#487

# JUPITER RADIO EMISSION

DATA CATALOG

GP-11A

Table of Contents



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## 1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP’s).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

***When printing, special settings may be required to make the text box appear on the printed output.***

| Version | Date | Person | Page | Description of Change |
|---|---|---|---|---|
| 01 | | | | |
| 02 | | | | |

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC INFORMATION SYSTEM:

http://nssdc.gsfc.nasa.gov/nmc/

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

a. Associated Documents    To find associated documents you will need to know the document ID number and then click here.
http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/

b. Core Catalog Materials

| REQ. AGENT | RAND NO. | ACQ. AGENT |
|---|---|---|
| DEW | | WSC |
| DHG | | |

# JUPITER RADIO EMISSION DATA CATALOG

## GP-11A

This data set consists of one tape. The tape is 1600 bpi, 9 track, with two files. The first file is binary, and the second is an ASCII version of the first. The data are not time ordered, but are ordered by frequency. The ´D´ and ´C´ number and time span follow:

| D# | C# | FILES | TIME SPAN |
|---|---|---|---|
| D-40295 | C-21035 | 2 | 04/19/61 - 11/06/71 |

JUPITER RADIO EMISSION DATA CATALOG GP-11A
ASCII VERSION (file 2 of tape)

The blocksize is 4930, and the logical record length is 58 (or a blocking factor of 85 logical records per block). The last record is short, with a blocksize of 1624 (28 logical records). The format is as follows:

| Word No. | Format | Word |
|---|---|---|
| 1 | I6 | DATE |
| 2 | I5 | JULIAN DATE |
| 3 | I4 | BEGINNING TIME |
| 4 | I4 | ENDING TIME |
| 5 | A1 | STATION CODE LETTER |
| 6 | I3 | FREQUENCY |
| 7 | I3 | LISTING OR ACTIVITY CODE |
| 8 | F8.3 | INITIAL CENTRAL MERIDIAN LONGITUDE |
| 9 | F8.3 | FINAL CENTRAL MERIDIAN LONGITUDE |
| 10 | F8.3 | INITIAL GEOCENTRIC PHASE OF IO |
| 11 | F8.3 | FINAL GEOCENTRIC PHASE OF IO |

Refer to page 18 of the documentation for a more complete description of the values. Note, words 5 and 6 in the documentation were switched.

NASA

Technical Memorandum 80308

# A Catalog of Jovian Decameter Radio Observations from 1957 - 1978

J. R. Thieman

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National Aeronautics and
Space Administration

**Goddard Space Flight Center**
Greenbelt, Maryland 20771

TM 80308

# A CATALOG OF JOVIAN DECAMETER-WAVE RADIO OBSERVATIONS FROM 1957-1978

James R. Thieman*

Laboratory for Extraterrestrial Physics

NASA/Goddard Space Flight Center

Greenbelt, Maryland 20771

*NAS/NRC Resident Research Associate

# Abstract

A catalog of over 200,000 hours of observation of Jupiter radio emission in the decameter-wavelength band has been created on magnetic tape and is available upon request. The data have been collected from 13 observing sites which are part of synoptic monitoring programs started by the Universities of Florida and Texas and the Goddard Space Flight Center. Observations were made at 14 fixed frequencies from 5 to 30 MHz. The characteristics of the tape recording technique and the data format are described. The combination of overlapping data from observing sites scattered world-wide lessens the effect of the earth's daily interruption of the ground-received signal. A power spectral analysis of the data shows no evidence of periodicities within the data other than the well-known influences of Jupiter, Io, and the earth. The dependence of the occurrence probability of emission on System III longitude and the phase of Io varies smoothly with frequency down to 15 MHz and then appears quite different at 10 MHz. The morphology of the radio sources is both complex and stable for periods of at least months and probably much longer.

## Introduction

Ever since the discovery by Burke and Franklin in 1955 (reference 1) of decameter-wavelength Jovian radio emissions regular observations of Jupiter have been conducted in the 5-30 MHz radio band. This publication describes a data catalog, available on magnetic tape, merging three large sets of fixed-frequency observations from the Universities of Florida and Texas and the Goddard Space Flight Center. The Texas and Goddard data have been published previously (references 2 through 7), but the present catalog represents the first convenient access to the Florida data as well as a valuable combination of over 200,000 hours of observation at 14 frequencies in a common format.

A large data base is important since Jupiter emission occurs only sporadically. Despite over two decades of effort the many facets of the Jovian decameter emission (often called DAM) defy a comprehensive explanation. DAM, however, exhibits periodicities on time scales from milliseconds to years and a complete picture of the phenomena has been difficult to obtain even in the 24 years since discovery. Not only is the emission itself intermittent, but the ground-based observations are usually limited to the nighttime hours when the ionosphere becomes quiescent, decreasing terrestrial interference with the planetary signal. Similarly, solar interference prevents data acquisition near the time of Jovian conjunction with the sun.

To combat these problems several groups established synoptic monitoring programs involving widely-scattered observing sites, thus increasing the chances of favorable observing conditions. As we shall see, even these groups miss a large portion of the emission. For a clearer understanding of the emission process a combination of the results of these various groups is valuable. This publication describes such a merged data base and some of the basic uses of it. It is hoped that others will find this catalog useful in the intensified research on DAM which has been stimulated by the Voyager mission (references 8 and 9). The data are available on magnetic tape and can be provided on request.

The next section presents a brief overview of the three synoptic monitoring programs which have provided the data for this catalog. This is followed by a listing of the particulars of the tape containing the combined data. The final section reports the results of some of the fundamental analyses which can be performed with the data.

## Synoptic Monitoring Programs

As mentioned above, the Universities of Florida and Texas, and Goddard Space Flight Center have served as collection points for the majority of fixed-frequency data taken during the past twenty years. Figure 1 displays the locations of the observing sites participating in these programs, identified by a code letter which is interpreted in Table I. The University of Colorado is absent from the list although it is noted for extensive observations of Jupiter at decameter wavelengths using a swept-frequency spectrograph. These records are important for overall studies of Jovian dynamic spectra, but a determination of Jovian emission behavior at individual frequencies is difficult to extract from their catalog. A summary of these data are to be found in Warwick et al. (reference 10).

The University of Florida began its regular observation program in 1957 at a frequency of 18 MHz. Since that time other data have been acquired at a number of frequencies (see Table II). The Maipu Radioastronomical Observatory in Chile was established in cooperation with Florida in 1960 and this added to the observations at 10, 15, 18, 20, 22, and 27 MHz while also inaugurating the frequencies of 5, 13, and 16 MHz. For a short period from 1964-66 a second observing site at Huanta, Chile contributed to the 10 and 18 MHz data. A description of the equipment and the method of data reduction can be found in H. I. Register's Ph.D. dissertation (reference 11).

A synoptic monitoring program was begun by Yale University in 1957 and in subsequent years observations were carried out at 10, 16, 20, 22, and 23 MHz. A site established at Kodaikanal, India contributed data from 1962-67 at 22 MHz. In 1967 the Yale program was moved to the University of Texas, and the frequencies of 19 and 23 MHz were discontinued, but valuable observations at 30 MHz, nearer the upper cutoff of Jupiter's DAM emission, began. The results as incorporated in the present data base are tabulated and described in greater detail in the catalog published by the University of Texas (reference 7).

A group at Goddard Space Flight Center, with the help of the

University of Texas, began the GSFC Jupiter Monitor Network in 1965. The only frequencies studied were 16.7 and 22 MHz, but the equipment was located at NASA Spacecraft Tracking and Data Network (STDN) stations scattered throughout the world with the intention of continuing observations around the clock. The difficulty of maintaining the equipment and the shutdown and relocation of many of the sites allowed this goal to be realized only for short periods. Nevertheless, the network has provided extensive records of Jupiter activity.

It should be noted that the Texas and GSFC/JMN data were obtained by interferometer pairs or arrays of antennas and consequently the occurrence probabilities are usually higher than data from Florida at comparable frequencies (see Table II) where individual Yagi antennas are the usual equipment. It is difficult to compare the sensitivities of the many observing sites since the values change with time, equipment, maintenance of equipment, ionospheric conditions, etc. All estimates of threshold flux densities for detection of Jovian activity, however, fall in the range from $10^4$-$5\times10^5$ Jy.

## Description of Data Tape

All of the previously-described observations have been reduced to a common format and merged on a single magnetic tape. Each record on the tape represents a continuous period of either listening time or Jovian decametric activity in accordance with the form outlined in Table III. The records are sorted by the following keys in descending order of importance:

1. frequency
2. year, month, and day
3. station code letter
4. beginning time of listening or activity
5. listening or activity code

Since there are presently almost 100,000 records in the catalog, a listing of all of the data is too bulky for publication. Detailed information is easier to obtain directly from the tape. The tape currently in use is unformatted and has been generated with the following data definition parameters using an IBM 360 computer:

1. 9 track tape
2. 1600 bits per inch
3. ~~standard label~~
4. logical record length = 48 bytes
5. variable blocksize
6. maximum blocksize = 32644 bytes
7. volume = serial = JPCAT1
8. data set name = JUPCAT

The last 44 bytes of each record contain the eleven four-byte words described in Table III. Note that Table III also lists the FORTRAN variable type of each of these words. The tape characteristics and the formatting of the data can be readily changed for compatibility with another machine.

## Initial Data Analysis

The major purpose of this publication is to document the existence and availability of the decametric observations catalog. Detailed analysis would unduly lengthen this work, so the present section will be limited to analyzing and displaying the major characteristics indicative of the quality of the data, such as the purity of the basic periodicities in the data and the extent of filtering of earth environment influences from the Jovian emission. The temporal and spectral behavior of earlier subsets of the catalog was studied in greater detail in two previous publications (references 12 and 13).

The importance of combining data from different stations is indicated by Table V. Listed are occurrence probability statistics for simultaneous observations at 22 MHz by various pairs of stations. Though these stations are all in the western hemisphere and some of them are separated by less than a thousand miles, the total activity seen by both stations during the same observing times is usually much less than the activity time identified by either station individually. Variation in equipment and sensitivities, changing ionospheric conditions, misidentification of storm times, etc. can explain these differences, but the important point is the improvement of data quantity and quality obtained by combining overlapping observations.

The periodicities in the data are apparent in Figure 2, which compares plots of spectral power versus period for 20 years of Florida 22-MHz data versus all cataloged 22-MHz data for the same period. Relative spectral power has been computed using the method of Kaiser and Alexander (reference 14). The major peaks are labeled according to the harmonics of the principle periods which combine to form them. The four major periods are: the earth (E) and Jupiter's (J) rotational periods (24 hr. and 10 hr.), the Jovian synodic period ($J_S$) relative to the earth (399 days), and Io's synodic period (Io) as viewed from Jupiter (13 hr). The prominent peaks are labeled in the lower plot by the low-order harmonics of these major periods which combine to form them. A fifth periodicity caused by the 12 year variation of the Jovicentric declination of the earth is too long a time interval to be included in the graph, but the perturbations apparent from this cycle are nevertheless quite important to DAM theory. For further discussion of this effect see the summary by Carr and Desch (reference 15).

The overpoweringly dominant 24-hour peak in the Florida data in Figure 2 is an artifact introduced by earth-based observations which, as explained earlier, are usually confined to nighttime hours. Because of this nocturnal cycle the morphology of Jupiter's emission must be pieced together from a multitude of data widely scattered in time, or, from consecutive records of observatories scattered around the world. In the lower part of Figure 2, the influence of the earth's rotation has obviously been diminished by combining all 22 MHz data within the catalog. This increases the relative size of the smaller maxima and simplifies the search for minor peaks indicative of periodicities dependent on some source other than the four listed above. A previous study of this type was performed by Kaiser and Alexander (reference 14). The larger amount of data has lowered the noise level which they encountered, but the results are the same. All of the major peaks can be identified as a harmonic or a combination of the low-order harmonics of the major periods. Other triggers of Jovian emission, for example, variations in the solar wind which should have a period of approximately 25 days if they recur with the rotational period of the sun, are not apparent in the data suggesting they are marginally periodic, aperiodic, or nonexistent.

The four major periods can be divided into observer-related and source-dependent groups. We have already discussed the earth's 24 hour interruption and the method of reducing its influence. The 399 day Jovian synodic period is also a result of earth-based observations since the data quality depends critically on the Jupiter-earth-sun angle and to some extent on the distance of Jupiter from the earth. It is impossible to eliminate this cycle from purely ground-based stations, but the period is long enough that it has little effect on the following study of the shorter periods.

The intrinsic influences on the sources, Jupiter's rotation and Io's orbital period, have long been studied in the form of plots of occurrence probability versus System III central meridian longitude and the phase of Io from superior geocentric conjunction. Figures 3 through 10 are plots of this type for the frequencies having more than 3000 hours of listening time in the catalog. Occurrence probability is computed for each $2^{\circ} \times 2^{\circ}$ interval of longitude and Io phase and then represented by one of

64 shades of grey normalized so that the maximum probability is completely black. Clearly for some of the lesser-observed frequencies the variations are not smooth and the data are thinly spread. This is especially obvious from the oft-appearing shallow upward slant of the pattern, since a single storm appears as a line with a slope equal to the 10-hour Jovian rotational period divided by the 42-hour cycle of Io's orbital phase relative to the earth.

Figures 3 through 10 present a steady progression from dominance of Io-independent radiation to almost complete control of Jovian emission by the position of Io. Some of the features of the higher probability regions, commonly called "sources", are quite persistent through the frequencies with the exception of the transition from 10 MHz to 15 MHz (Figures 3 and 4). Although 10 MHz is one of the lesser-observed frequencies a year-by-year analysis shows features, such as the band of radiation centered at 200° longitude, which are long-lasting characteristics of this frequency though absent at higher frequencies. The apparent discontinuity at 10 MHz as well as other details of the dependence of source morphology on frequency have been discussed in Thieman and Smith (reference 12).

To what level of detail are the features observable in the sources repetitive and therefore indicative of a stable pattern of emission? This can be readily tested by dividing the 22 MHz data into two groups: observations made after conjunction but before opposition, and observations after opposition but before conjunction. Figures 11 and 12 are plots made from these groups.

Comparison of the plots shows that many of the finer details of the sources remain stable for periods of at least months since the plots have no observation times in common and the features must last long enough to appear on both plots and occur often enough to be distinguishable. (The after-opposition plot is not as smooth as its counterpart since observing sessions after opposition are centered on the early evening hours when the earth's ionosphere is still adjusting from the daytime solar influence making reception more difficult.) The obvious reproducibility even to the bulges in the high probability source regions implies that the beaming pattern is both complex and stable. Also, there is no evidence of change in observed source structure with the local time of the observer relative to Jupiter, but the difference in the average Jupiter-sun-earth angle between the two plots is quite small (approximately $10^{\circ}$ to $15^{\circ}$). Thus, the morphology of the features appears to be reproducible down to levels of occurrence probability of the order of 25% or less.

## Conclusion

Some will argue that the extensive data from the Voyager planetary radio astronomy experiments makes the synoptic monitoring results obsolete. Even as only a basis of comparison the ground-based observations are a valuable aid to the interpretation of Voyager findings. Though the spacecraft return round-the-clock data, there is still incomplete coverage of all longitude-Io phase combinations, and nearly all observations are from positive Jovicentric declinations. Thus the earth-based catalog complements Voyager in the DAM frequency range. In addition, the temporal extent of the data base provides the means for measuring long period changes in the sources, of the order of years.

In summary, the combination of the output of many observing sites suppresses the effects of the earth's rotation on the data and radio storms missed by one station are often picked up by others. Analysis of periodicities within the data shows no statistically significant peaks for the solar rotation period or other unknown periodic influences. System III longitude versus Io phase occurrence probability diagrams are quite similar in the morphology of the high probability Io-related sources from one frequency to the next. Only in the transition from 15 MHz to 10 MHz do the plots appear to differ markedly. Within each frequency the source morphology remains remarkably consistent with time as evidenced by separate plots of 22 MHz data before and after opposition.

Finally, for those interested in obtaining the cataloged data, a copy of the master catalog tape will be deposited in the National Space Science Data Center within Goddard Space Flight Center. A copy of this tape could then be obtained by contacting either the center or this author.

## Acknowledgments

This work was made possible by a research associateship from the National Academy of Sciences/National Research Council. Data have been provided through the cooperation of the radio astronomy observing groups at the Universities of Florida and Texas and the Goddard Space Flight Center. W. W. Richardson and A. G. Smith of the University of Florida and J. K. Alexander, M. L. Kaiser, S. S. Vaughan, and P. G. Harper of GSFC are especially to be thanked for their aid in the preparation of this catalog.

Table I

STATION CODE LETTERS

| Code Letter | Station |
|---|---|
| A | Tracking Station, Carnarvon, W. A., Australia |
| C | Clark Lake Radio Observatory, Borrego Springs, California |
| F | University of Florida Radio Observatory, Old Town, Florida |
| G | Goddard Space Flight Center, Greenbelt, Maryland |
| H | Maipu Radioastronomical Observatory (Field Site), Huanta, Chile |
| I | Kodaikanal Astrophysical Observatory, Kodaikanal, India |
| K | NASA/STDN Station, Kauai, Hawaii |
| M | Maipu Radioastronomical Observatory, Maipu, Chile |
| N | Nancay Radio Astronomy Observatory, Nancay, France |
| O | NASA/STDN Station, Orroral Valley (Canberra), Australia |
| S | NASA/STDN Station, Grand Canary Island, Spain |
| T | University of Texas Radio Astronomy Observatory, Marfa, Texas |
| Y | Bethany Observing Station, Yale Observatory, New Haven, Connecticut |

Table II

FREQUENCY STATISTICS

| Freq. (MHz) | Station Code | Years | Activity (Hours) | Listening (Hours) | Occur. Prob. |
|---|---|---|---|---|---|
| 5 | M | 1961-64 | 24.4 | 447.4 | 0.055 |
| 10 | F | 1965-67 | 133.2 | 1057.2 | 0.126 |
| | M | 1961-66 | 295.0 | 2264.7 | 0.130 |
| | H | 1965-66 | 3.2 | 120.1 | 0.027 |
| | T | 1968,70-71 | 2.5 | 79.7 | 0.031 |
| | | | 433.9 | 3521.7 | 0.123 |
| 12 | F | 1965-67 | 148.8 | 1245.9 | 0.120 |
| 13 | M | 1974-75 | 84.7 | 1513.1 | 0.056 |
| 15 | F | 1961-69,72-73,75-78 | 828.4 | 8928.7 | 0.093 |
| | M | 1961-62 | 276.0 | 2016.0 | 0.137 |
| | | | 1104.4 | 10944.7 | 0.101 |
| 16 | M | 1960,65-70,73-77 | 270.7 | 5656.4 | 0.048 |
| | Y | 1960,65-66 | 120.2 | 698.8 | 0.172 |
| | T | 1967-71 | 127.6 | 1303.9 | 0.098 |
| | G | 1965-78 | 1469.3 | 8919.4 | 0.165 |
| | C | 1966-67,69-74 | 219.4 | 3227.3 | 0.068 |
| | K | 1967-74,76-77 | 313.1 | 2037.8 | 0.154 |
| | A | 1966-72 | 106.3 | 1606.6 | 0.066 |
| | S | 1968-74 | 141.1 | 2788.9 | 0.051 |
| | N | 1977-78 | 170.8 | 718.1 | 0.238 |
| | O | 1977-78 | 34.2 | 334.9 | 0.102 |
| | | | 2972.7 | 27292.1 | 0.109 |
| 18 | F | 1957-78 | 1523.2 | 17657.9 | 0.086 |
| | M | 1960-77 | 827.1 | 14333.2 | 0.058 |
| | H | 1964-66 | 165.0 | 1508.9 | 0.109 |
| | | | 2515.3 | 33500.0 | 0.075 |
| 19 | Y | 1959-60 | 8.6 | 161.3 | 0.053 |
| 20 | F | 1964-78 | 745.9 | 14540.0 | 0.051 |
| | M | 1960-61 | 73.8 | 2001.6 | 0.037 |
| | Y | 1959-66 | 728.5 | 7230.4 | 0.101 |
| | T | 1967-71 | 122.2 | 1784.2 | 0.069 |
| | | | 1670.4 | 25556.2 | 0.065 |

Table II - continued

| Freq. (MHz) | Station Code | Years | Activity (Hours) | Listening (Hours) | Occur. Prob. |
|---|---|---|---|---|---|
| 22 | F | 1957-78 | 826.9 | 19761.2 | 0.042 |
| | M | 1960-61,63-77 | 443.9 | 14715.6 | 0.030 |
| | Y | 1958-66 | 631.0 | 9465.7 | 0.067 |
| | T | 1967-71 | 122.5 | 2643.0 | 0.046 |
| | I | 1962-67 | 136.9 | 2056.3 | 0.067 |
| | G | 1965-78 | 455.6 | 11882.2 | 0.038 |
| | C | 1969-74 | 82.1 | 5672.9 | 0.015 |
| | K | 1967-74,76-77 | 106.3 | 4320.4 | 0.025 |
| | A | 1966-72 | 49.4 | 3817.8 | 0.013 |
| | S | 1969-74 | 41.8 | 5022.6 | 0.008 |
| | N | 1977-78 | 43.1 | 894.3 | 0.048 |
| | O | 1977-78 | 19.8 | 1061.3 | 0.019 |
| | | | 2959.3 | 81313.3 | 0.036 |
| 23 | Y | 1958-60 | 17.5 | 485.5 | 0.036 |
| 25 | F | 1969-73 | 34.8 | 2183.8 | 0.016 |
| 27 | F | 1958-73,77-78 | 155.2 | 15793.1 | 0.010 |
| | M | 1960-77 | 120.1 | 13763.5 | 0.009 |
| | | | 275.3 | 29556.6 | 0.009 |
| 30 | T | 1967-71 | 31.5 | 3445.5 | 0.009 |
| | | Totals | 12281.6 | 221167.1 | 0.056 |

Table III

CATALOG RECORD DESCRIPTION

| Word No. | FORTRAN Type | Description |
|---|---|---|
| 1 | Integer | Date of event in year, month, day format as follows: YYMMDD. Observations continuing through 2400 hours UT are broken into separate days. |
| 2 | Integer | Julian Date of event less 2400000. |
| 3 | Integer | Beginning Time of event in hours and minutes in the form: HHMM (Universal Time). |
| 4 | Integer | Ending Time of event in hours and minutes in the form: HHMM (Universal Time). |
| 5 | Integer | Frequency in megahertz. |
| 6 | Alphabetic | Station Code Letter (see Table I). |
| 7 | Integer | Listening or Activity Code. Quality codes are often included for activity events (see Table IV). |
| 8 | Real | Initial Central Meridian Longitude (1965) in degrees. |
| 9 | Real | Final Central Meridian Longitude (1965) in degrees. |
| 10 | Real | Initial Geocentric Phase of Io in degrees. |
| 11 | Real | Final Geocentric Phase of Io in degrees. |

## Table IV

## LISTENING AND ACTIVITY CODE DESCRIPTIONS

The seventh word in the catalog record is a three digit integer which has the following meaning in the ones, tens, and hundreds digits.

### Listening Events

For all listening events all three digits of the code will be zero. Any number greater than zero represents activity.

### Activity Events

Goddard Data - ones digit only
- 1 - All activity

Florida Data - ones digit only
- 1 - Certain Jupiter activity
- 2 - Probable Jupiter activity
- 3 - Possible Jupiter activity

Texas Data*
- Hundreds digit - storm type
  - 1 - Main storm in observing time
  - 2 - Precursor in observing time
  - 3 - Post-cursor in observing time
  - 4 - Main storm outside observing time
  - 5 - Precursor outside observing time
  - 6 - Post-cursor outside observing time
- Tens digit - storm strength
  - 0 - Not specified
  - 1 - Strong (peak flux greater than 20 times Cygnus A)
  - 2 - Moderate (peak flux 10-20 times Cygnus A)
  - 3 - Weak (less than 10 times Cygnus A)
- Ones digit - storm credibility
  - 1 - Certain (probability event is Jovian 99%)
  - 2 - Probable (probability event is Jovian 90%)
  - 3 - Possible (probability event is Jovian 50%)
  - 4 - As in 1, but may be solar emission
  - 5 - As in 2, but may be solar emission
  - 6 - As in 3, but may be solar emission

* Observing time for Texas data is defined as the time when a radio storm exceeding a predetermined threshold flux could be detected if present. This table and other information on the Texas data code is condensed from reference 7.

Table V

OCCURRENCE PROBABILITIES FOR SIMULTANEOUS OBSERVATIONS AT 22 MHz

| Common Obs. Time (hrs) | Station 1* Code | Station 1* Occ. Prob. | Station 2* Code | Station 2* Occ. Prob. | Common Act. Occ. Prob. |
|---|---|---|---|---|---|
| 5224.4 | F | Ø.Ø31 | G | Ø.Ø4Ø | Ø.Ø2Ø |
| 8282.7 | F | Ø.Ø43 | M | Ø.Ø33 | Ø.Ø21 |
| 1288.9 | F | Ø.Ø23 | T | Ø.Ø58 | Ø.Ø21 |
| 3839.Ø | F | Ø.Ø56 | Y | Ø.Ø84 | Ø.Ø43 |
| 5671.Ø | G | Ø.Ø39 | M | Ø.Ø25 | Ø.Ø15 |
| 12Ø2.6 | G | Ø.Ø34 | T | Ø.Ø5Ø | Ø.Ø27 |
| 1368.1 | M | Ø.Ø13 | T | Ø.Ø47 | Ø.Ø1Ø |
| 2361.8 | M | Ø.Ø52 | Y | Ø.Ø82 | Ø.Ø37 |

* The station code letter is interpreted in Table I.

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# Figure Captions

Figure 1. Mercator plot of the world showing the locations of the decameter-wave radio observatories contributing data to the catalog. The station code letters are interpreted in Table I.

Figure 2. Relative spectral power versus period for all Florida 22 MHz data (upper panel) and all 22 MHz data (lower panel) in the catalog. In the lower plot the major peaks are labeled according to the harmonics of the four major periods which form them (earth's rotational period, E; Jupiter's rotational period, J; Io's synodic period relative to Jupiter, Io; and Jupiter's synodic period relative to the earth, $J_s$). The method of computation is described in Kaiser and Alexander (reference 14).

Figure 3. Normalized occurrence probability of 10 MHz radio emission versus central meridian longitude and the position of Io from superior geocentric conjunction (Io phase). Occurrence probability is represented by one of 64 shades of grey for each $2°\times2°$ interval in longitude and Io phase. The probabilities are normalized so that the highest value is black.

Figure 4. Same as for Figure 3, but for 15 MHz data.

Figure 5. Same as for Figure 3, but for 16 MHz data.

Figure 6. Same as for Figure 3, but for 18 MHz data.

Figure 7. Same as for Figure 3, but for 20 MHz data.

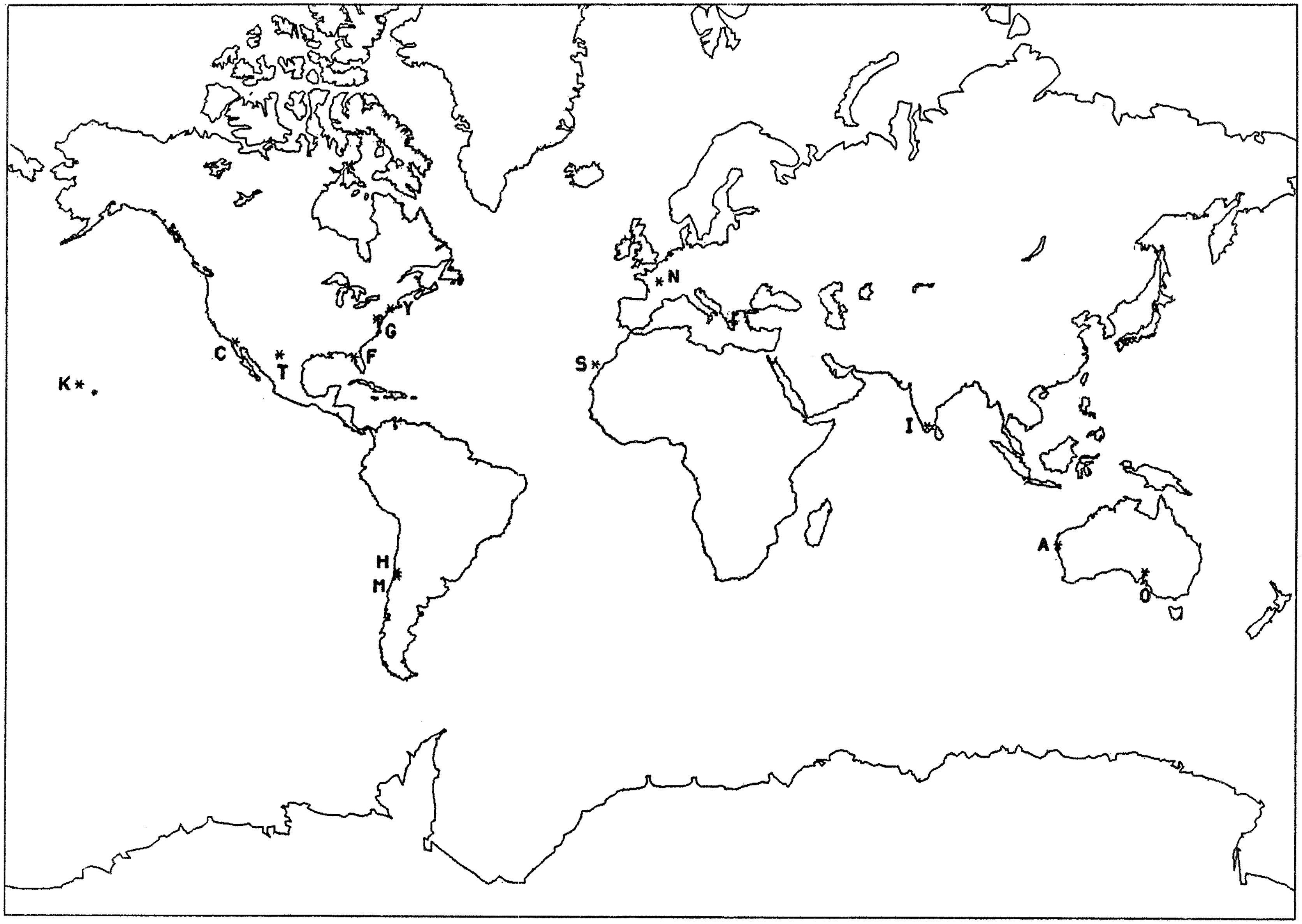
Figure 8. Same as for Figure 3, but for 22 MHz data.

Figure 9. Same as for Figure 3, but for 27 MHz data.

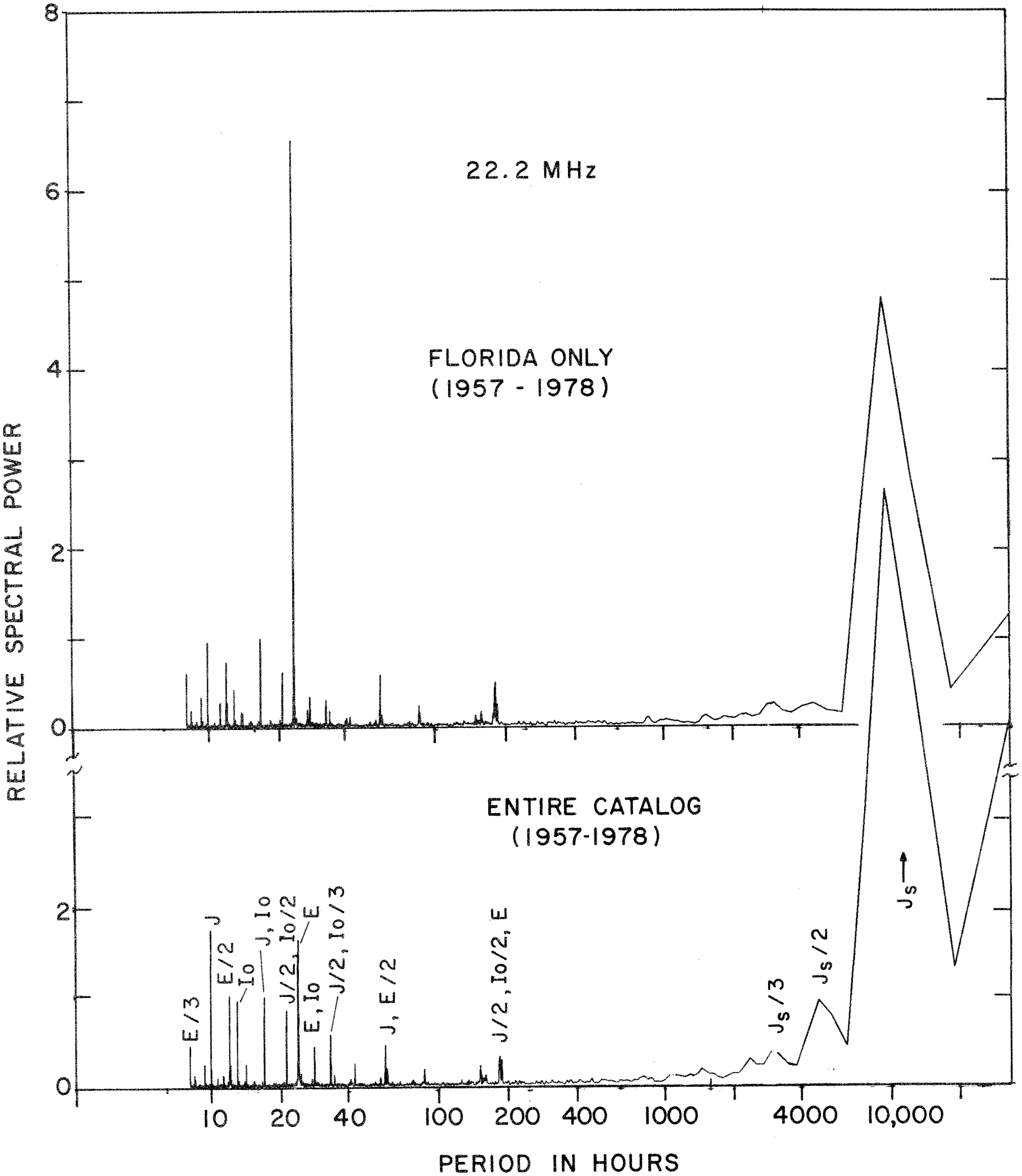
Figure 10. Same as for Figure 3, but for 30 MHz data.

Figure 11. Same as for Figure 3, but for all 22 MHz data after conjunction and before opposition.

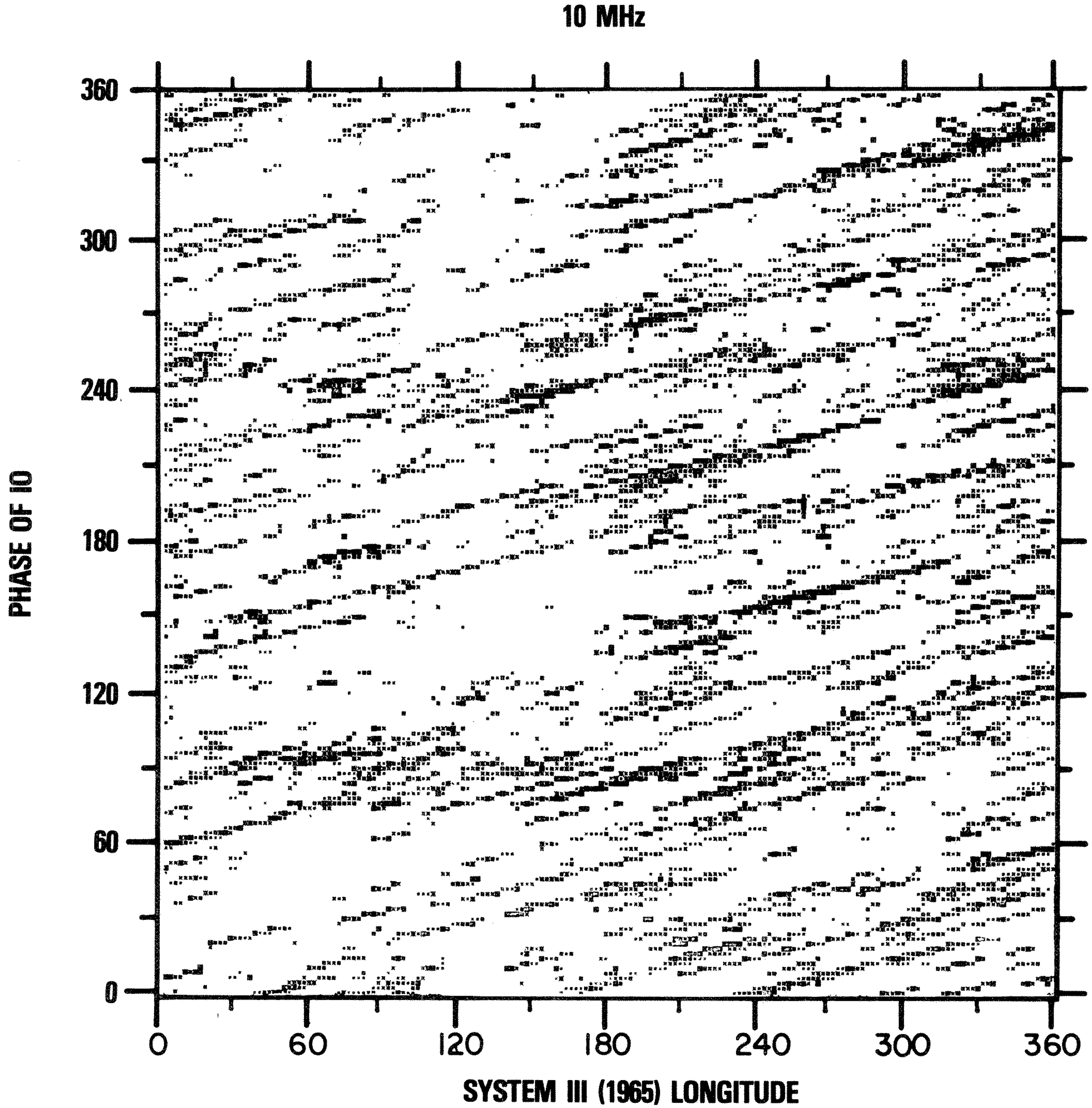
Figure 12. Same as for Figure 3, but for all 22 MHz data before conjunction and after opposition.



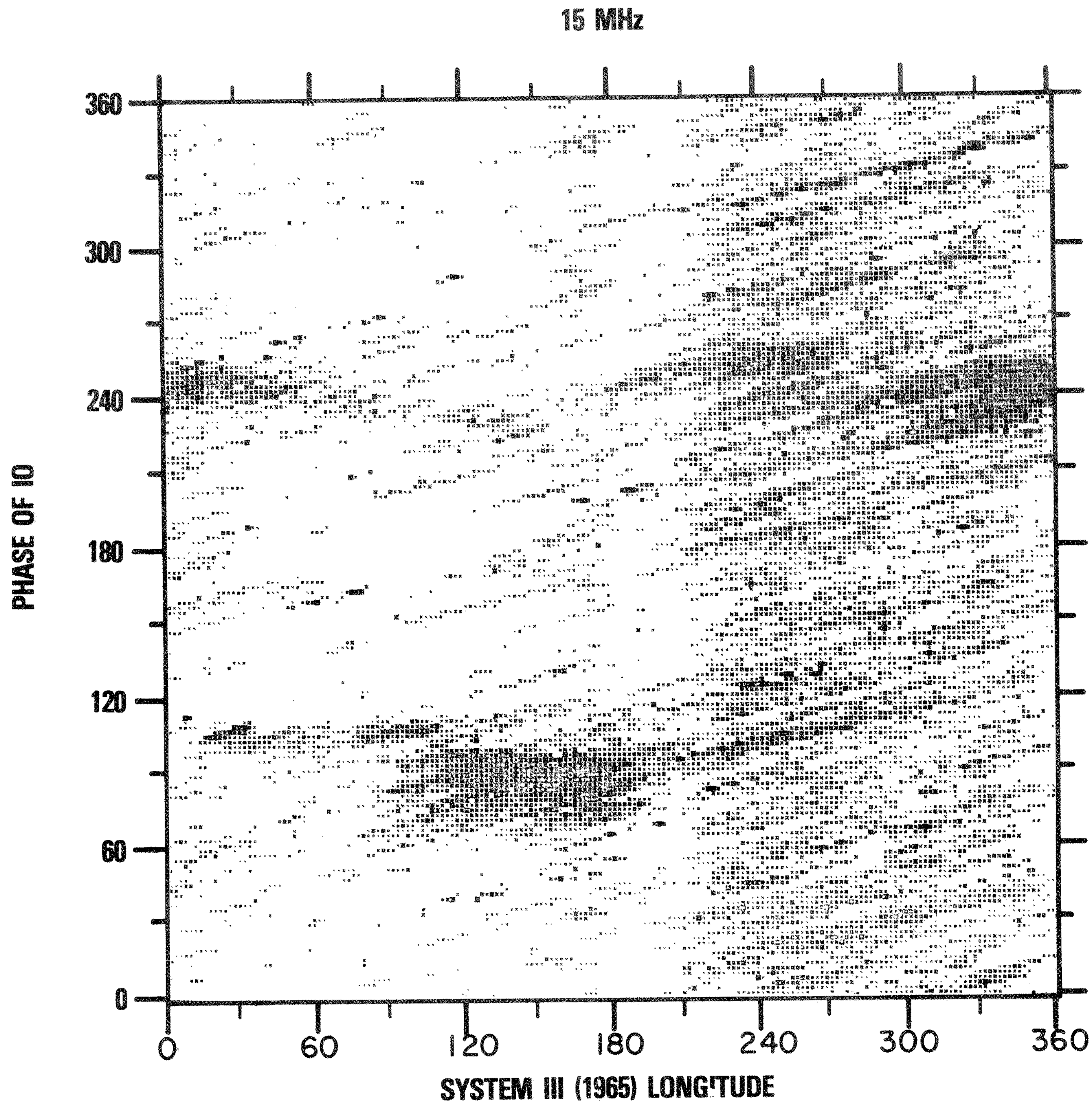
K
C
T
F
G
Y
H
M
S
N
I
A
O

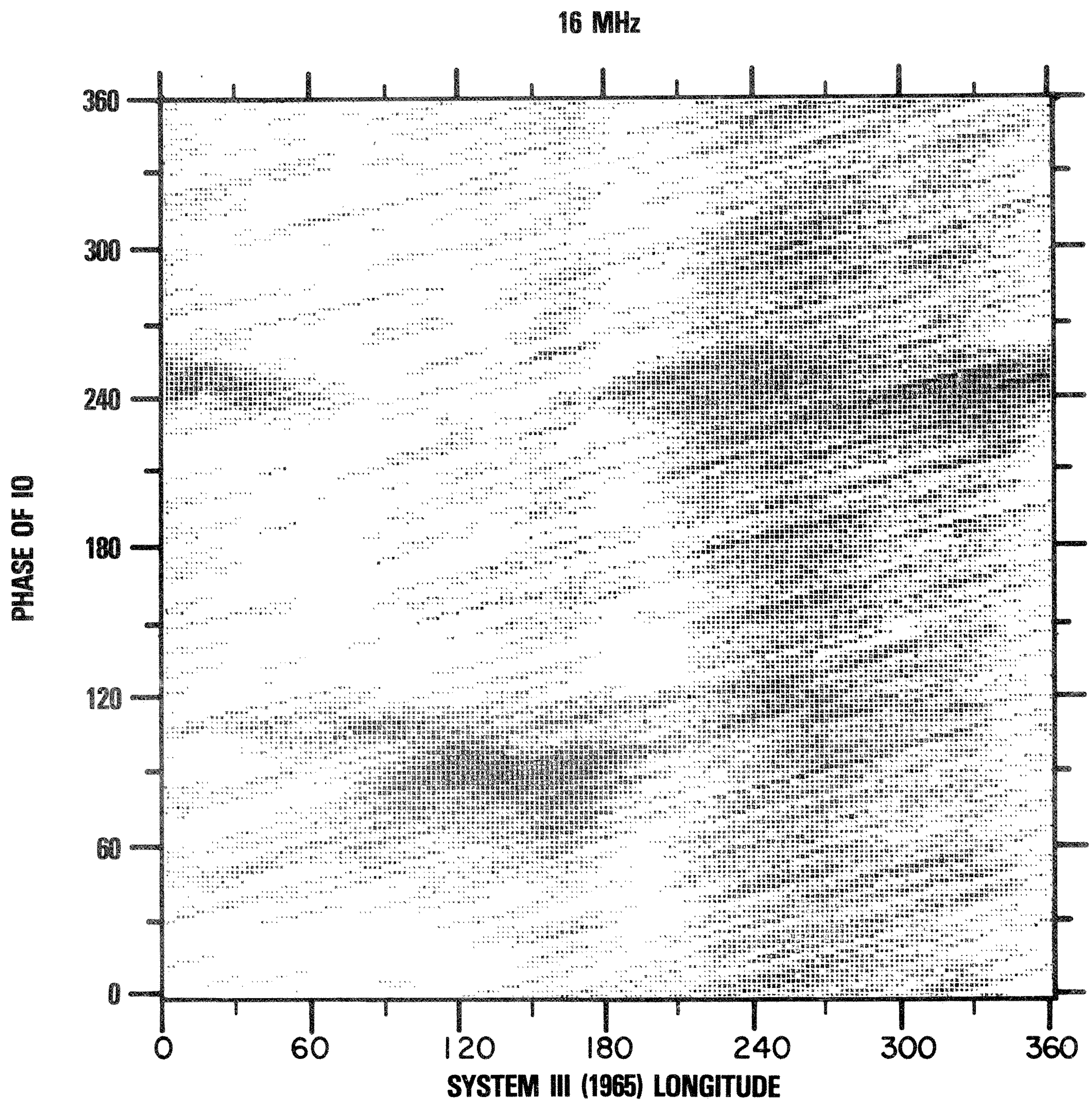


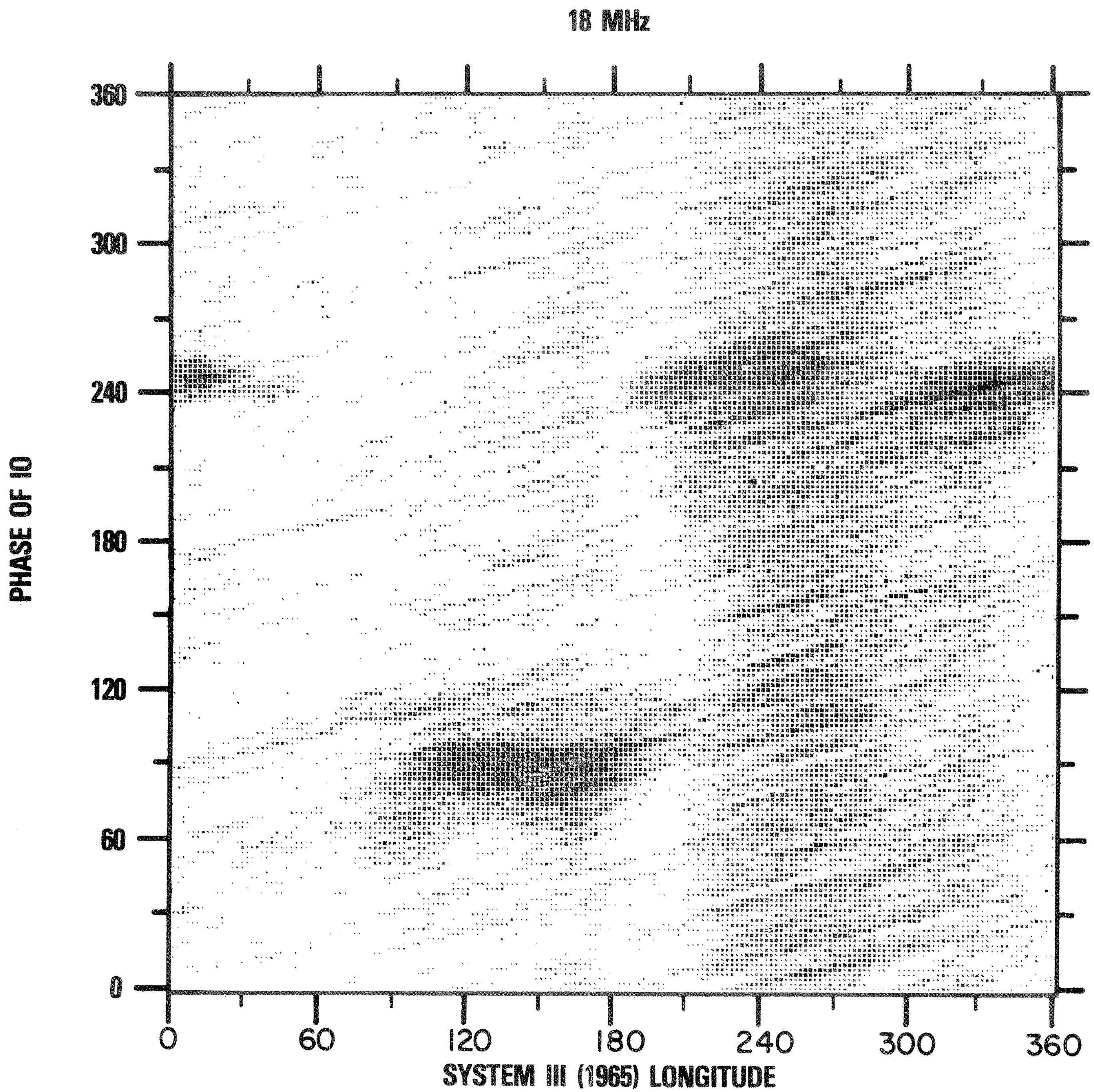
22.2 MHz
FLORIDA ONLY
(1957 - 1978)
ENTIRE CATALOG
(1957-1978)
RELATIVE SPECTRAL POWER
PERIOD IN HOURS
E/3
J
E/2
Io
J, Io
J/2, Io/2
E
E, Io
J/2, Io/3
J, E/2
J/2, Io/2, E
$J_s$/3
$J_s$/2
$J_s$
0
2
4
6
8
10
20
40
100
200
400
1000
4000
10,000



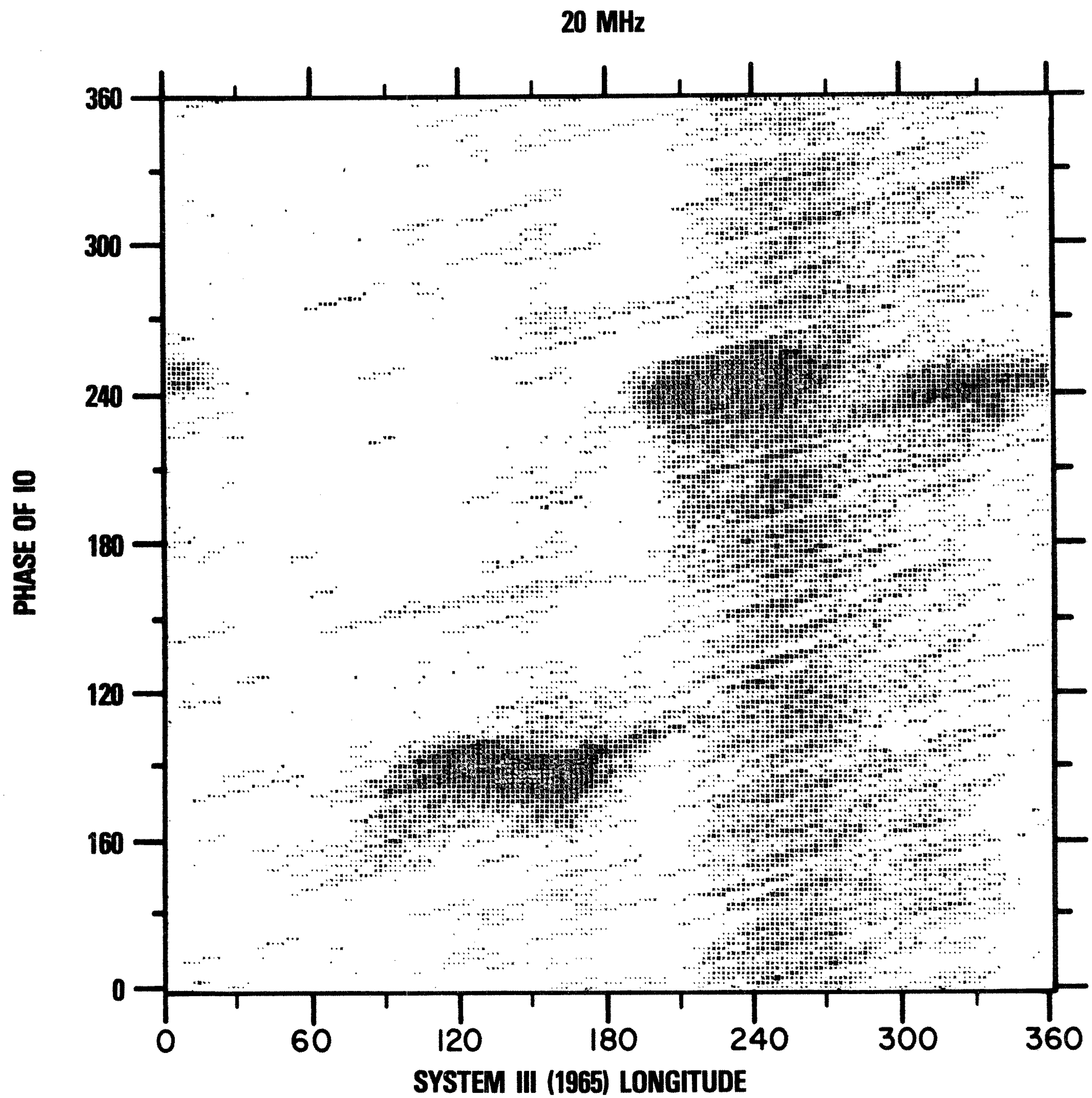
10 MHz
360
300
240
180
120
60
0
PHASE OF IO
0
60
120
180
240
300
360
SYSTEM III (1965) LONGITUDE

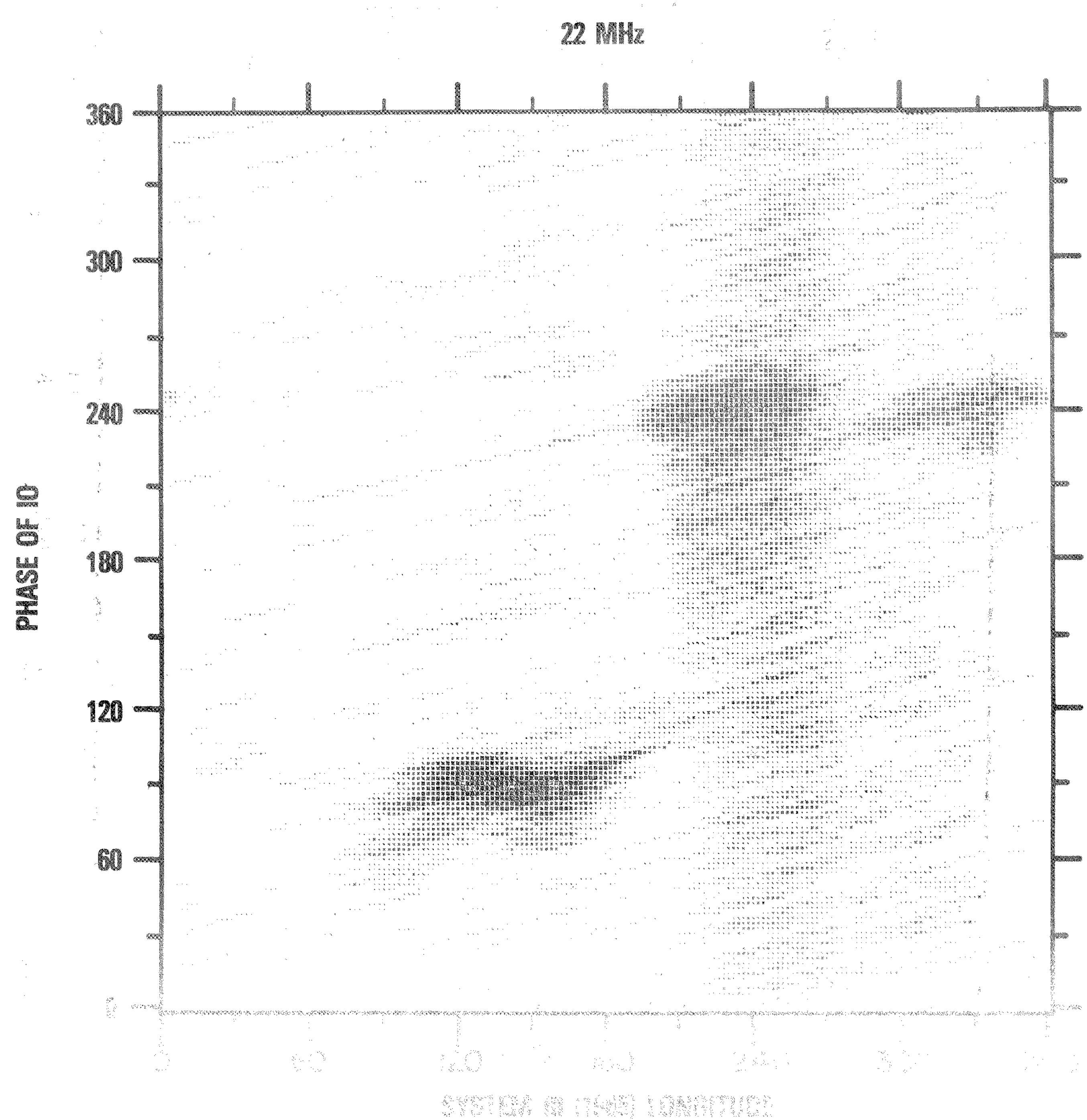

15 MHz
PHASE OF IO
0
60
120
180
240
300
360
SYSTEM III (1965) LONGITUDE

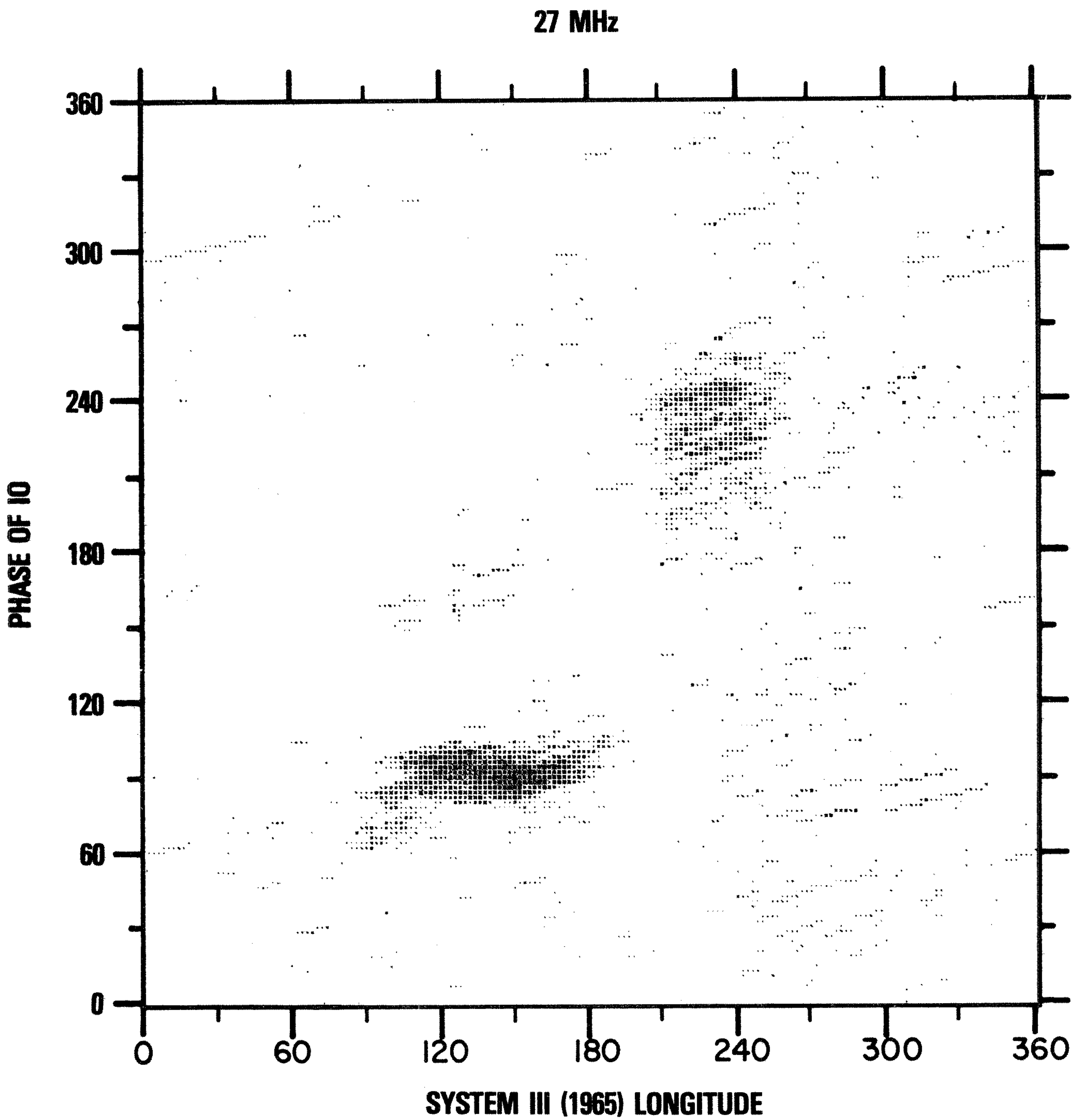

16 MHz
360
300
240
180
120
60
0
PHASE OF IO
0
60
120
180
240
300
360
SYSTEM III (1965) LONGITUDE



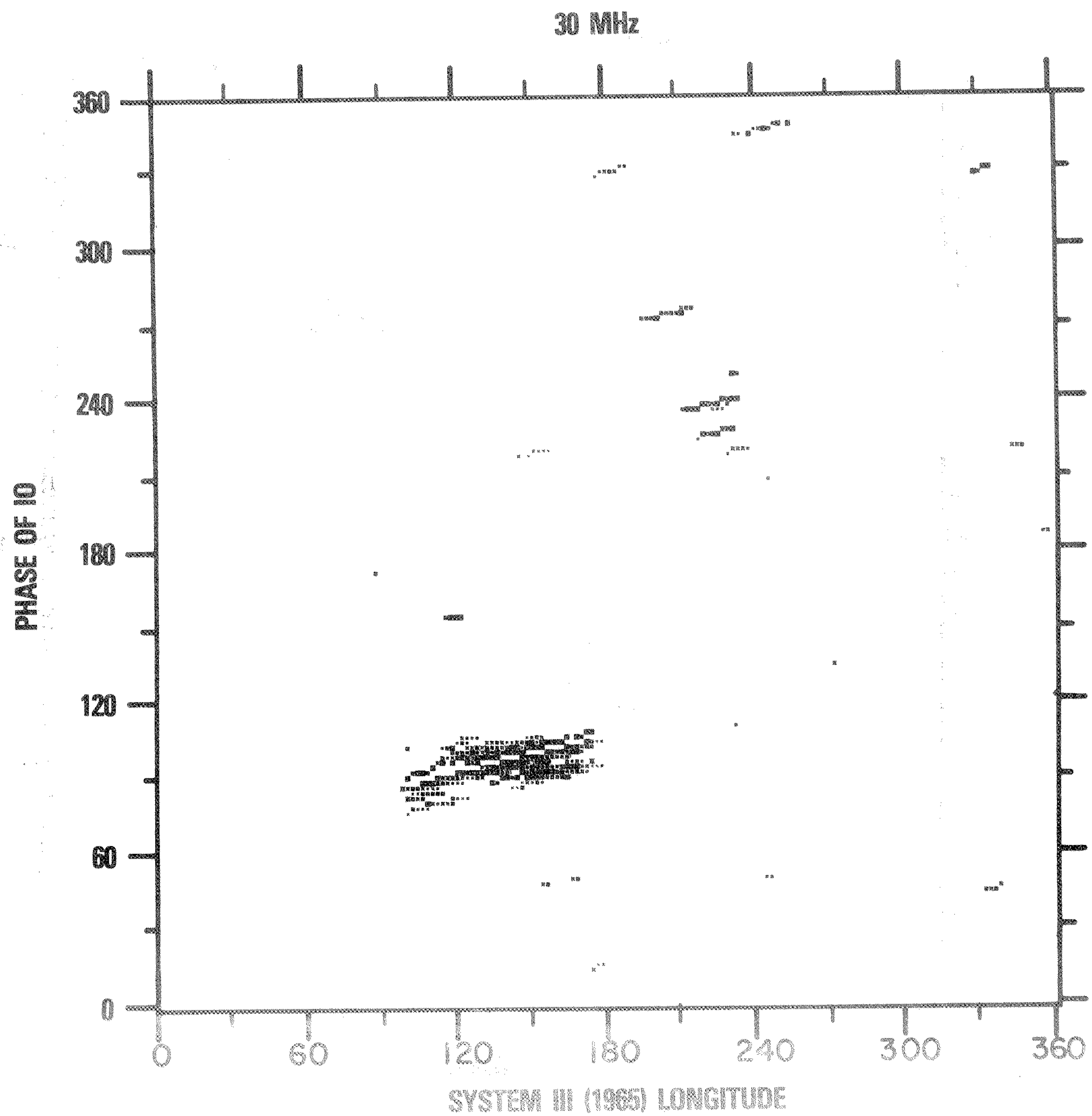
18 MHz
360
300
240
180
120
60
0
PHASE OF IO
0
60
120
180
240
300
360
SYSTEM III (1965) LONGITUDE

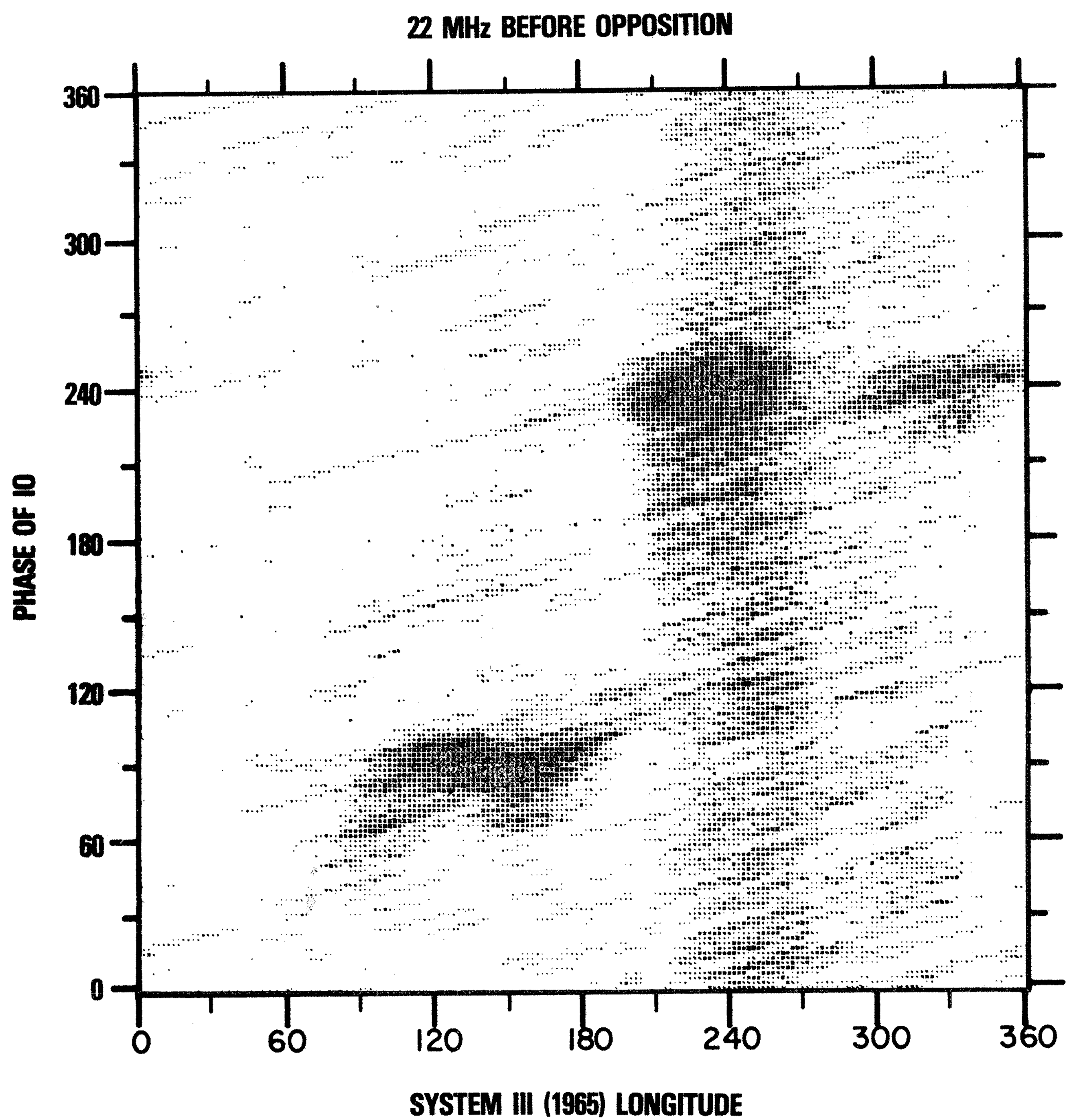

20 MHz
PHASE OF IO
360
300
240
180
120
160
0
0
60
120
180
240
300
360
SYSTEM III (1965) LONGITUDE

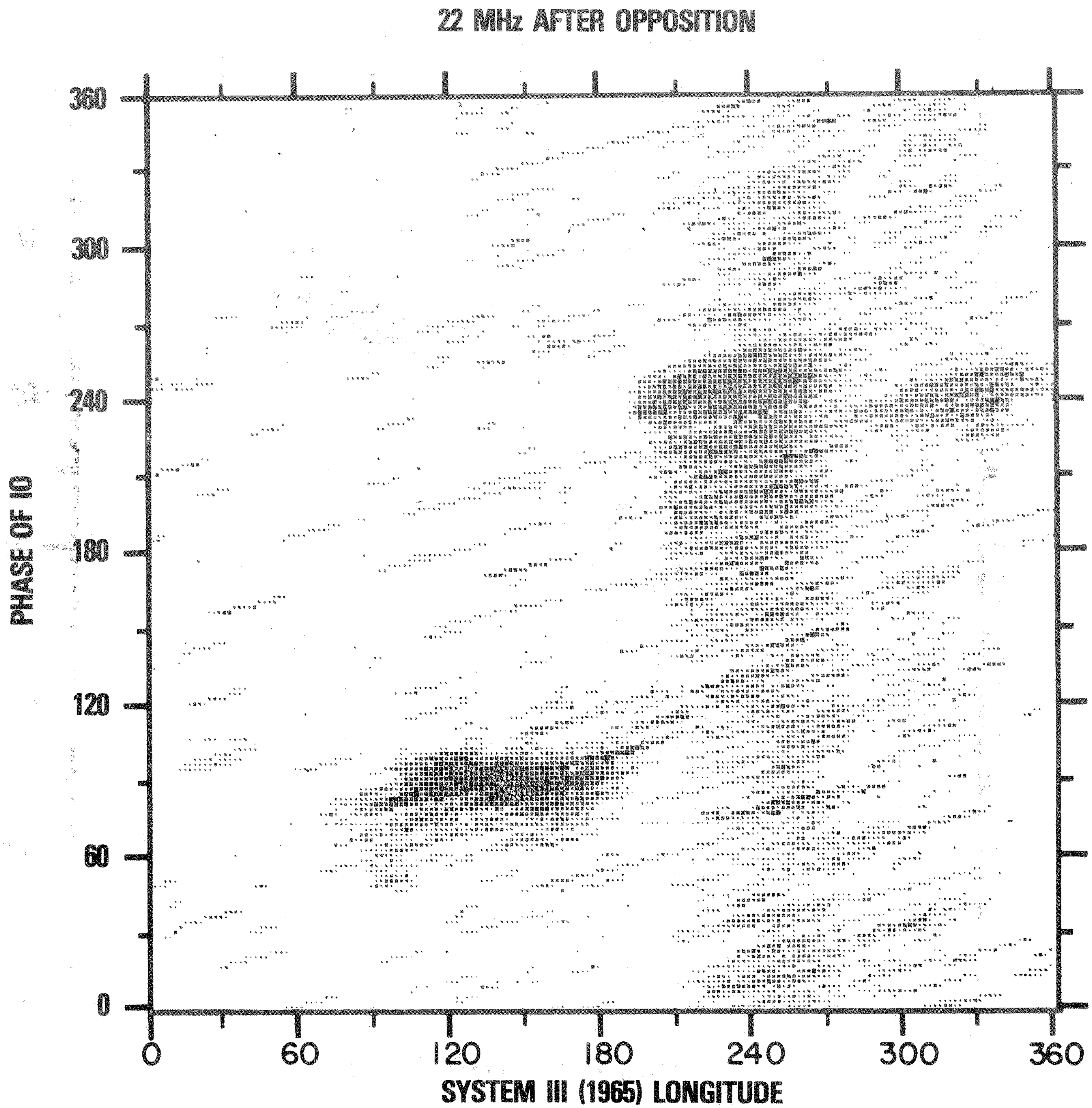

22 MHz
PHASE OF IO
360
300
240
180
120
60
SYSTEM III (1965) LONGITUDE



27 MHz
PHASE OF IO
0
60
120
180
240
300
360
SYSTEM III (1965) LONGITUDE


30 MHz
PHASE OF IO
360
300
240
180
120
60
0
0
60
120
180
240
300
360
SYSTEM III (1965) LONGITUDE


22 MHz BEFORE OPPOSITION
PHASE OF IO
360
300
240
180
120
60
0
0
60
120
180
240
300
360
SYSTEM III (1965) LONGITUDE


22 MHz AFTER OPPOSITION
360
300
240
180
120
60
0
PHASE OF IO
0
60
120
180
240
300
360
SYSTEM III (1965) LONGITUDE

# BIBLIOGRAPHIC DATA SHEET

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| TM80308 | | |

| | |
|---|---|
| 4. Title and Subtitle<br>A Catalog of Jovian Decameter-Wave Radio Observations from 1957-1978 | 5. Report Date<br>August 1979<br>6. Performing Organization Code<br>695 |
| 7. Author(s)<br>James R. Thieman | 8. Performing Organization Report No. |
| 9. Performing Organization Name and Address<br>Goddard Space Flight Center<br>Greenbelt, Maryland 20771 | 10. Work Unit No.<br>11. Contract or Grant No. |
| 12. Sponsoring Agency Name and Address | 13. Type of Report and Period Covered<br>Working Paper<br>14. Sponsoring Agency Code |

15. Supplementary Notes

16. Abstract


A catalog of over 200,000 hours of observation of Jupiter radio emission in the decameter-wavelength band has been created on magnetic tape and is available upon request. The data have been collected from 13 observing sites which are part of synoptic monitoring programs started by the Universities of Florida and Texas and the Goddard Space Flight Center. Observations were made at 14 fixed frequencies from 5 to 30 MHz. The characteristics of the tape recording technique and the data format are described. The combination of overlapping data from observing sites scattered world-wide lessens the effect of the earth's daily interruption of the ground-received signal. A power spectral analysis of the data shows no evidence of periodicities within the data other than the well-known influences of Jupiter, Io, and the earth. The dependence of the occurrence probability of emission on System III longitude and the phase of Io varies smoothly with frequency down to 15 MHz and then appears quite different at 10 MHz. The morphology of the radio sources is both complex and stable for periods of at least months and probably much longer.


| 17. Key Words (Selected by Author(s)) | 18. Distribution Statement |
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| Jupiter radio emission, decamter-wavelength | |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price* |
|---|---|---|---|
| U | U | 36 | |

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GSFC 25-44 (10/77)

D-40295
[redacted]
04/19/61 - 1/1061

DUMP OF TAPE X451

INPUT TAPE X451 ON MT1
DATA INPUT H9 NF 3 FL 3 1 1

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| ( 40) | 40404040 | 40404040 | 40404040 | 40404040 | 40404040 | 40404040 | 40404040 | 40404040 | 40404040 | 40404040 |

FILE 1 RECORD 3 LENGTH 80BYTES

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
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| ( 40) | 4040F1F4 | F3F8F340 | 40404040 | 40404040 | 40404040 | 40404040 | 40404040 | 40404040 | 40404040 | 40404040 |

| FILE | INPUT RECS. | DATA RECORDS INPUT | MAX. SIZE | READ ERROR SUMMARY PERM | ZERO B | SHORT | UNDEF. | INPUT RETRIES #RECS. | TOTAL# |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 4 | 80 | 0 | 0 | 0 | 0 | 0 | 0 |

Date

FILE 2 RECORD 1 LENGTH 32644BYTES

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| ( 40) | 422D95E8 | 4311FEE8 | 431222C7 | 00300000 | 00095OC7 | 0000922E | 000003FF | 00000400 | D4404040 | 00000005 |
| ( 80) | 00000000 | 413DBF39 | 41476B69 | 43104BB6 | 43104DF5 | 00300000 | 00095OC7 | 0000922E | 000003FF | 00000400 |
| ( 120) | D4404040 | 00000005 | 00000001 | 413DBF39 | 41476B69 | 43104BB6 | 43104DF5 | 00300000 | 000950D2 | 00009239 |
| ( 160) | 000003A3 | 000003A8 | D4404040 | 00000005 | 00000000 | 42BC9B5C | 42BFA134 | 4314AD30 | 4314B870 | 00300000 |
| ( 200) | 000950D2 | 00009239 | 000003B7 | 000003F5 | D4404040 | 00000005 | 00000000 | 42C8E2FE | 42D5FFAB | 4314DA34 |
| ( 240) | 43150BBE | 00300000 | 0009512C | 0000924E | 00000214 | 00000224 | D4404040 | 00000005 | 00000000 | 4314ECF3 |
| ( 280) | 431507BA | 42FB101E | 42FD4E68 | 00300000 | 0009512C | 0000924E | 00000214 | 00000224 | D4404040 | 00000005 |
| ( 320) | 00000001 | 43146CF3 | 431507BA | 42FB101E | 42FD4E68 | 00300000 | 0009513F | 00009261 | 00000262 | 000003B6 |
| ( 360) | D4404040 | 00000005 | 00000000 | 4314C234 | 42692808 | 42A478C9 | 42C37A75 | 00300000 | 00095140 | 00009262 |
| ( 400) | 00000195 | 00000352 | D4404040 | 00000005 | 00000000 | 422F39EB | 42DB8BC1 | 4315D79E | 421DF2B2 | 00300000 |
| ( 440) | 00095140 | 00009262 | 00000285 | 000002C8 | D4404040 | 00000005 | 00000001 | 428FF795 | 42A04AC9 | 41C2C92B |
| ( 480) | 421002B4 | 00300000 | 00095140 | 00009262 | 0000032C | 0000034E | D4404040 | 00000005 | 00000001 | 42C491E9 |
| ( 520) | 42D9209D | 4218BAA2 | 421D60F9 | 00300000 | 00095192 | 0000926E | 000003A7 | 000003F8 | D4404040 | 00000005 |
| ( 560) | 00000000 | 42FED6FF | 43117A14 | 4313F4E9 | 43145197 | 00300000 | 000951F7 | 0000928E | 000001A4 | 000001FD |
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| ( 720) | 42FB63FB | 00300000 | 00097846 | 000093C5 | 00000401 | 00000410 | D4404040 | 00000005 | 00000001 | 42268407 |
| ( 760) | 422F9583 | 42F5C344 | 42F7DFA7 | 00300000 | 00097846 | 000093C5 | 00000410 | 00000415 | D4404040 | 00000005 |
| ( 800) | 00000002 | 422F9583 | 42329B58 | 42F7DFA7 | 42F893C0 | 00300000 | 00097846 | 000093C5 | 00000415 | 00000451 |
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| ( 880) | 000003E8 | 0000044C | D4404040 | 00000005 | 00000000 | 427315AE | 42975BB6 | 42843F61 | 428CCAD8 | 00300000 |
| ( 920) | 00097849 | 000093C8 | 000003E8 | 0000041A | D4404040 | 00000005 | 00000001 | 427315AE | 42915009 | 42843F61 |
| ( 960) | 428B5E4E | 00300000 | 00097849 | 000093C8 | 0000041F | 0000044C | D4404040 | 00000005 | 00000001 | 429455DE |
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| ( 1080) | D4404040 | 00000005 | 00000002 | 4310CAC8 | 4310FB26 | 4315C1E9 | 43150CF3 | 00300000 | 0009784A | 000093C9 |
| ( 1120) | 000003F8 | 000003FA | D4404040 | 00000005 | 00000002 | 4311352F | 43114888 | 43151A6C | 43151EEA | 00300000 |
| ( 1160) | 0009784A | 000093C9 | 00000403 | 00000455 | D4404040 | 00000005 | 00000001 | 43119F96 | 431335DA | 43153320 |
| ( 1200) | 43159179 | 00300000 | 0009784D | 000093CC | 00000393 | 0000045B | D4404040 | 00000005 | 00000000 | 4314A297 |
| ( 1240) | 422AB5BB | 42DC2692 | 42ED1156 | 00300000 | 0009784D | 000093CC | 00000393 | 000003AC | D4404040 | 00000005 |
| ( 1280) | 00000002 | 4314A297 | 4315946A | 42DC2692 | 42DFADA5 | 00300000 | 0009784D | 000093CC | 000003AC | 00000401 |
| ( 1320) | D4404040 | 00000005 | 00000001 | 4315946A | 41C7E450 | 42DFADA5 | 42E60610 | 00300000 | 0009784D | 000093CC |
| ( 1360) | 00000401 | 00000406 | D4404040 | 00000005 | 00000002 | 41C7E450 | 41F811EF | 42E60610 | 42E6BA77 | 00300000 |
| ( 1400) | 0009784F | 000093CE | 0000020D | 00000466 | D4404040 | 00000005 | 00000000 | 428444B8 | 4315E84B | 42EA90AD |
| ( 1440) | 4311D459 | 00300000 | 0009784F | 000093CE | 0000025C | 00000261 | D4404040 | 00000005 | 00000002 | 429BD8C1 |
| ( 1480) | 429EDE9A | 42F00E53 | 42FCC277 | 00300000 | 0009784F | 000093CE | 0000026E | 00000273 | D4404040 | 00000005 |
| ( 1520) | 00000002 | 42A6BA9C | 42A9C077 | 42F296C2 | 42F34AD8 | 00300000 | 0009784F | 000093CE | 00000285 | 0000028A |
| ( 1560) | D4404040 | 00000005 | 00000003 | 42B4A253 | 42B7A82C | 42F5D306 | 42F6870A | 00300000 | 0009784F | 000093CE |
| ( 1600) | 000002BC | 000002D0 | D4404040 | 00000005 | 00000002 | 42EDE3F0 | 42C9CB4E | 42F7EF07 | 42FABED4 | 00300000 |
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| ( 1720) | 43111222 | 43109EA2 | 4310E517 | 00300000 | 0009784F | 000093CE | 0000039F | 000003A4 | D4404040 | 00000005 |
| ( 1760) | 000000C3 | 43116931 | 4311998E | 4310C94D | 4310D487 | 00300000 | 0009784F | 000093CE | 000003B1 | 000003B6 |

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( 29880)   E3404040  0000001E  00000000  42912FBB  42973AEA  42DE0573  42DF718F

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(     40)   4040F7F9  F2F9F740  F0F0F0F0  F0F0F0F0  F0F1F4F3  0CCC0000  00000000  00000000  00404040  40404040

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(     40)   4040F1F4  F3F8F340  40404040  40404040  40404040  40404040  40404040  40404040  40404040  40404040

        FILE   INPUT    DATA RECORDS    MAX.           READ ERROR SUMMARY          INPUT RETRIES
               RECS.        INPUT       SIZE       PERM  ZERO B   SHORT  UNDEF.  #RECS.  TOTAL#
          3        2    3                 80          0       0       0       0       0       0

 EOJ        DUMP STOPPED AFTER FILE   3          # OF PERMANENT READ ERRORS  0

START TIME 07/23/80  09:24:33        STOP TIME 07/23/80  09:25:29

$$
$DO CDLIST
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024M 5 1 3.859 4.464 260.732 260.87261051437433 931 936M 5 0 188.607 191.630 330.824 331.52761051437433 9511013M 5 0 200.6
98 213.999 333.638 336.73461060437454 532 548M 5 0 326.809 336.483 251.063 253.30661060437454 532 548M 5 1 326.809 336.483 251.0
63 253.30661062337473 610 950M 5 0 332.138 105.156 164.472 195.47861062437474 405 850M 5 0 47.226 219.546 349.476 29.948610624
37474 645 712M 5 1 143.967 160.292 12.174 16.01161062437474 812 846M 5 1 196.570 217.127 24.542 29.37961070637486 9351016M
5 0 254.840 279.630 319.307 325.09961080737518 420 509M 5 0 205.725 235.351 310.458 317.39261080737518 420 509M 5 1 205.725 235
.351 310.458 317.3926206143782910051105M 5 0 26.425 62.698 242.947 251.3916206143782910251040M 5 1 38.516 47.584 245.763 247
.8746206143782910401045M 5 2 47.584 50.607 247.874 248.5776206143782910451105M 5 1 50.607 62.698 248.577 251.39162061737832 1
0001100M 5 0 115.085 151.358 132.248 140.7926206173783210001050M 5 1 115.085 145.313 132.248 139.3886206173783210551100M 5 1 1
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36.108 336.8096206183783310161018M 5 2 275.324 276.535 337.651 337.9326206183783310271109M 5 1 281.974 307.366 339.195 345.09262
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5M 5 1 345.276 12.482 223.678 230.0246206213783610251030M 5 2 12.482 15.504 230.024 230.72862062337838 5251126M 5 0 132.260
350.518 234.565 285.27262062337838 604 609M 5 2 155.847 158.870 240.056 240.76062062337838 622 627M 5 2 166.729 169.752 242.589
243.29262062337838 645 650M 5 3 180.634 183.657 245.624 246.52762062337838 700 720M 5 2 189.703 201.794 247.934 250.74562062337
838 734 739M 5 2 210.258 213.281 252.713 253.41662062337838 908 918M 5 1 267.088 273.133 265.915 267.31862062337838 927 932M 5
3 278.574 281.597 268.581 269.28362062337838 945 950M 5 1 289.457 292.479 271.107 271.80862062737842 9001030M 5 0 144.800 199.0
12 358.052 10.73162062837843 820 910M 5 0 271.010 301.239 196.753 203.82562062837843 841 856M 5 1 283.706 292.775 199.724 201.8
4562062837843 905 910M 5 1 298.216 301.239 203.118 203.82562062937844 5051130M 5 0 303.713 176.477 11.785 60.29362062937844 50
5 523M 5 2 303.713 314.596 11.785 14.32462062937844 710 750M 5 3 19.286 43.469 29.438 35.09662070137846 9301110M 5 0 45
.129 105.588 96.544 110.78962070337848 520 610M 5 0 195.194 225.423 108.327 115.45162070337848 9301125M 5 0 346.341 55.869 143
.933 160.28762070437849 555 905M 5 0 6.964 121.836 316.624 343.30762070437849 640 645M 5 1 34.171 37.194 322.938 323.8406207
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5 2 77.097 80.119 332.907 333.61062070437849 806 816M 5 1 86.165 92.211 335.014 336.41962070437849 825 830M 5 1 97.653 1
00.676 337.684 338.38762070437849 835 903M 5 1 103.699 120.627 339.090 343.02662070537850 530 645M 5 0 142.461 187.800 157.129 1
67.78362070737852 5051215M 5 0 68.578 326.555 200.763 261.29562070737852 538 555M 5 2 86.530 96.808 205.425 207.8266207073785
2 600 605M 5 2 101.831 104.854 208.532 209.23662070737852 605 608M 5 1 104.854 106.068 209.236 209.66162070737852 623 625M 5 2
115.737 116.946 211.778 212.06062070737852 625 640M 5 1 116.946 126.015 212.060 214.17662070737852 645 655M 5 1 129.038 135.084
214.881 216.29262070737852 721 725M 5 2 150.803 153.222 219.957 220.52162070737852 725 730M 5 1 153.222 156.245 220.521 221.226
62070737852 730 735M 5 2 156.245 159.268 221.226 221.93062070737852 735 745M 5 1 159.268 165.314 221.930 223.33962070737852 745
750M 5 2 165.314 168.337 223.339 224.04462070737852 815 825M 5 1 183.452 189.498 227.565 228.97362070737852 825 835M 5 2 189.4
98 195.544 228.973 230.38062070737852 835 843M 5 1 195.544 200.380 230.380 231.50662070737852 857 859M 5 2 208.845 210.054 233.4
76 233.75862070737852 957 959M 5 2 245.121 246.330 241.914 242.1906207073785210201025M 5 1 259.026 262.049 245.147 245.85062070 7
3785210531055M 5 1 278.978 280.187 249.783 250.0646207073785211241127M 5 2 297.720 299.534 254.136 254.55862070837853 4401005M
5 0 204.083 40.578 39.857 86.04462070837853 801 804M 5 1 325.607 327.421 68.598 68.82462070837853 818 820M 5 1 335.885 337
.095 70.816 71.10062070837853 825 827M 5 1 340.118 341.327 71.811 72.09862070837853 837 845M 5 1 347.373 352.209 73.518 74
.65762070837853 850 855M 5 1 355.233 358.256 75.368 76.0806207083785310451140M 5 0 64.761 98.014 91.741 99.57562070937854
500 700M 5 0 6.797 79.349 246.949 263.795

FILE 2 RECORD 1144 1624 BYTES


7108074117122202400T 30  0 235.227 295.673 267.944 282.18571080841171   0 420T 30  0 295.673  92.831 282.185 319.19171080841172222152
400T 30  0  22.621  86.089 110.691 125.41071080941172   0 140T 30  0  86.089 146.535 125.410 139.44071080941173232024 00T 30  0 212.3
24 236.502 323.698 329.38071081041173   0 400T 30  0 236.502  21.571 329.380   3.39371082341187230024 00T 30  0 145.711 181.976 288.3
50 296.88771082441187   0 335T 30  0 181.976 311.927 296.887 327.43071082541188  40 330T 30  0 356.524  99.276 145.307 169.252710825
4118922202400T 30  0  62.272 122.715 329.717 343.88171082641189   0 210T 30  0 122.715 201.289 343.881   2.25271082841191  20 210T 3
0  0  75.531 142.017  33.373  48.81871082841192234024 00T 30  0 201.715 213.804 230.474 233.31871082941192   0 315T 30  0 213.804 331
.665 233.318 261.06971083041194222523 30T 30  0  97.098 136.385 266.909 276.16271083141194  10 250T 30  0 160.562 257.268 281.055 304
.60871083141195234524 00T 30  0 295.805 304.871 121.242 123.34871090141195   0 245T 30  0 304.871  44.599 123.348 146.53871090241196
130 200T 30  0 149.620 167.752 340.183 344.42671090241197221024 00T 30  0 179.087 245.572 154.399 169.91771090341197   0 310T 30  0 2
45.572   0.410 169.917 196.80071090341198234524 00T 30  0  26.853  35.919  12.047  14.15971090441198   0 150T 30  0  35.919 102.404
14.159  29.62671090541199   0 150T 30  0 186.264 252.749 216.787 232.42671090541200223024 00T 30  0 282.210 336.607  47.967  60.58271
090641200   0 250T 30  0 336.607  79.356  60.582  84.39771090741202235024 00T 30  0 271.242 277.287 105.503 106.90671090841202   0 25
0T 30  0 277.287  20.035 106.906 130.771