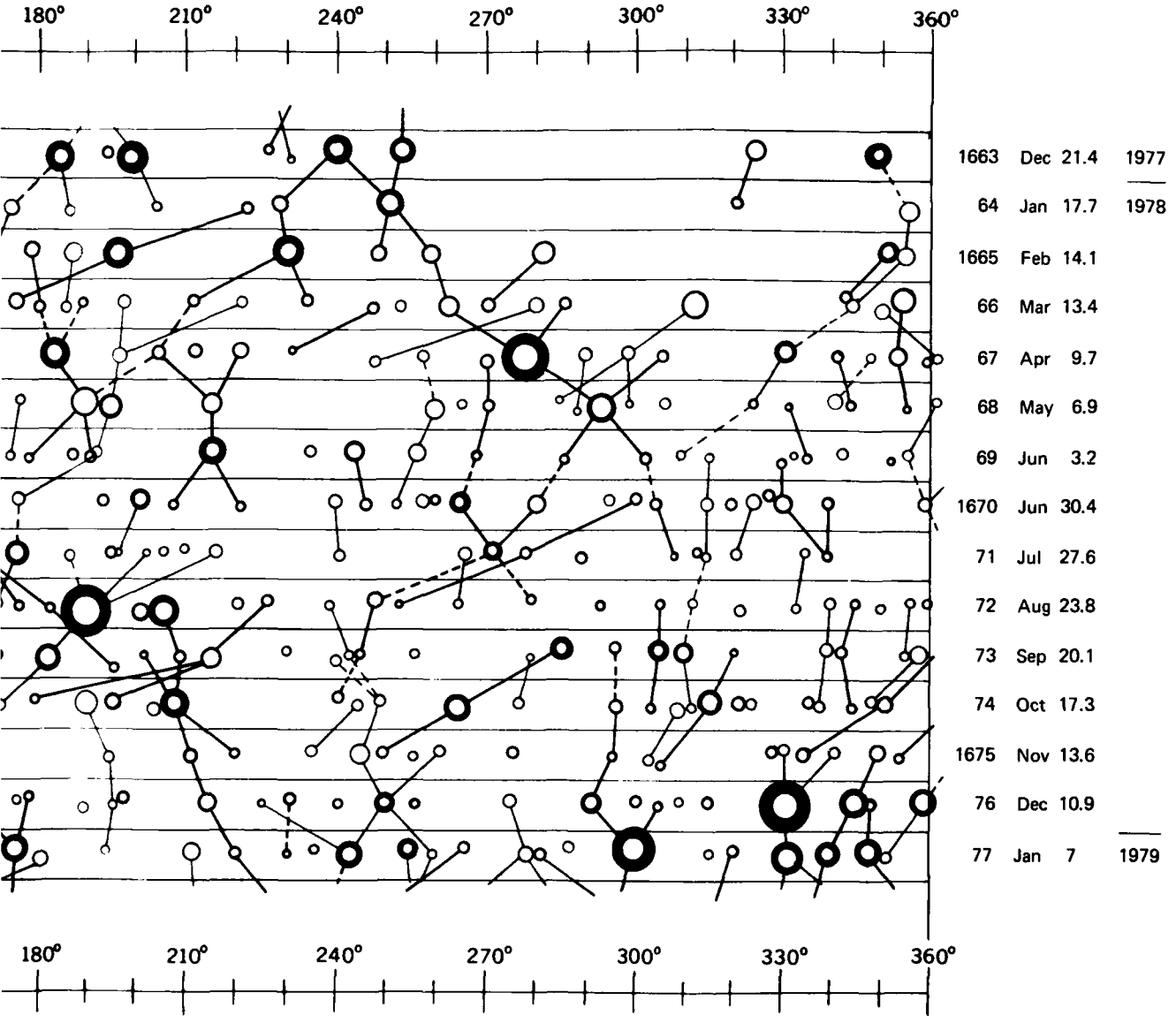
1978 Northern Hemisphere  1978 Southern Hemisphere

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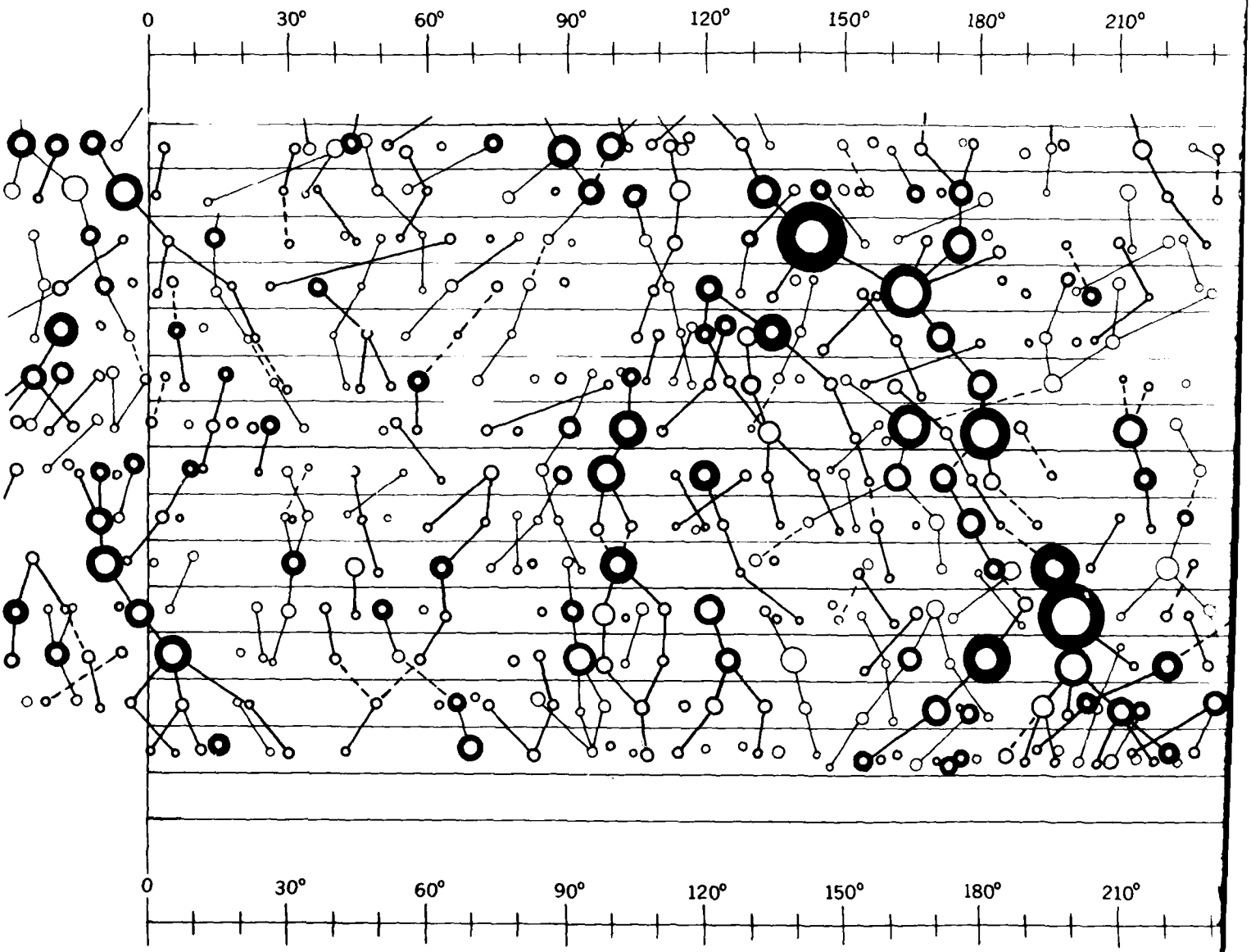
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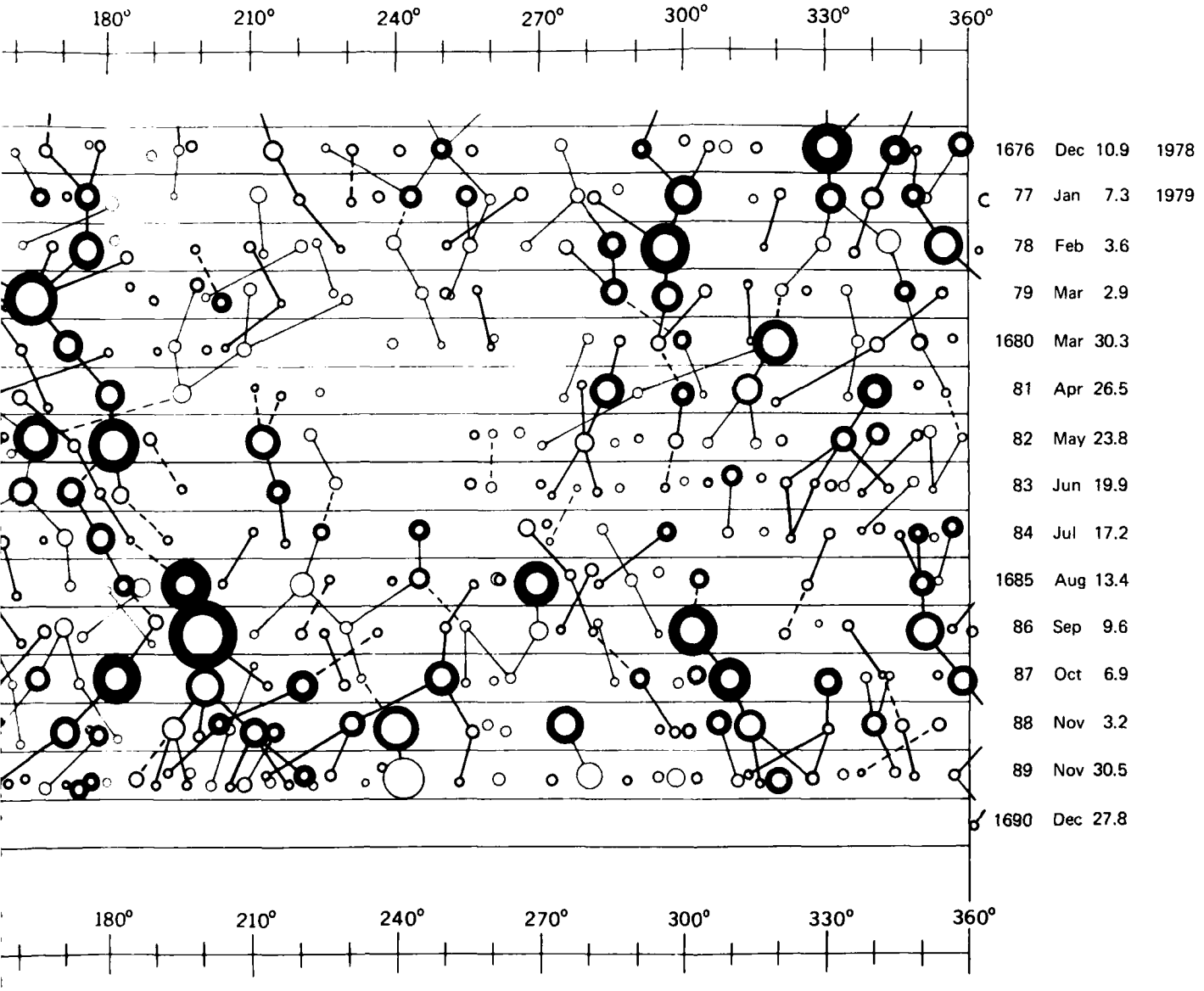


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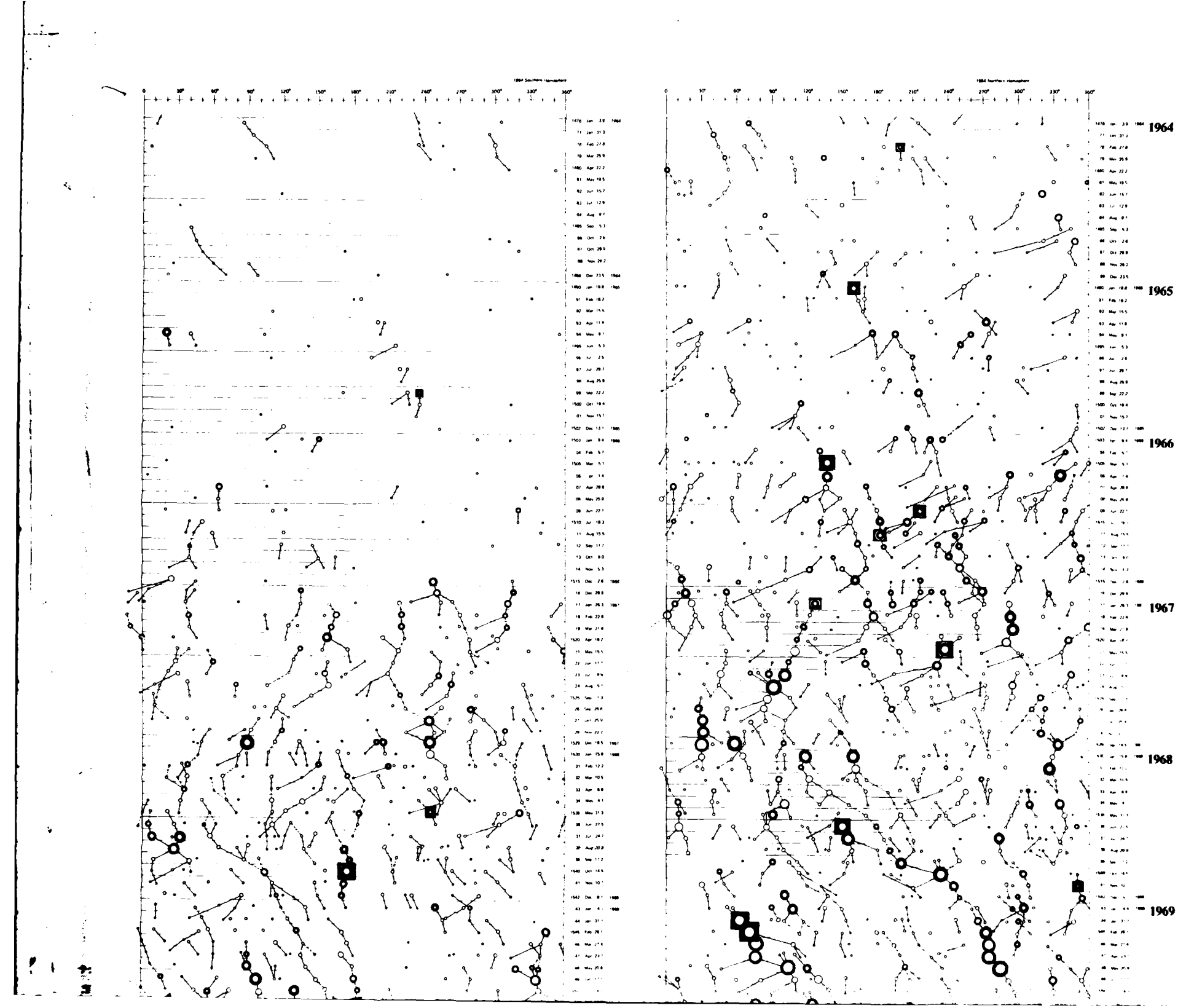
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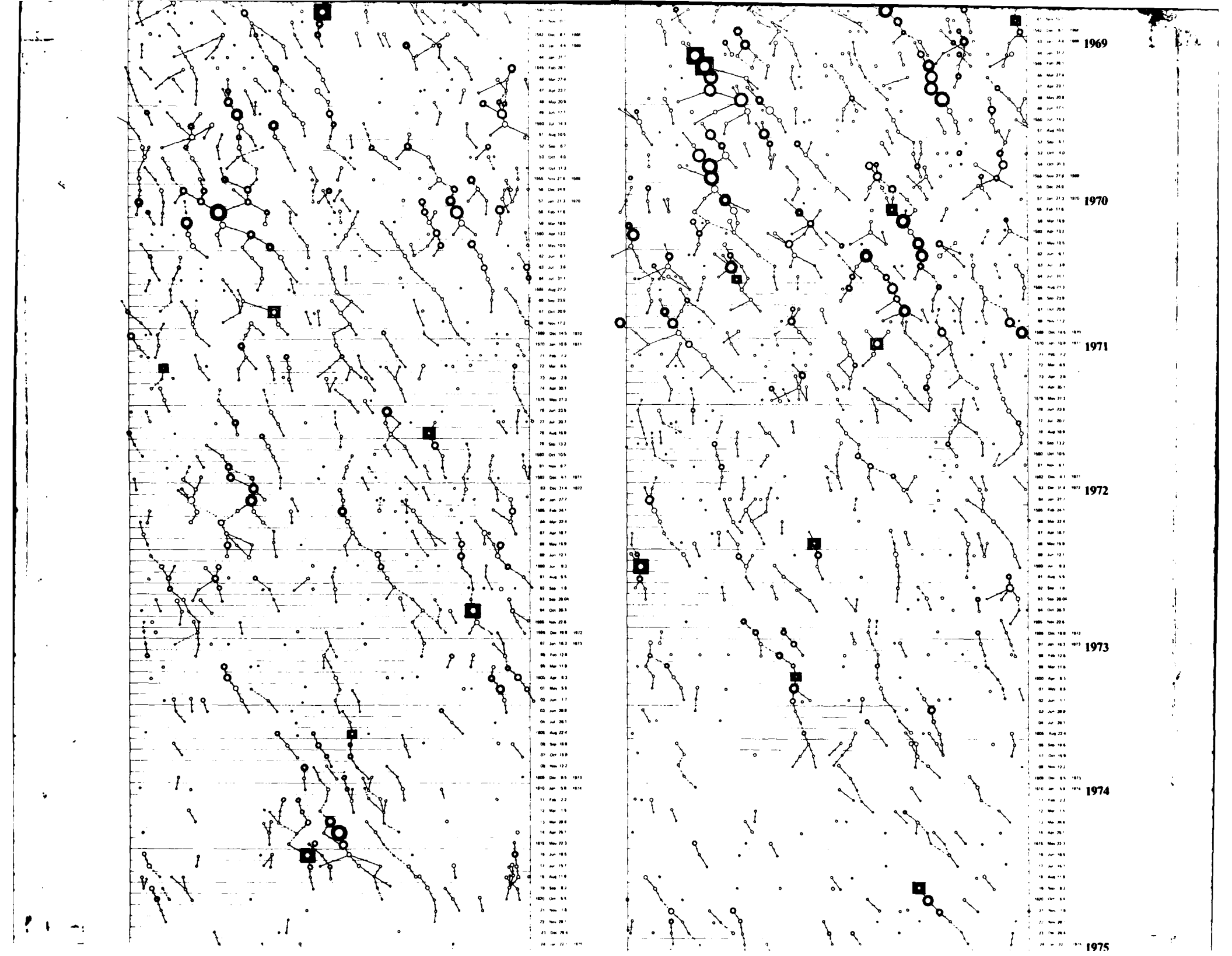
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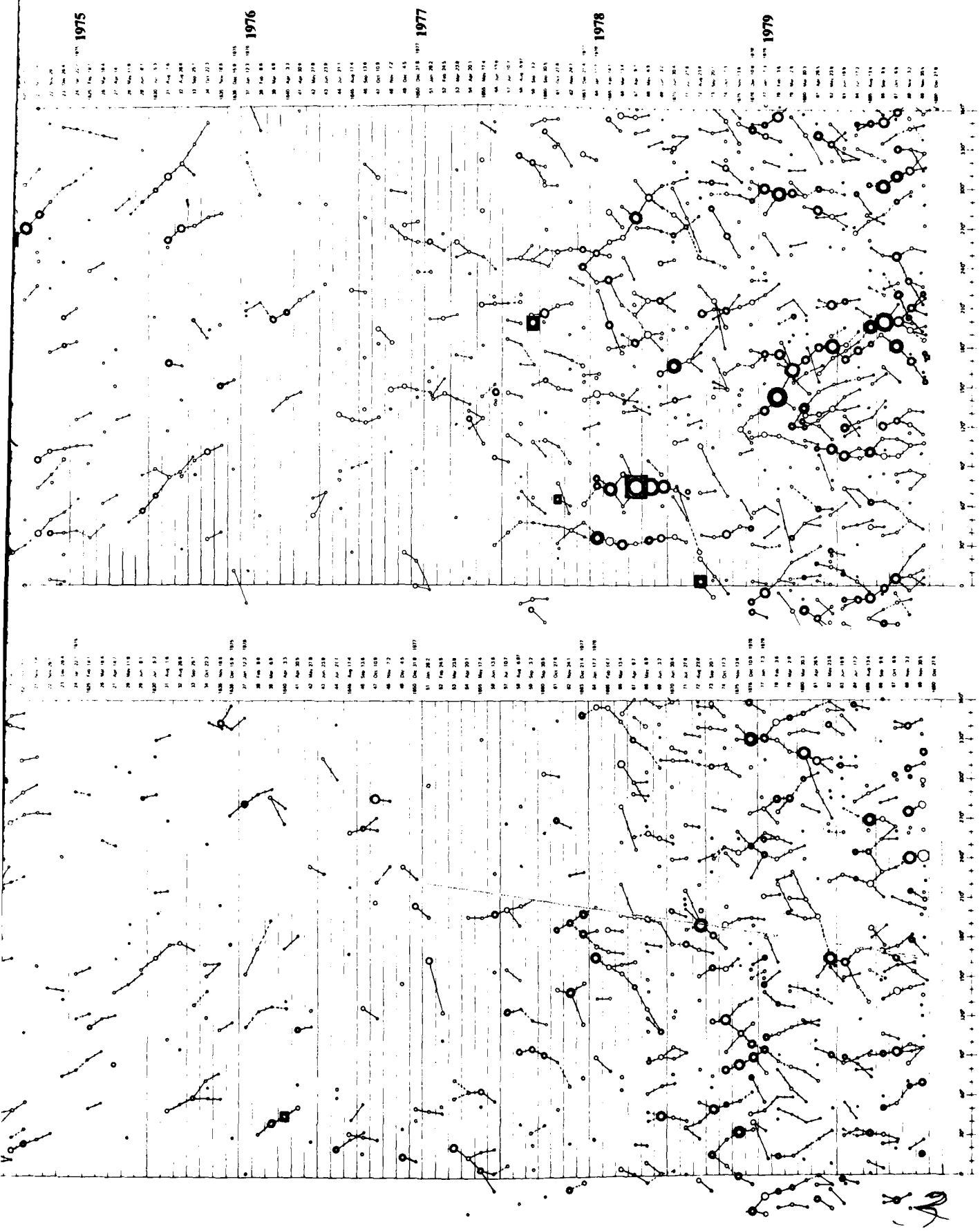
SOLAR CYCLES 20 AND 21 (1964–1979)



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