HEINRICH-HERTZ-INSTITUT FÜR SCHWINGUNGSFORSCHUNG
BERLIN-CHARLOTTENBURG

Technischer Bericht Nr. 154

Results of Statistical Evaluations of Photographic Records of VLF-Atmospherics Parameters Supplemented by Monthly Averaged Values of Azimuthal Dependent Atmospherics Rates

(Ergänzung der Ergebnisse statistischer Auswertungen fotografischer Registrierungen von VLF-Atmosphericsparametern durch Monatsmittelwerte richtungsabhängiger Atmosphericsraten)

von

Ing. grad. G. Heydt

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Zusammenfassung:

In diesem Bericht werden die Ergebnisse von mittels Peilungen und Gruppenlaufzeitdifferenz-Messungen erhaltenen Ortungen von Quellgebieten der Atmosphericsaktivität gezeigt. Die Ergebnisse wurden für vier winterliche und für vier sommerliche Monate auf Weltkarten zusammengefaßt, auf denen sich Quellgebiete der Atmosphericsaktivität deutlich abzeichnen.
Zur quantitativen Ergänzung dieser Ergebnisse wird der Tagesgang von monatlich gemittelten Raten von Atmospherics gezeigt, deren Einfallsrichtung den jeweiligen Quellgebieten entspricht.
Die sehr unterschiedlichen Tagesgänge weisen darauf hin, daß Atmospherics im Bereich des Amazonas, in Mittelamerika und in Westafrika vorwiegend bei Wärmegewittern erzeugt werden, während die Atmosphericserzeugung im Bereich der nordamerikanischen Ostküste und im Mittelmeergebiet im Winter mit Frontgewittern zusammenhängt.
Mit Hilfe dieser Ergebnisse läßt sich der monatlich gemittelte Tagesgang der "Rundum"-Aktivität zwanglos erklären.
Die Atmosphericsraten aus einer jeweils 25-tägigen Beobachtungsperiode im Feb./März 1971 und zum gleichen Zeitraum des Jahres 1972 wurden ebenfalls gemittelt. Die Tagesgänge dieser Atmosphericsraten zeigen in den verschiedenen Richtungssektoren in beiden Jahren eine sehr ähnliche Charakteristik; sie unterscheiden sich jedoch hinsichtlich der Absolutwerte der Raten zum Teil beträchtlich.
Die hier vorgelegten Auswertungen beruhen überwiegend auf Messungen der Berliner Station des weltweiten VLF-Atmospherics-Analysator Stationsnetzes.
Der Bericht ist in englischer Sprache verfaßt, um den Meinungsaustausch mit ausländischen Fachkollegen zu erleichtern.

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Results of Statistical Evaluations of Photographic Records of VLF-Atmospherics Parameters Supplemented by Monthly Averaged Values of Azimuthal Dependent Atmospherics Rates

by G. Heydt

Summary:

This report presents results of localizations of sources of the atmospherics activity by means of direction finding and of measurements of group delay differences. The results obtained from observation periods of four months in the winter and in the summer respectively were collected on world maps. Marked areas of sources of the atmospherics activity are shown by these maps.
A quantitative supplement of these results is given in form of monthly averaged atmospherics rates which were measured as functions of the azimuth.
There are different characteristics of the diurnal variations of these rates which correspond to the respective areas of atmospherics sources. This points to the fact that atmospherics coming from the Amazonas region, from Central America and from Western Africa are mainly caused by heat storms, whereas atmospherics coming from the East coast of North America and from the Mediterranean are due to lightnings occuring at front storms.
By means of these results the monthly averaged diurnal variation of the all-around activity can be easily explained.
Averaged atmospherics rates of an observation period from 11. Feb. - 6. March 1971 were compared with rates obtained from the same period of 1972. The characteristics of the diurnal variations of the sector rates are quite similar in both years, but there were found considerable differences in the absolute values of the rates.
The evaluations given by this report are mainly based on data recorded at the Berlin station of the global VLF-Atmospherics-Analyser Network.

1. Introduction

The Atmospherics-Analyser Network with stations in the USA, in Japan, in Argentina and in Germany was established in Dec. 1970 and has since been operated.
Photographic records of the direction of arrival γ, of the spectral amplitude (SA) at 7 kHz, of the spectral amplitude ratio (SAR) between 9 and 5 kHz and of the group delay difference (GDD) between 8 and 6 kHz of VLF-Atmospherics are carried out as described by Heydt (1971).
Additionally, measurements of atmospherics rates as functions of the azimuth are executed at the stations. A description of this kind of records was given by Heydt (1972).
The main application field of the photographic records is the position finding of atmospherics sources. In doing so, it is impossible to derive reliable data of the pulse rates caused by the different sources. On the other hand, it is impossible too to derive reliable distance data from the records of atmospherics rates. These records merely allow a coarse distinction between pulse rates caused by near and by far sources.
These circumstances suggest an attempt to combine the results of the evaluations of the two kinds of records. This report gives first results of this attempt. The evaluation work has been done in a statistical way in order to obtain a general survey of the variations of the measured atmospherics parameters with respect to both daytime and season.
The results obtained in such a statistical way may be an important basis for the analysis of single events (Heydt and Raupach, 1972).
At the present state of our evaluation it seems to be useful to gain some first results in order to derive guiding principles for a more systematical evaluation. For that reason most of the data used in this report are data derived from observations of the Berlin station. These data are the most complete ones (HHI, 1972) and well prepared for data processing. To avoid the difficulties in interpreting the activity of near sources because of the multi-mode-propagation (Harth,1971), the evaluations were mainly concentrated on the winter and spring season.

2. Review on the All-around Activity

Besides the measurements of azimuthal dependent atmospherics rates the Atmospherics Analyser enables measurements of the all-around atmospherics rate. This rate we call the rate AN. The counting threshold at the recording of this rate is 0.8 µV/Hz·m at 5 kHz.
In accordance to the statistical way of evaluation we computed monthly average values of the all-around activity as functions of the day-time. These average values we call $\overline{AN}$.
Fig.1 shows these rates $\overline{AN}$ on five diagrams corresponding to the five months Dec. 1970 till Apr. 1971. The main feature of these curves is the well-known minimum of activity about local noon. It may be assumed that the slope down during the morning hours is mainly due to the increasing propagation attenuation which occurs when the propagation paths get under day-time conditions. Accordingly, the begin of this slope shifts from about 700 GMT in December to about 400 GMT in April due to the seasonal variation of the length of the day-time. Another feature of the curves is the maximum at about 2100 GMT which appears during the winter months. During March and April this maximum seems to be covered by some other activities.Of course, similar records have been carried out formerly by means of more simple constructed instruments. The special ability of the Atmospherics Analyser is to separate the contributions of different sources to the all-around atmospherics activity. This will be shown in the following sections.

3. Experiments in Localizing Centers of the Sources of the Atmospherics Activity by Means of Direction Finding and of GDD-Measurements

In 1971, the author of these lines made a first attempt to localize atmospherics sources by means of first observations of the new Atmospherics Analyser Network (Heydt,1971). Using a simple one-mode-propagation model, the data of cluster centers on photographic GDD-γ records were transferred to world maps. The cluster centers were plotted as little squares the size of which gave a coarse indication of the pulse rate coming from the source. This kind of graphic presentation has been carried on using the data obtained during 1971.

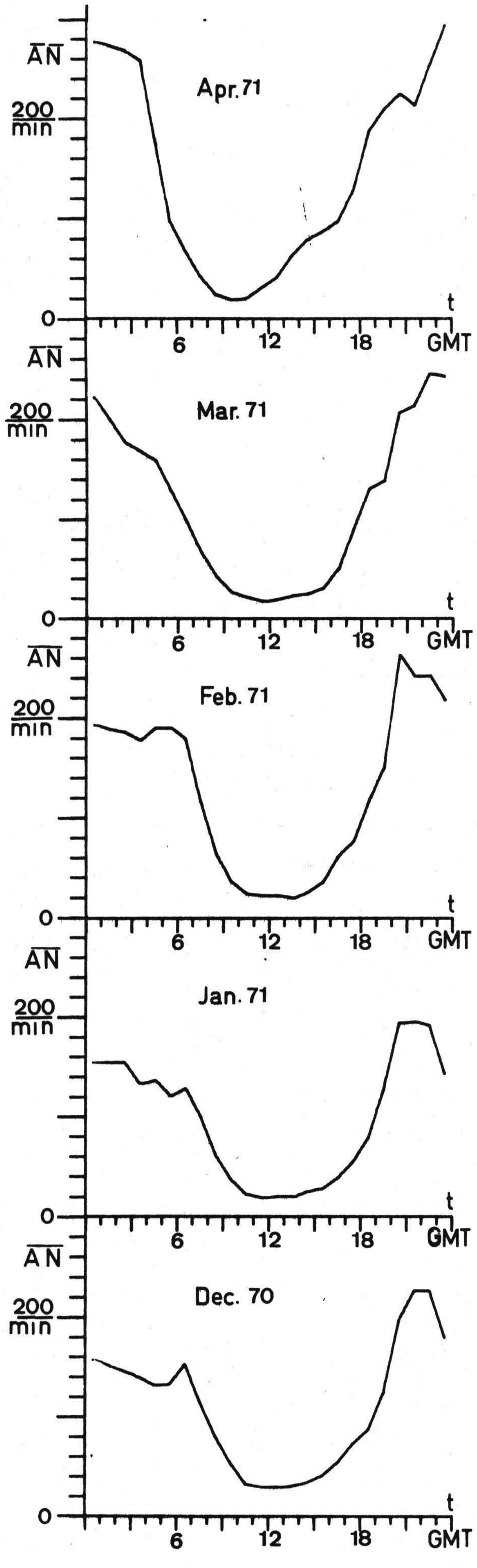

Fig. 1: Monthly averaged all-around activity as functions of day-time

In order to get a review on the atmospherics activity of the winter season, all localizations which were obtained between Dec. 1., 1970 and March 31., 1971 at the same observation time were collected on one map, respectively. The position of the boundary between day and night of the longest and of the shortest duration of daylight during this observation period were plotted on the maps.

Let us assume that these localizations somewhat conform to the real position of the atmospherics sources. Thus, a survey of Fig. 2 - 6 leads to the following results:

a) There are some regions where at certain observation times the localizations are considerably clustered so that the squares are frequently overlapping one another. This is the case at an area at West Africa (Fig.2, 1800 GMT), at the Amazonas region (Fig. 3, 2100 GMT), and at a region at the Gulfe of Panama (Fig. 3 and 4, 2100 and 0000 GMT). In all these cases the sunset was near to the sources. Generally, the activity at these regions is found considerably decreased at the next observation time i.e. after three hours.

b) There are some other regions where the activity is observed for more than one observation time and where the localizations look somewhat diffuse compared to the activity at the regions mentioned above. Regions of this kind are the Northern and the Southern Atlantic, the Atlantic coast of North America and the surroundings of the Mediterranean.

c) A region with lacking atmospherics sources situated obviously within the receiving range of the Berlin station is found at all observation times at the middle of the Atlantic (20^{o}N, 40^{o} W).

It should be a task for experts in climatology to decide whether these localizations of atmospherics sources are in conformity with the present knowlegde of this science. For us as non-experts in climatology they seem to be quite reasonable.

However, although these plots give a perceivable impression of the regions of atmospherics sources they yield no reliable quantitative of the number of atmospherics which were received from the different regions. Moreover, the observation intervals of three hours are too apart to allow a resonable monitoring of

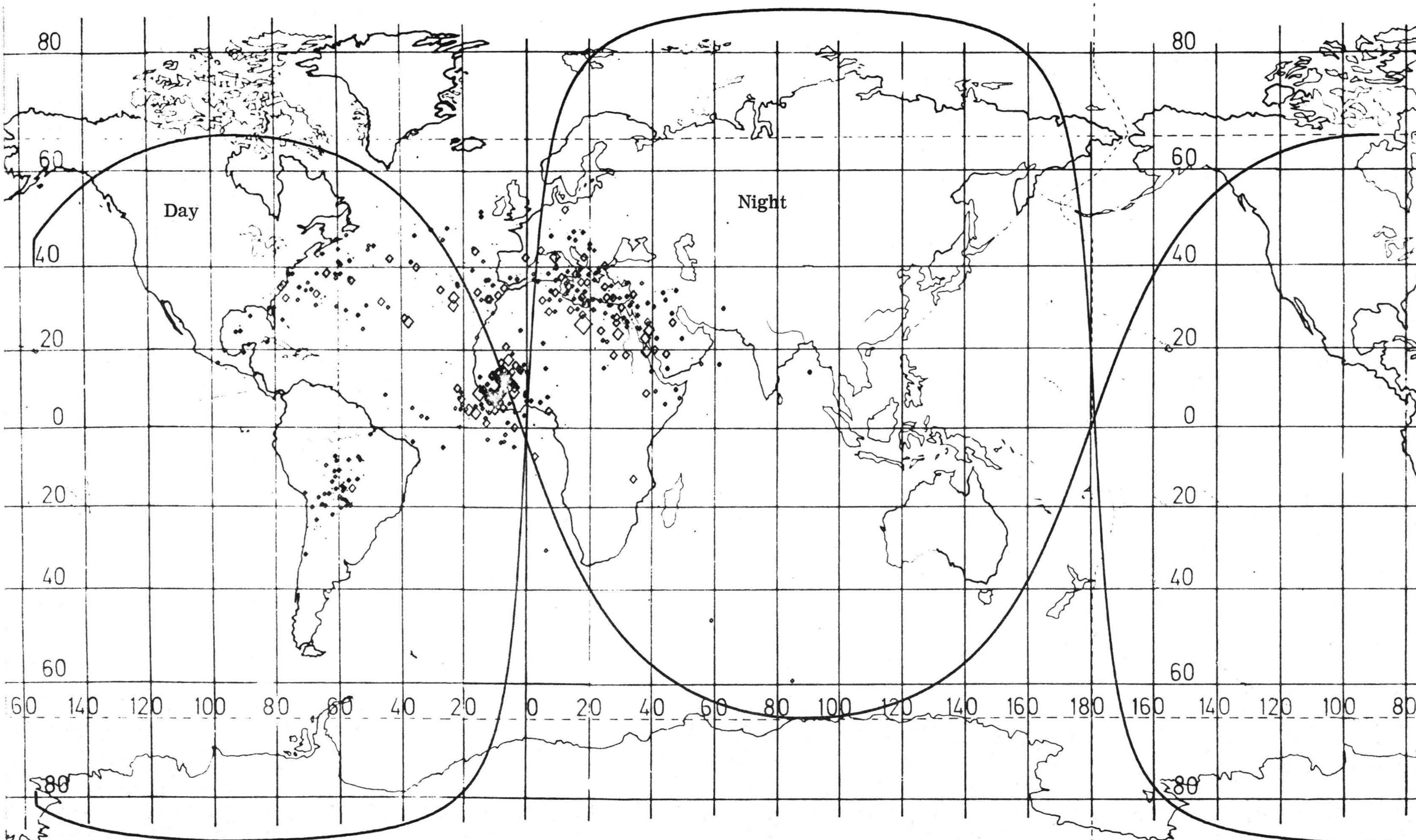

Fig. 2: GDD - γ localizations, Berlin, 1.12.70 - 31.3.71, 1800 GMT

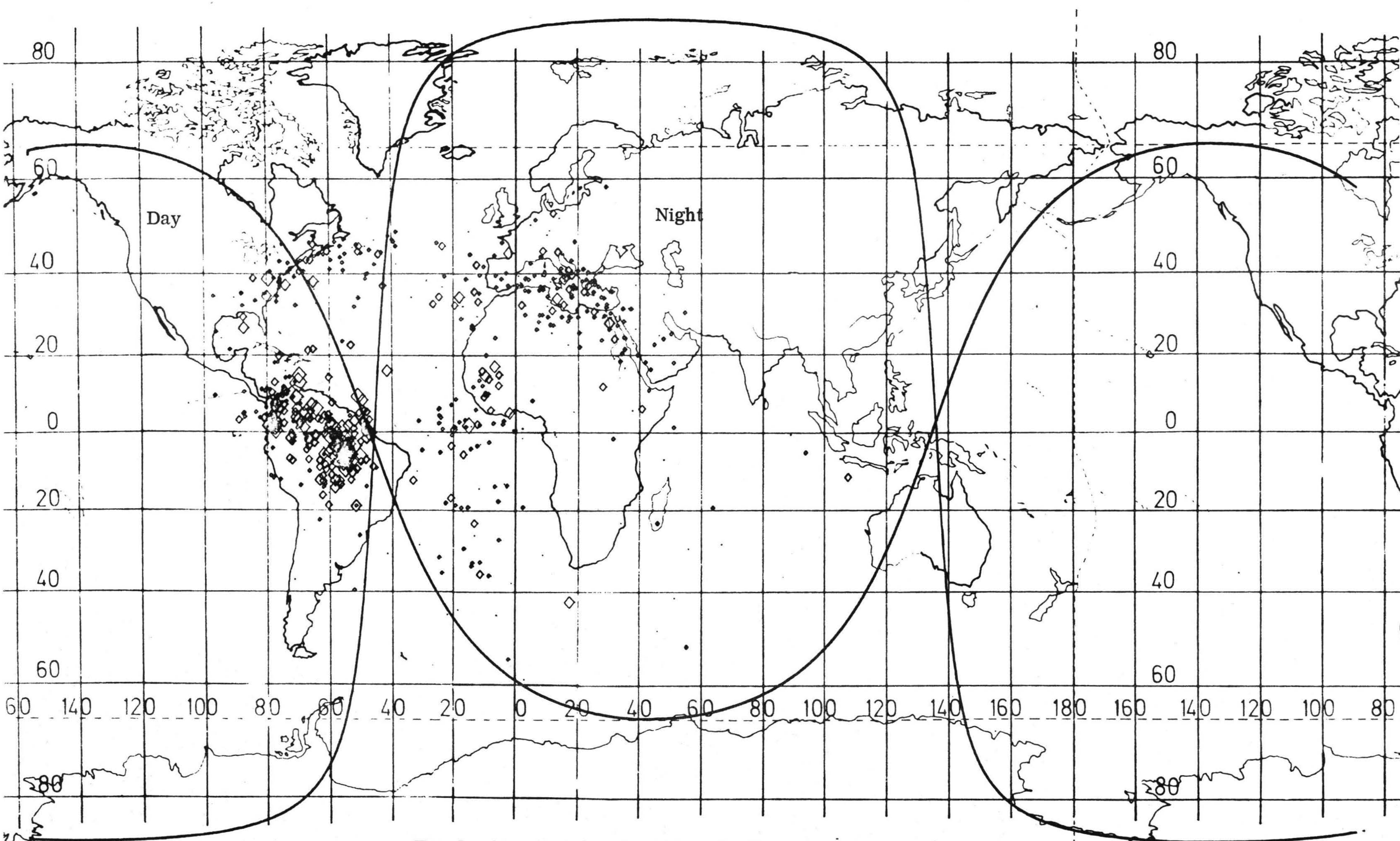

Fig. 3: GDD - γ localizations, Berlin, 1.12.70 - 31.3.71, 2100 GMT

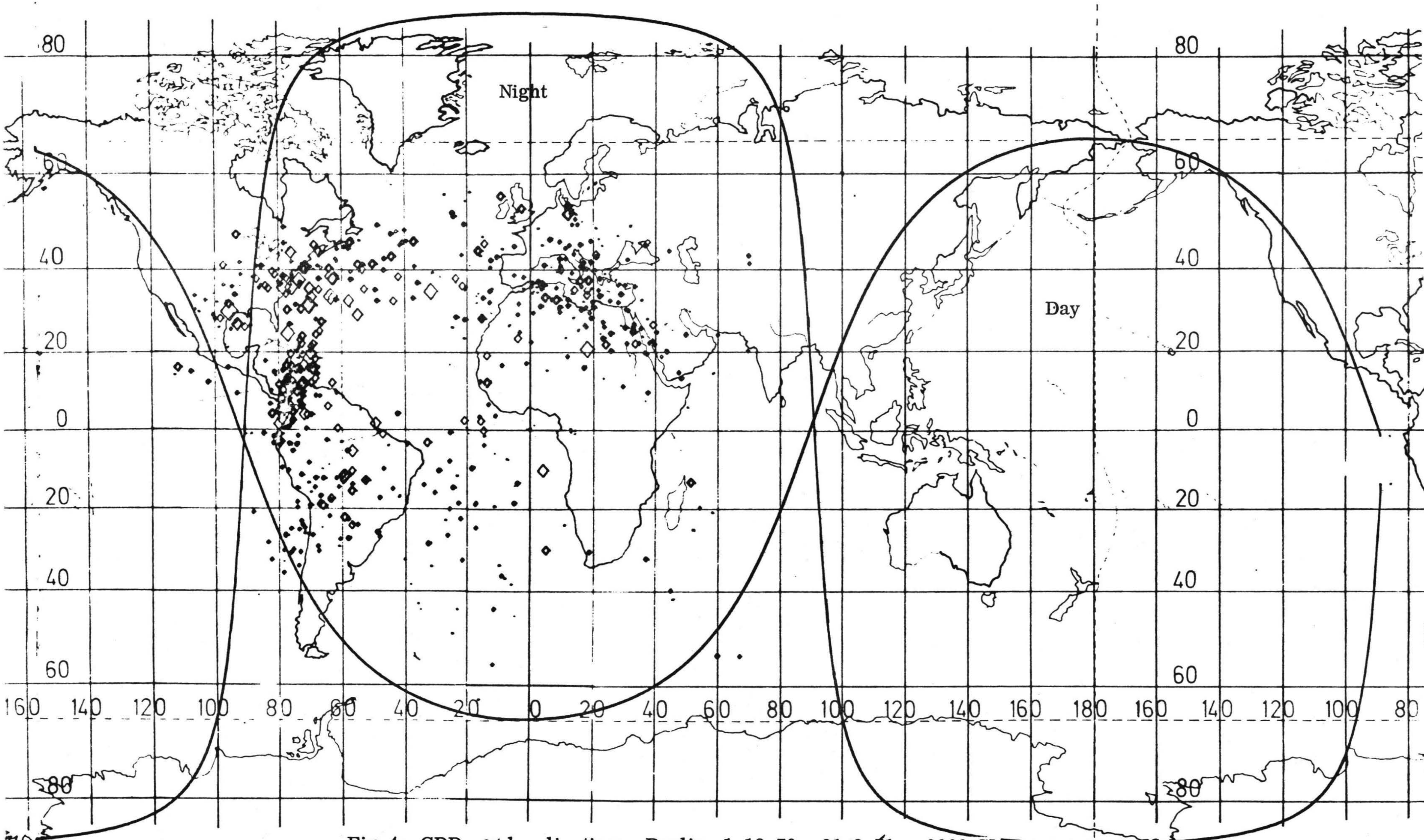

Fig. 4: GDD - γ localizations, Berlin, 1.12.70 - 31.3.71, 0000 GMT

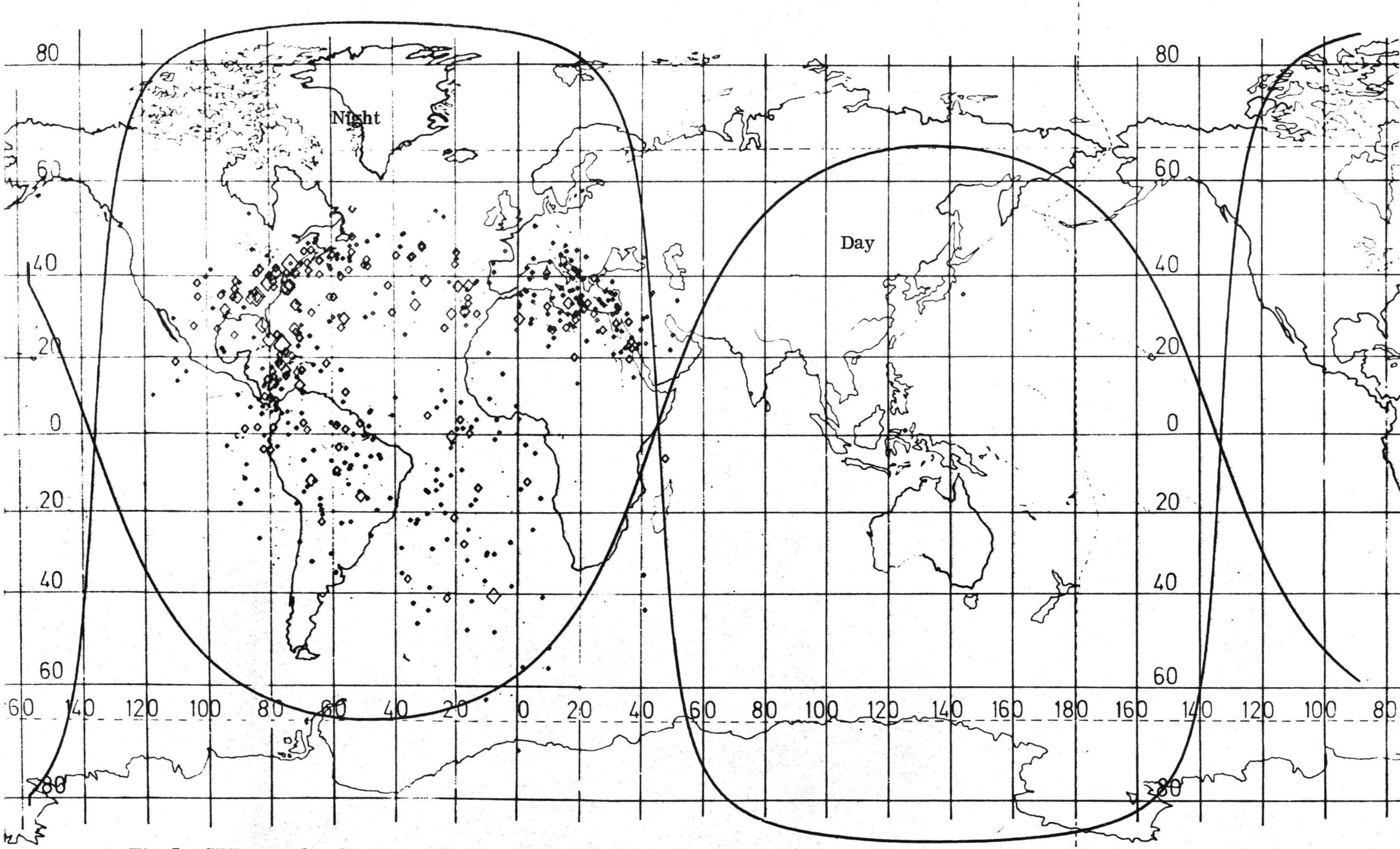

Fig. 5: GDD - γ localizations, Berlin, 1.12.70 - 31.3.71, 0300 GMT

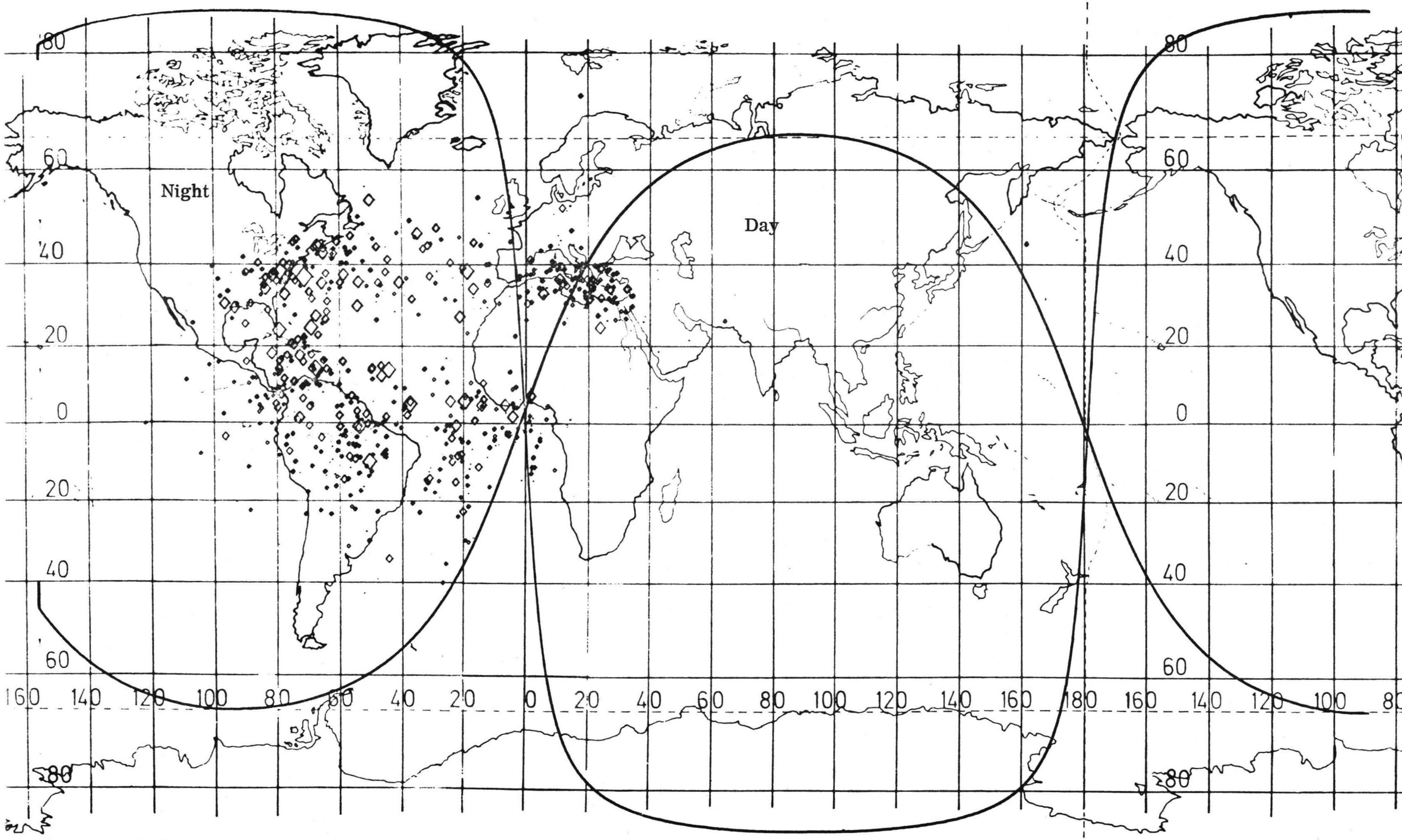

Fig. 6: GDD - γ localizations , Berlin , 1.12.70 - 31.3.71 , 0600 GMT

the diurnal variation of the atmospherics activity of the different regions. For that reason, the results of statistical evaluations of azimuthal dependent atmospherics rates should be applied to this problem.

4. Results of Statistical Evaluations of Azimuthal Dependent Atmospherics Rates

4.1. Description of the Different Atmospherics Rates

The measurements of atmospherics rates as functions of the azimuth are executed automatically by the Atmospherics Analyser by means of a special sector selector circuit. In this mode of operation, a sector with a width of 12^{o} is switched step-by-step every two minutes with steps of 12^{o}. Thus, the horizon is sampled in one hour and a counting of atmospherics rates as functions of the azimuth becomes possible.

There are three different kinds of atmospherics rates measured by the Atmospherics Analyser, besides the all-around rate AN:

a) The total number of atmospherics exceeding the threshold of 0.8 μV/Hz·m at 5 kHz <u>and</u> coming from the preselected sector. This number, related to the time unit of one minute, we call the rate N.

b) The number of atmospherics exceeding the same threshold <u>and</u> coming from the same sector <u>and</u> having a GDD lower than 150 μsec. This number, related to the time unit of one minute, we call the rate NN. In this report, we will make use of the difference of the two mentioned rates. This difference i.e. the rate of atmospherics with a GDD $>$150 μsec we call the rate FN.
Thus, $FN = N - NN$.
It may be assumed that the rate FN is mainly indicating atmospherics coming from far sources.
Fig.7 shows a world map with thirty great circle lines crossing at Berlin. These lines correspond to the limits of the thirty sectors which are successively scanned. Additionally, two boundaries valid for GDD = 150 μsec were plotted on the map using the one-mode-propagation model for day-time and for night-time conditions. A cluster with a symmetrical shape of its GDD distribution function will cause a ratio FN/N of 0.5 if its mean value of GDD is just 150 μsec.

c) A third atmospherics rate measured as functions of the azimuth and with the same threshold as the rates mentioned above is the rate FA. This rate depends on the ratio of the spectral amplitudes at 9 kHz (A_9) and at 5 kHz (A_5) as follows:

$$FA = \frac{0.13 \cdot \sum_{n=1}^{n=n_{tot}} \frac{A_9(n)}{A_5(n)}}{2 \cdot min}$$

where n_{tot} is the total number of atmospherics which occur during the scanning period of two minutes. Since the total number of atmospherics is determined by the rate N, one can derive the average value of A_9/A_5 by dividing the rate FA by the rate N :

$$\overline{\frac{A_9}{A_5}} \approx 6 \cdot \frac{FA}{N}$$

It must be pointed out that this average value of the amplitude ratios is not identical with the mean value of the amplitude ratio SAR which is read from the photographic records. The reason why there is a difference is that SAR is measured on a logarithmic scale, whereas the ratio A_9/A_5 is valued in a linear way.

However, the main purpose of the rate FA is to find out whether there is a possibility to compensate the influence of the variations of the propagation attenuation. In section 4.4.3. we will show a result of this compensation effect.

The atmospherics rates mentioned above are indicated by means of d.c. voltages by the Atmospherics Analyser. Thus, a continuous observation of the rates by means of strip chart recorders is possible and executed at the stations. In Berlin, the information is stored additionally on magnetic tape by means of a special data recording system. At present, data of the period from 1.12.70 till 30.4.71 have been stored by this system and have been prepared for data processing and evaluation.

4.2. Monthly Averaged Atmospherics Rates

Besides tables of the rates N, FN and FA as functions of the azimuth and as functions of the day-time for every day of the observation period, tables of monthly averaged rates $\overline{N}$, $\overline{FN}$ and $\overline{FA}$ have been computed. These tables are shown in the appendix.

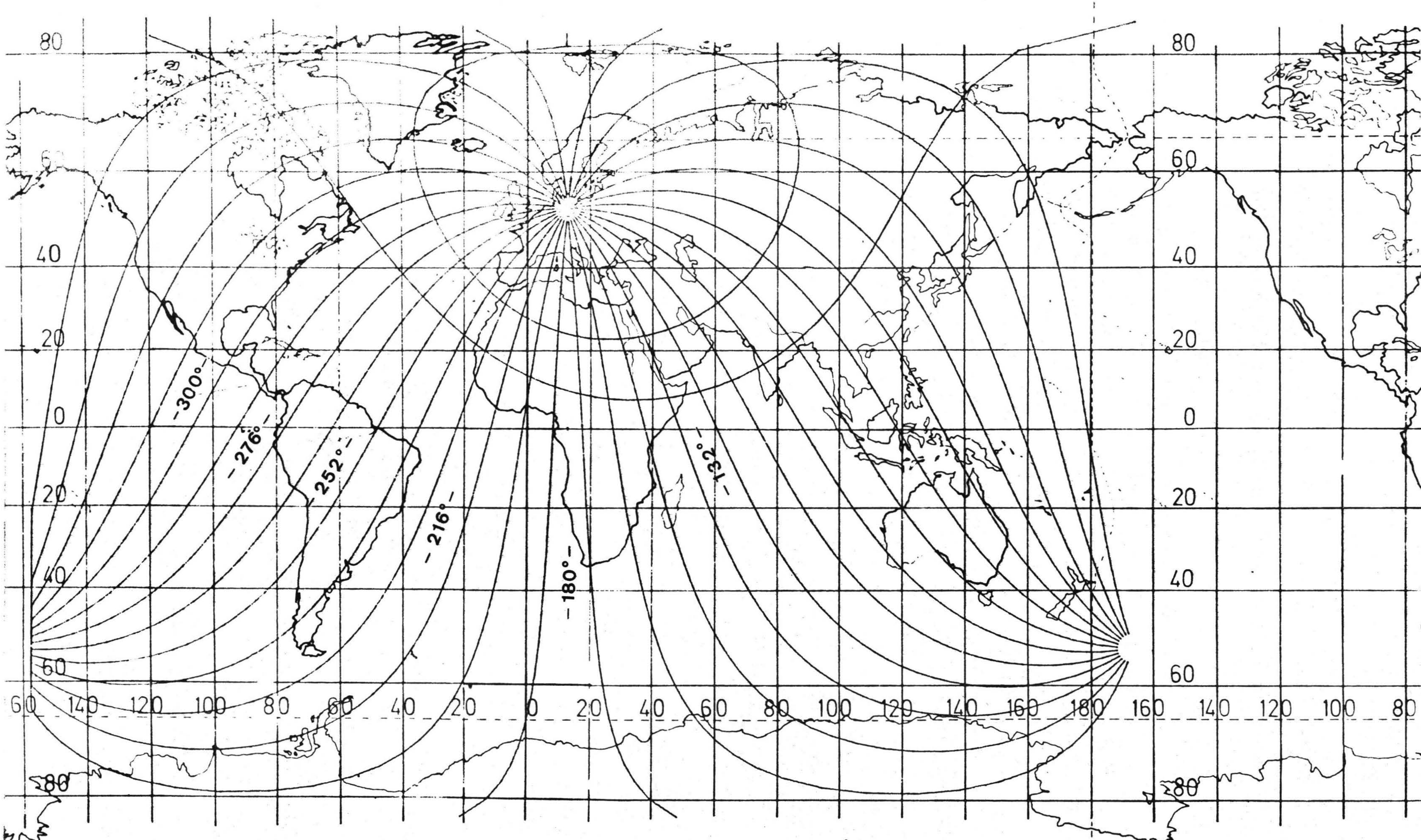

Fig. 7: World map with sector limits and boundaries between "near" and "far" sources

The following hints are given to facilitate the reading of the tables:

a) The abbreviations shown by the first line of the head of the tables mean the chief points of the compass.
b) The figures given in the three subsequent lines must be read in a vertical sequence. These figures indicate the center of the respective sector in degree. Or, to give an example, the figure combination $\begin{smallmatrix}2\\1\\6\end{smallmatrix}$ in these lines heads the column which gives the atmospherics rates of the sector centered on 216°.
c) The hourly rates are measured during time intervals (GMT) which are printed at the left side of the tables. The exact moment of the scanning time of a sector depends on the value of the sector center itself. The sector centered on 96° is scanned during the first two minutes of every hour. The scanning of the next sectors follows in succession every two minutes so that the sector centered on 84° is the last one of the hour.
d) In the tables, the rates are given in number/minutes. In the case of the rate FA the rates are valued by the amplitude ratios A_9/A_5 of course.
f) Between 0100 - 0200 GMT, a calibration of the Atmospherics Analyser is executed automatically. Thus, no rates are given by the tables at this time interval. In the case of using the figures of the tables for plotting diagrams, the rates of the calibration hour were found by interpolation between the rates of the preceding and of the subsequent hour in order to get coherent curves.

4.3. Monthly Averaged Atmospherics Rates of Selected Sectors of the Azimuth as Functions of Day-time

In accordance to the localizations of atmospherics sources as shown by Fig. 2 - 6 , monthly averaged atmospherics rates of six selected sectors have been plotted as functions of the day-time of the months Dec.70 - Apr.71 using the tables mentioned above.

4.3.1. Atmospherics Rates $\overline{FN}$ of the sector centered on 252° (Amazonas Region)

As Fig.7 shows, this sector points just to the Amazonas region.

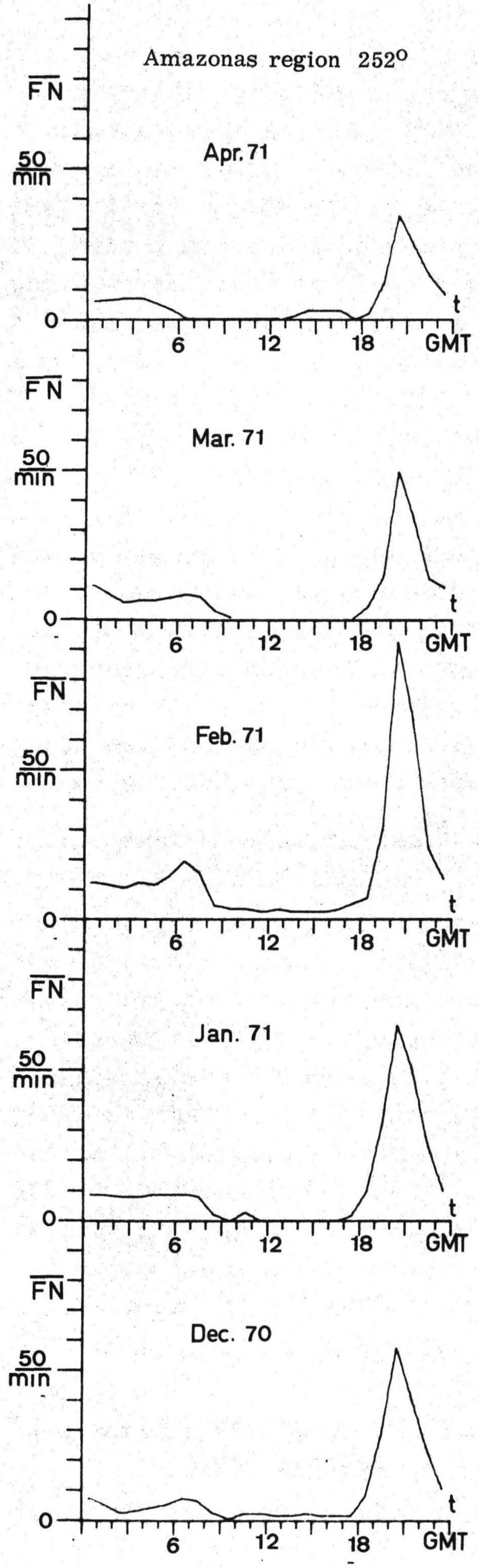

Fig. 8: Rates $\overline{FN}$ of the sector 252°

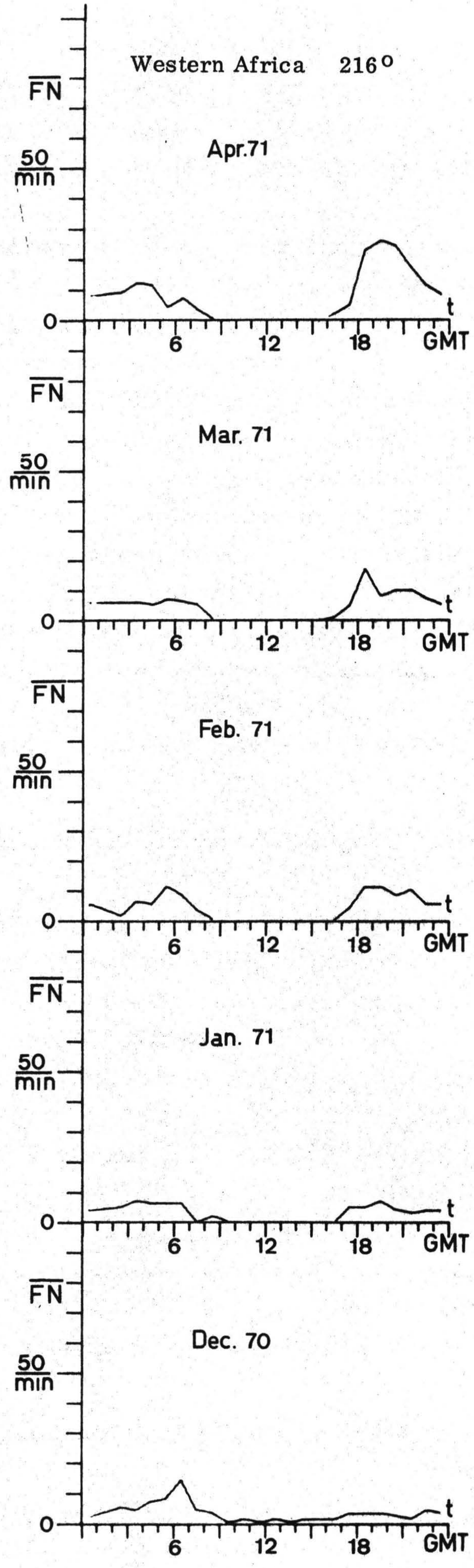

Fig. 9: Rates $\overline{FN}$ of the sector 216°

In accordance with Fig.3, this region is a very active source of atmospherics at about 2100 GMT. The rate FN ("Far activity") was used in order to avoid contributions of near sources to this part of the sector activity.
The main features of the five diagrams of Fig.8 are the marked peaks which occur at the observation interval 2000 - 2100 GMT. A simple explanation for this sharp maximum is the assumption that it is caused by the combination of two effects.
The slope up is probably due to the decreasing attenuation which occurs when the propagation path gets gradually under night-time conditions. The slope down is probably caused by a decrease of the lightning activity during the local evening hours at the source region. During the hours after the maximum, the atmospherics rates coming from this sector remain at a rather low level till the propagation path gets under day-time conditions again.
Obviously, the highest averaged rates occur during February. There is a distinct decrease of the peak rates of March and of April compared to the February rates, and the rates of January and of December are lower too.

4.3.2. Atmospherics Rates $\overline{FN}$ of the Sector Centered on 216° (Western Africa)

The averaged atmospherics rates $\overline{FN}$ shown by Fig. 9 are mainly caused by atmospherics coming from a sector which points at a region at the West African coast at about Guinea. This region was shown by Fig. 2 as a active one at 1800 GMT.
Looking on the diagrams of Fig.9 we find times of the highest rates at the interval of 1800 - 1900 or 1900 - 2000 GMT in March and in April,respectively. On the diagrams of February and of April, this maximum is very weak and on the December diagram, the maximum is completely vanished. The highest maximum we find on the April diagram but it must be stated that this maximum is not so sharp as the 2100 GMT maximum of the 252° sector. For the rest, the April diagrams of the two sectors look rather similar.

4.3.3. Atmospherics Rates $\overline{FN}$ of the Sector Centered on 276° (Central America)

Fig.3 and Fig.4 show atmospherics sources clustered in a region

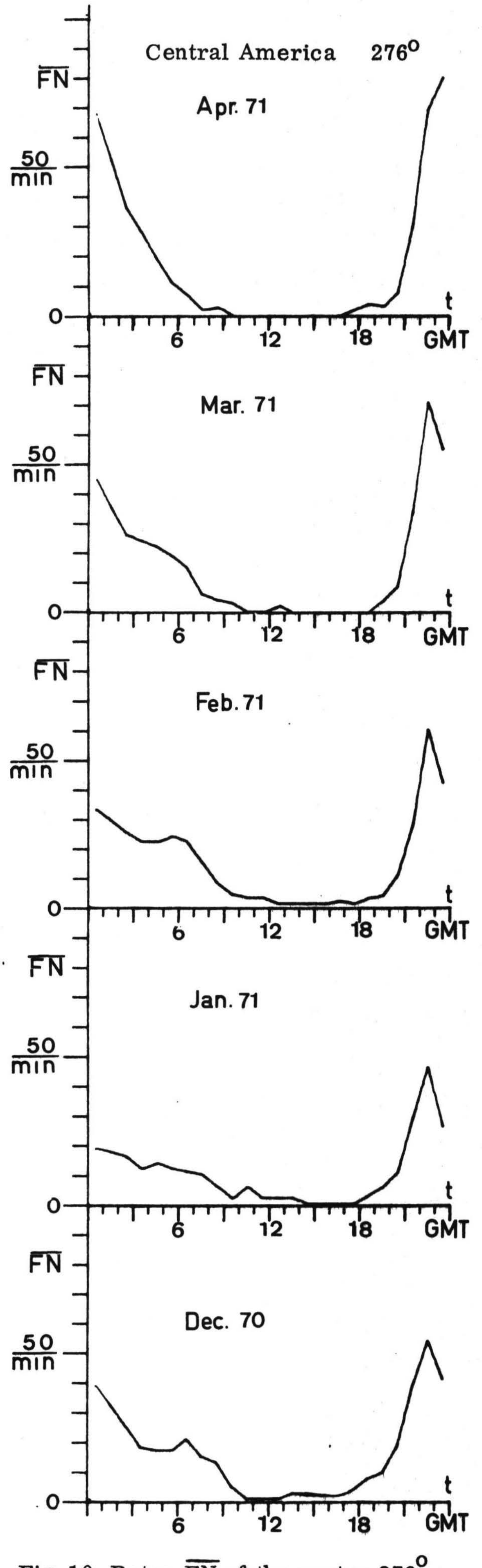

Fig. 10: Rates $\overline{FN}$ of the sector 276°

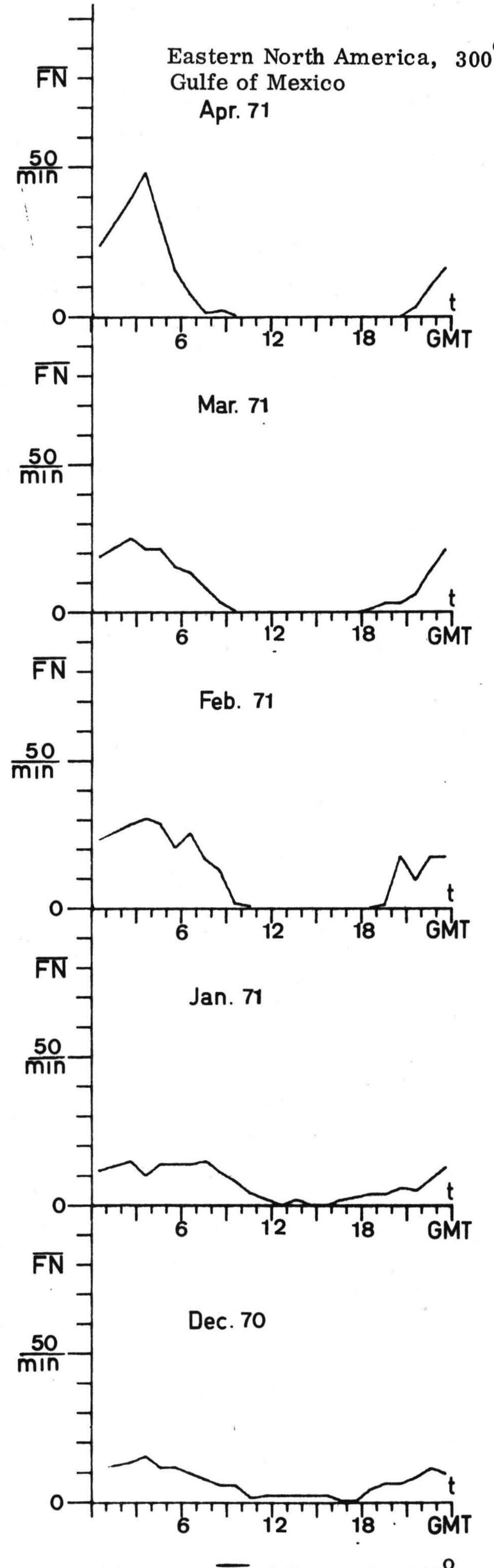

Fig. 11: Rates $\overline{FN}$ of the sector 300°

at the Gulfe of Panama at 2100 and at 0000 GMT, respectively. The sector which corresponds to this region is the sector centered on 276°. The diagrams of Fig.10 show the rates $\overline{FN}$ of this sector. During December - March, these diagrams show a marked peak at the interval 2200 - 2300 GMT. In April, the maximum occurs at 2300 - 2400 GMT and it appears to be not so very sharp. During December - March, the rate level after the maximum is rather high compared to the shape of the curves of Fig.8.

4.3.4. Atmospherics Rates $\overline{FN}$ of the Sector Centered on 300° (Eastern North America, Gulfe of Mexico)

This sector includes the eastern part of North America and the Gulfe of Panama. It can be stated that the diagrams of the months December - March shown by Fig.11 show no marked maximum during the hours with night-time propagation conditions. Only on the April diagram appears a peak at the interval 0300 - 0400 GMT, but the slope down of this maximum is probably due to increasing propagation attenuation and not due to decreasing source activity.

4.3.5. Atmospherics Rates $\overline{N}$ of the Sector Centered on 180° (Mediterranean)

Following Fig.2-6, the main region of atmospherics sources southern of Berlin during the winter is the region of the Mediterranean. The diagrams of Fig.12 show the rates $\overline{N}$ of that sector that points from Berlin just to the South. All these diagrams show rather low rates and no marked diurnal or seasonal variations.

4.3.6. Atmospherics Rates of the Sector centered on 132° (Hither Asia)

The rates which were received coming from this sector are rather low during December - March. During March and April, a flat maximum occurs at the interval 1800 - 1900 GMT. Fig.2 shows the most of the localizations within this sector being in Hither Asia.

4.4. Summary of Informations Derived from Fig.8-13

4.4.1. Types of Diurnal Variations of the Sector Activity

Obviously, there are two different types of the diurnal variations of the atmospherics rates which occur within the different sectors.

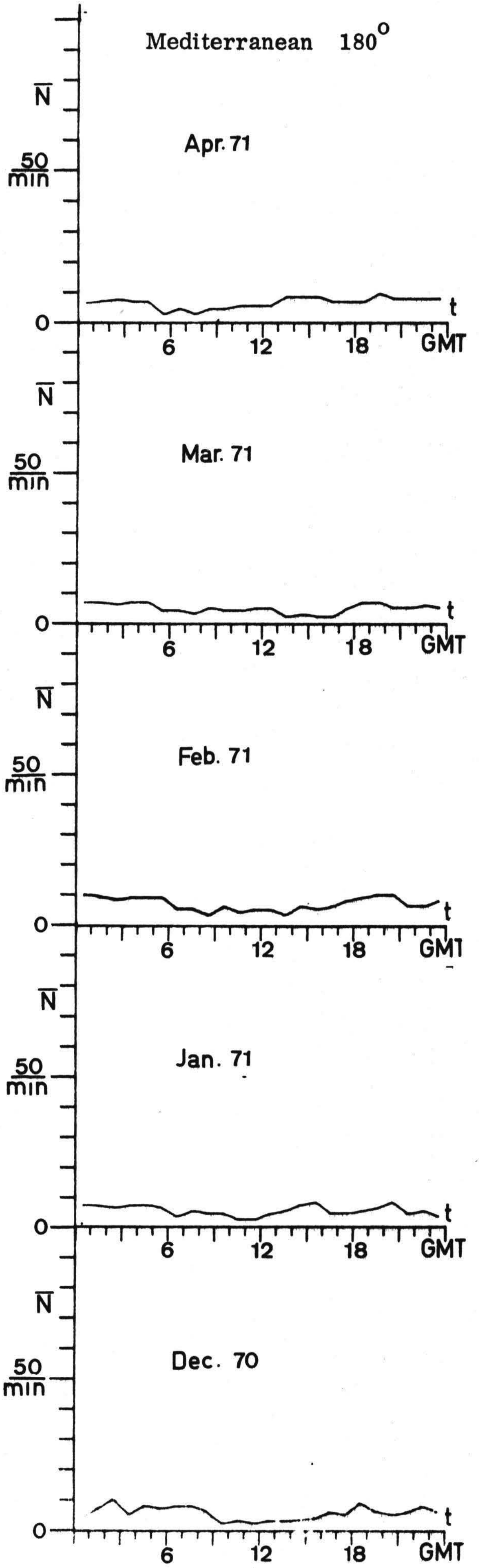

Fig. 12: Rates $\overline{N}$ of the sector 180°

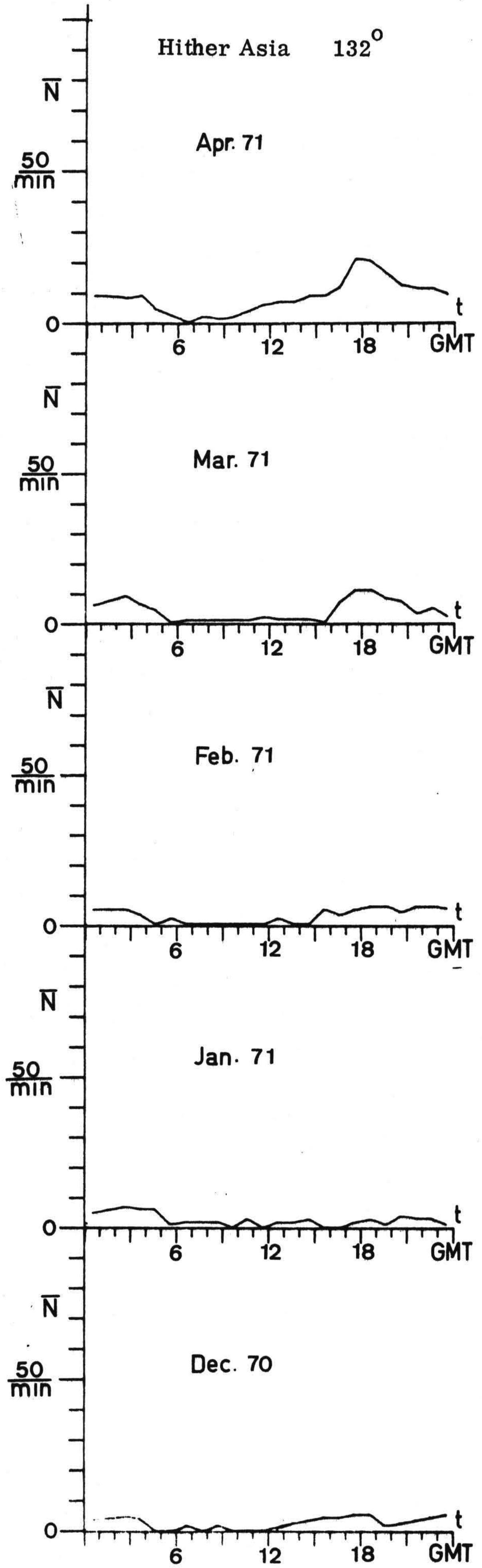

Fig. 13: Rates $\overline{N}$ of the sector 132°

One type shows rates with a marked and peaky maximum. This maximum occurs at the receiving station at these observation times at which the region of origin is near local sunset. After local sunset, the atmospherics rates decrease considerably. Corresponding to the localizations shown by Fig.2-6 and to the atmospherics rates shown by Fig.8-13, regions of origin of this kind are the Amazonas region, the region at Guinea and the region of the Gulfe of Panama. During the observation period Dec.70 - Apr.71 the month with the highest average rates was Feb.71 at the Amazonas sector, Apr.71 at the Guinea sector and March 71 at the sector that includes the Gulfe of Panama.
It may be assumed, that these atmospherics rates are caused by heat storms the activity of which decreases when local sunset occurs. This assumption is backed by the results of a short review on photographic records of the San Miguel station where the activity of the Amazonas region was indicated as a clearly decreasing one at 000 GMT compared to 2100 GMT.
Anyhow, it must be pointed out, that the time at which the highest rates are observed is probably not identical with the time of the highest lightning avtivity. The latter time will be somewhat earlier and the shape of the curves is considerably influenced by the propagation attenuation.
The second type of diurnal variations occurs at the sectors centered on 300° and on 180° (Northern America and Mediterranean). In these cases, there is no marked maximum and the rate activity is lasting at a rather constant level for that time of the day at which the propagation paths are under night-time conditions. Probably, these rates are due to storms which occured at weather fronts.

4.4.2. Explanation of the Diurnal Variations of the All-Around Activity $\overline{AN}$

Since the six sectors mentioned above include the main regions with atmospherics sources within the receiving range of the Berlin station, it is easily possible to explain the shape of the curves of the all-around activity AN shown by Fig.1.
Obviously, the maximum in the evening hours is mainly caused by the successively occuring peaks of activity at Western Africa, at the Amazonas region and at the Gulfe of Panama region.

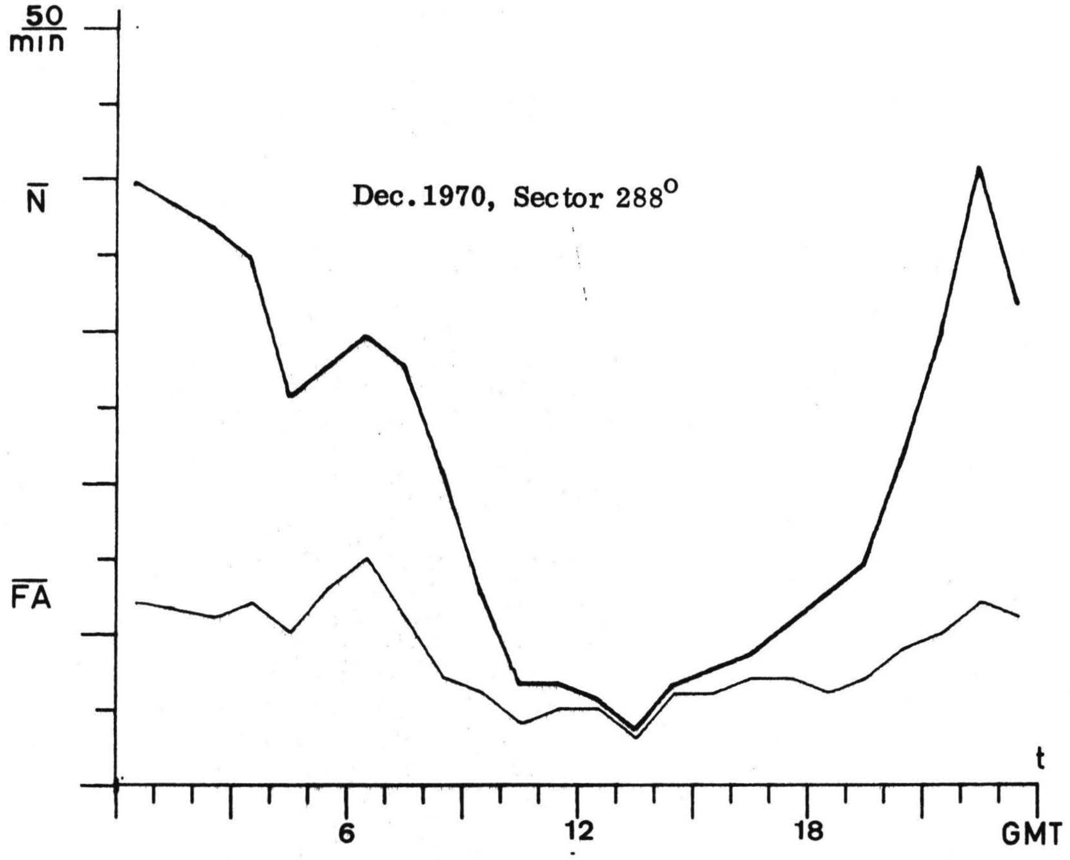

Fig. 14: Comparison between rates $\overline{N}$ and $\overline{FA}$ of the same sector

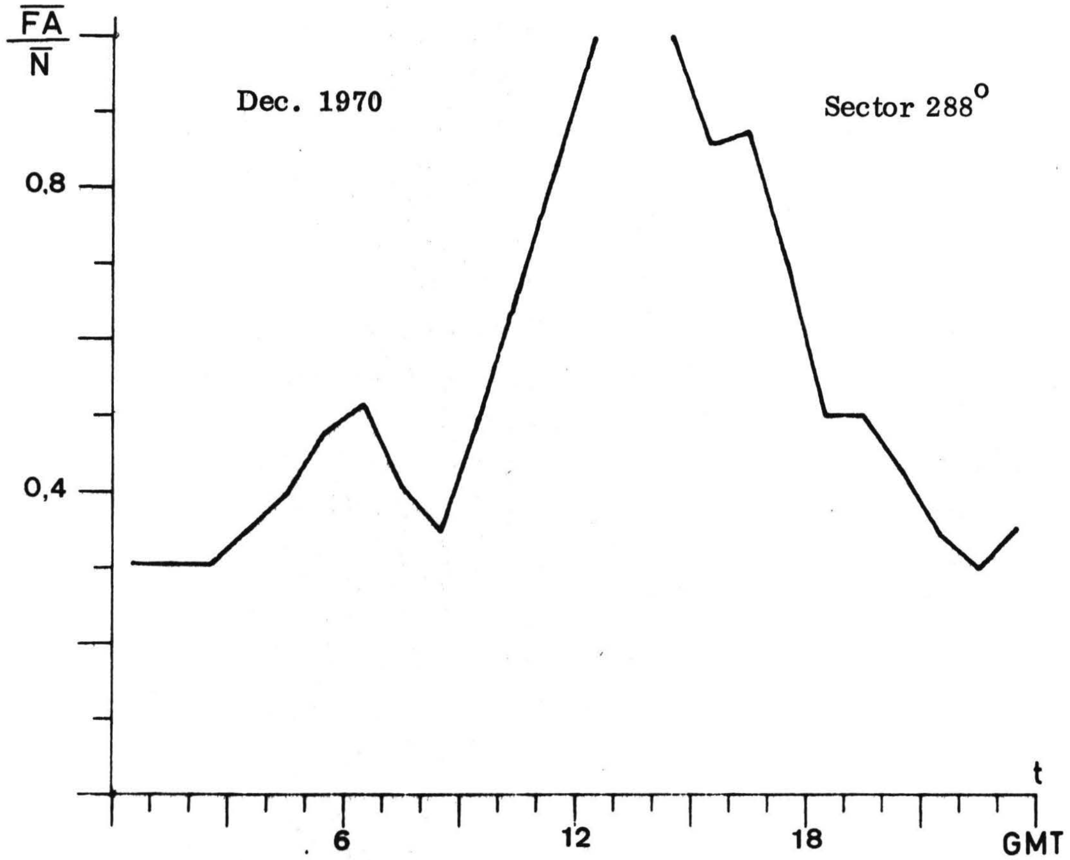

Fig. 15: Ratio $\overline{FA}/\overline{N}$ of the rates of Fig. 14

The mutual intensity of these components determines the details of the shape of the maximum of the different months.
The rather constant level during the hours after the maximum seems to be mainly composed of the activity of the regions with front storm activity and of the activity of storms on sea regions.

4.4.3. Some Remarks on the Influence of the Propagation Attenuation on the Atmospherics Rates

For the purpose of monitoring the global lightning activity the influence of the propagation attenuation must be considered in order to be able to find out the real contributions of the different regions of storm activity to the global activity.
Generally, it may be assumed, that a high attenuation is connected with a high value of the SAR on the photographic records. Thus, an attempt seems to be promising to use the SAR to compensate the influence of the attenuation. As a first step of this attempt, a GDD-SAR correlation based on a 13 months period of Berlin measurements is now under way in order to find out averaged values of the SAR of the regions as functions of the day-time. At present, the results of this correlation analysis remain to be seen.
An attempt of automatic compensation of the attenuation is executed by the Atmospheric Analyser at the measurements of the rate FA as described in section 4.1. .
Fig.14 shows the atmospherics rates $\overline{N}$ and $\overline{FA}$ of the sector centered on 288° of Dec.70. In this sector, there seem to occur mainly long lasting storms and therefore, atmospherics coming from this sector can be received for all hours of the day.
Looking at Fig.14, we find the ratio between the night and the day level of the rate $\overline{N}$ to be about 5.0, whereas in the case of the rate $\overline{FA}$ this ratio becomes something about 2.4 . Thus, the influence of the increasing attenuation during day-time appears to be reduced and the application of the rate FA may be more suitable for monitoring the lightning activity.
On Fig.15, the ratio $\overline{FA}/\overline{N}$ is plotted versus observation time. The marked increasing of this ratio during the daylight hours is caused by the increasing amplitude ratios A_9/A_5 at which an increasing of the attenuation may be expected too.

Averaging period:
11.2. - 6.3.
Thick lines: 1971
Tenuous lines: 1972

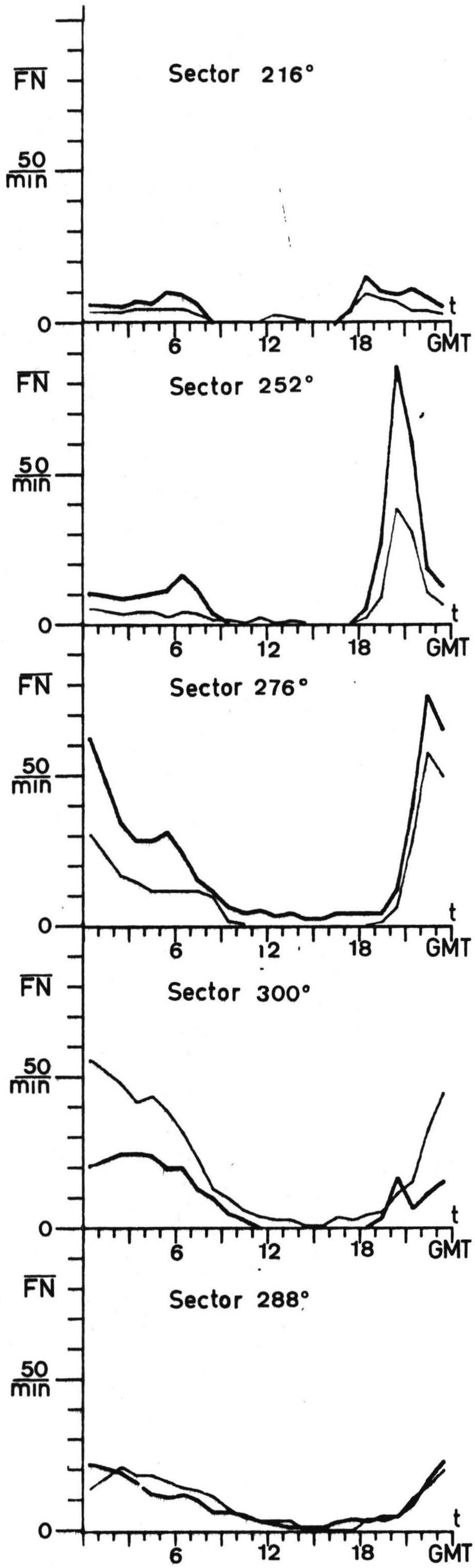

Fig. 16: Comparison between rates $\overline{FN}$ of different years

4.5. A Comparison between Atmospherics Rates Measured 1971 and 1972

In order to make a first comparison between averaged atmospherics rates measured at the same observation period of different years, the atmospherics rates of a period of 25 days (11.Feb. - 6.March) were averaged for both the years, 1971 and 1972. (Data of this period of 1972 are already processed now, because they were obtained during the Fourth Intensification Interval X 4 of the Ten Year Program of the International Commission on Atmospheric Electricity ICAE).

The diagrams of Fig.16 show the atmospherics rates $\overline{FN}$ of five different sectors versus observation time. In these diagrams, the rates of the year 1971 are drawn with thick lines, whereas the lines indicating the rates of 1972 are more tenuous ones. Obviously, the characteristic shape of the curves of the different years is very similar. On the other hand, there are considerable differences of the absolute values of the rates at the different years. The activity of this period of 1972 seems to be lower as 1971 in South and Central America (sector 252^{o} and sector 276^{o}), and somewhat lower in Western Africa too (sector 216^{o}).

A marked higher activity was measured within the sector centered on 300^{o} which includes the front storms on the North American east coast. This higher activity in 1972 seems to be restricted at just this sector, because the activity of the sector next to it (288^{o}) is quite the same in 1972 and in 1971.

Thus, it is evident that the monthly averaged atmospherics rates originated at the different regions may differ considerably from one year to the other.

5. Some More Results of Localizing Regions of Enhanced Lightning Activity by Means of GDD-Measurements and Direction Finding

5.1. Results of Measurements of the Waldorf Station

Fig.17 shows results of photographic records of the Waldorf station of an observation period from 19. Dec. 1970 - 31.Mar. 1971. The observation time was 000 GMT and the map was plotted in the same manner as Fig.2-6. This plot is backing the results of the Berlin records of the same observation time (Fig.4) in several details:

The activity center in Central America is shown by the Waldorf

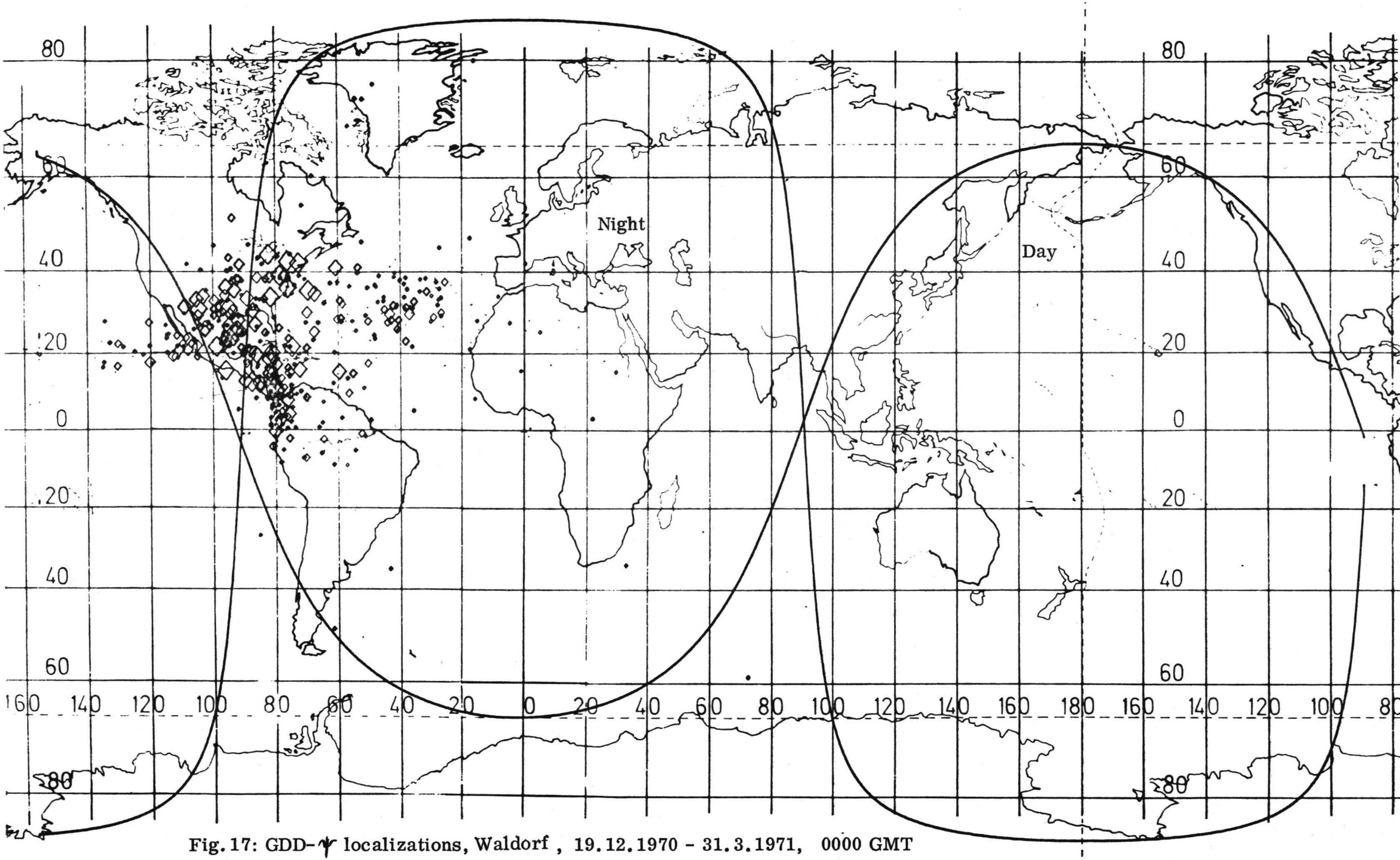

Fig. 17: GDD-ψ localizations, Waldorf , 19.12.1970 - 31.3.1971, 0000 GMT

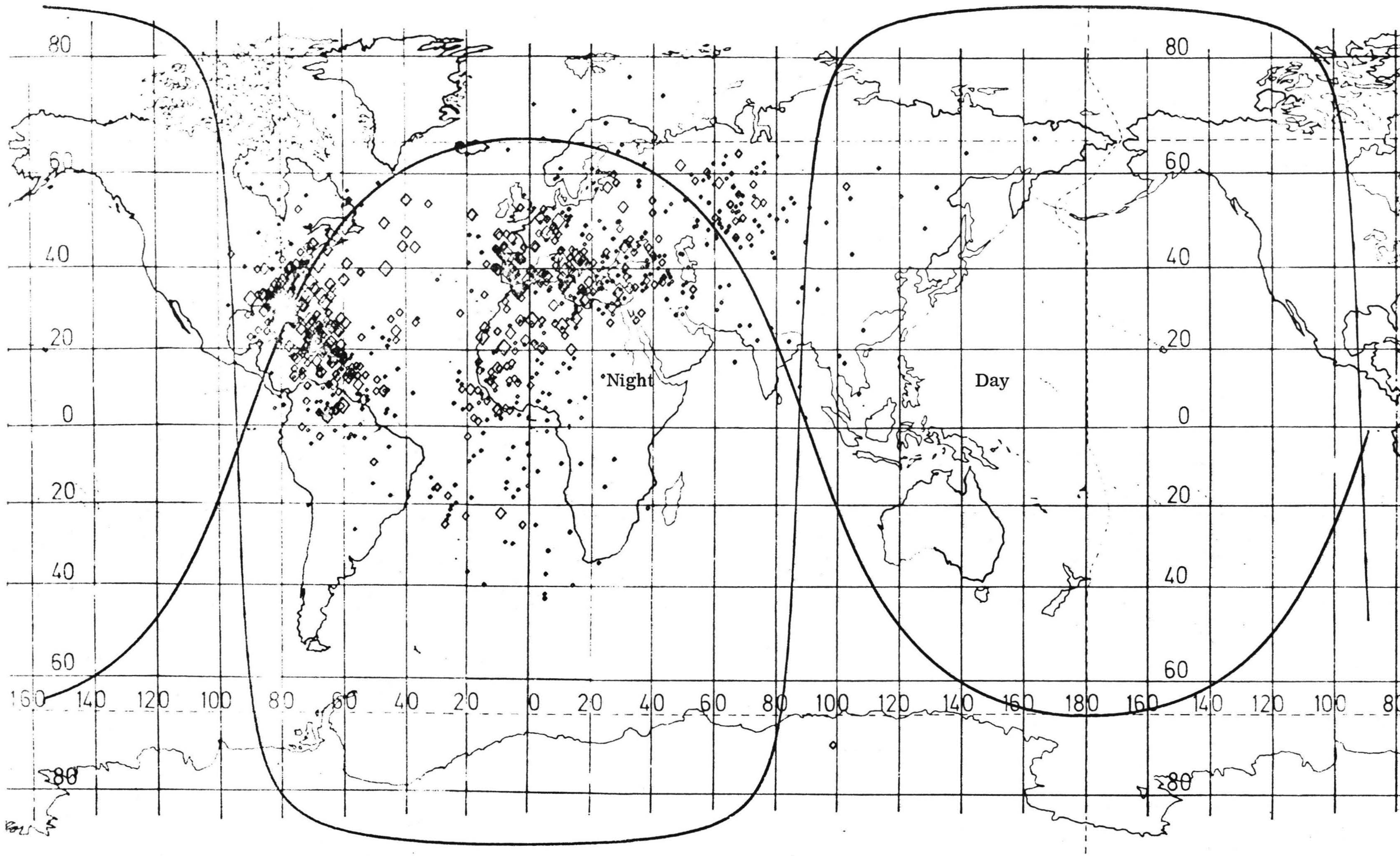

Fig. 18: GDD - ψ localizations, Berlin, 1.6. - 30.9.1971, 0000 GMT

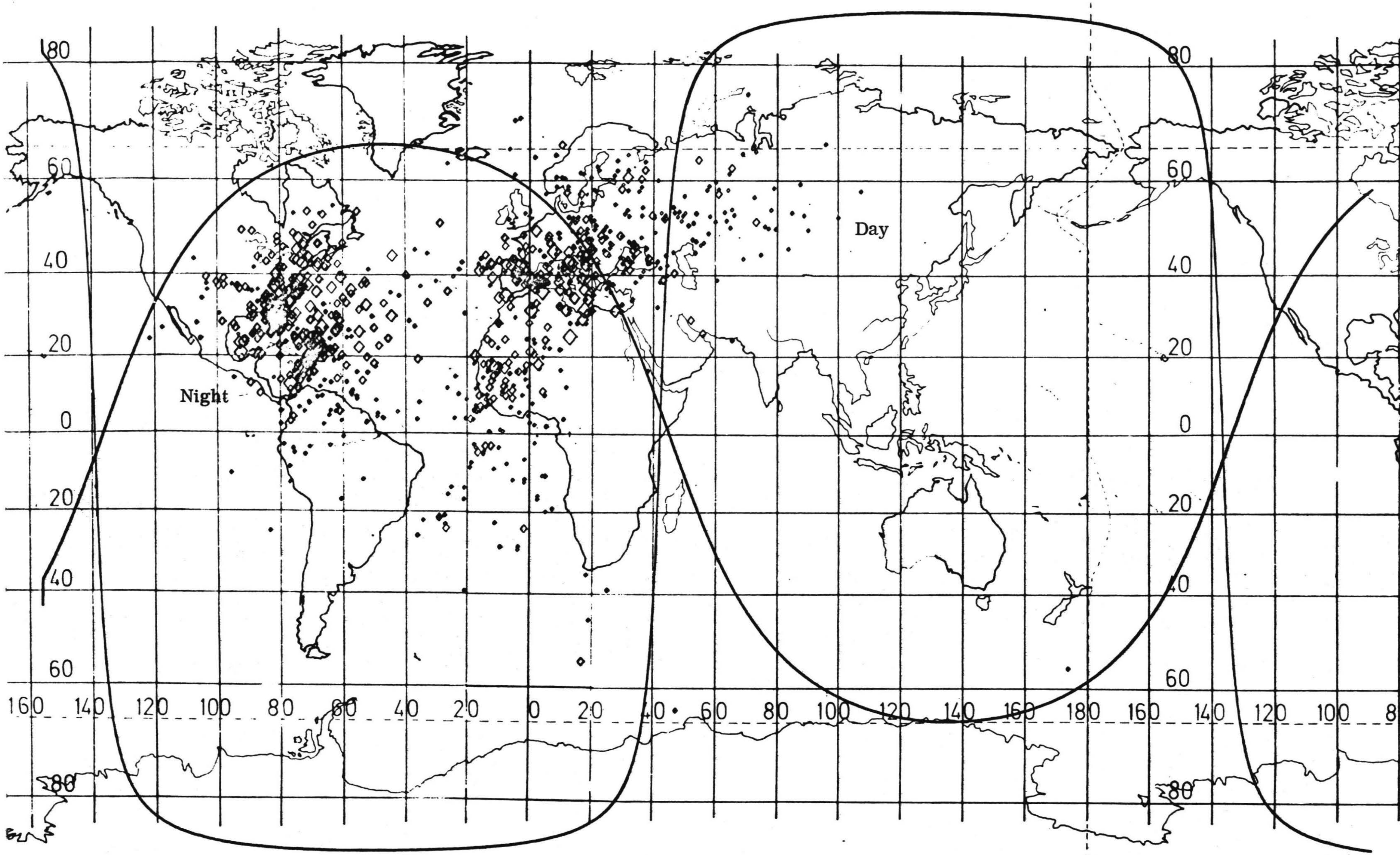

Fig. 19: GDD - γ localizations, Berlin, 1.6. - 30. 9. 1971, 0300 GMT

station too , and the activity at the Gulfe of Mexico is indicated by both the stations. In the case of the latter activity, the Waldorf station "sees" a much stronger activity of course, due to the short propagation path. Further, the activity "seen" by the Berlin station very near to Waldorf is confirmed by Fig.17 by the number of large squares which are located near Waldorf. On the other hand, there are some discrepancies:

Firstly, the cluster of localizations on the middle of the North Atlantic on Fig.17 is not confirmed by Fig.4. Since the localizations by means of GDD seems to work quite well in the case of propagation directions from West to the East, it may be assumed that the Berlin localizations on the Atlantic are the more reliable ones. Thus, the one-mode-propagation model in its present form seems to be not applicable in the case of East-West propagation at night-time conditions.

Secondly, there are only a few localizations in the North-East of Waldorf on Fig.17 compared to the Berlin localizations. This seems to be a hint that the problem of the "visibility" of single sources from one station should be carefully investigated.

5.2. Results of Photographic Records during the Summer 1971

In order to get a review of the shifting of the areas of enhanced lightning activity as functions of the season, maps containing the results of Berlin measurements have been plotted of the period of June - September 1971.

Fig.18 shows the results of the observation time 0000 GMT. The main feature of this map is the hook-shaped cluster of localizations at the Caribean Sea and at the East coast of North America. Obviously, the activity in the area of America has shifted from the South to the North.

The activity in Europe has increased and shifted to the North too. The localizations at the Sahara are rather doubtful, of course. Probably, they are due to the influence of multi-mode propagation at which rather near sources cause high values of the GDD. The simple one-mode model, which was used at the plotting of the maps, transfers these high GDD values into great distances.

Fig.19 shows a similar plot of an observation time of 0300 GMT. On this map, the hook-shaped cluster remains nearly at the same

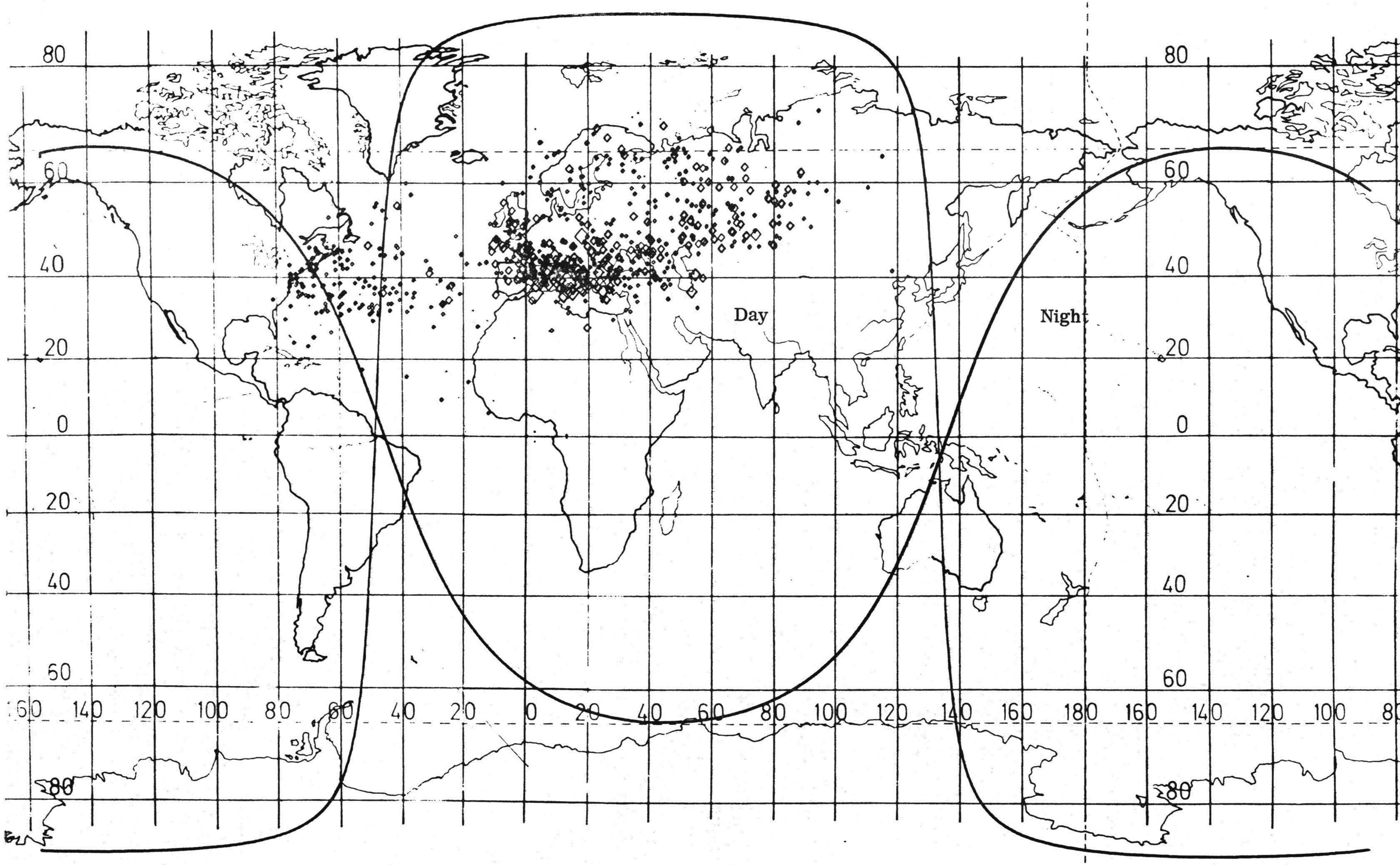

Fig. 20: GDD - Υ localizations, Berlin, 1.6. - 30.9.1971, 09oo GMT

place which seems to be an indication of the constancy of the propagation conditions between 0000 and 0300 GMT at these propagation paths.

Finally, Fig.20 shows a map which was plotted by means of a daytime propagation model (reflection height 70 km) for the observation time 0900 GMT. During summer, the local lightning activity in Central Europe has its mimimum just about this time. Thus, the "very near activity" does not disturb the observations of more distant sources. The localizations indicate rather a wall of little squares, beginning at Western Europe and continued along South and South-East Europe. In eastern directions there are a number of sources located at greater distances at Central Russia.

6. Conclusion

Reviewing the preceding chapters, it may be stated that many details of the maps and of the diagrams look quite reasonable and offer a promising outlook for the task of monitoring the global lightning activity. It seems to be possible to assign one or two areas of the globe to each of a network of about ten stations in order to a continuous monitoring of the atmospherics rates which are originated at these areas. These stations should be carefully positioned so that they would have an optimum position with respect to their observation areas,and they should be located at regions where the "very near " storm activity is low for a longer period of the year.

However, there are some important problems which should be solved before one can decide to start such a monitoring problem.

Firstly, it is obvious that there is only a fraction of atmospherics coming from distant sources which exceed the the sensitizing threshold of the Atmospherics Analyser. It seems to be important to learn what kind of lightnings or what kind of propagation conditions are connected with these atmospherics and to find out whether it is suitable to conclude from measurements of these kinds of atmospherics or lightnings to the whole storm activity.

Secondly, methods should be developed to compensate the influence of the propagation attenuation. The atmospherics rate FA is a first step to this, but it is certainly not sufficient for the purpose mentioned above. Before starting a development of some

other kinds of rates, a more realistic knowledge of the attenuation conditions is necessary. Further, the deviations of the behaviour of the GDD from the one-mode model in the case of East-West propagation at night-time should be explained. There are likewise some hints which points to deviations of the normally expected diurnal variations of GDD in the case of South-North propagation at some times of the night.
Finally, it should be tried to find out the reason of the straying of the single GDD- and SAR-measurements with respect of the cluster center and to search for methods to reduce it.

7. Acknowledgement

The operating of the VLF-Atmospherics-Analyser Network and the evaluation work in Berlin is sponsored by the Deutsche Forschungsgemeinschaft.
The author is grateful to Mr.H.Dolezalek (Office of Naval Research), Mr.R.V.Anderson (Naval Research Laboratory), Dr.T.Takeuti (Institute of Atmospherics Research) and Mr.C.Hofmann (Observatorio nacional de fisica cosmica) for operating the observation stations and for data exchange.

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Appendix: Tables of Monthly Averaged Atmospherics Rates December 1970 - April 1971

AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING DEC. 1970
PULS RATE [NUMBER/MIN]. SECTOR WIDTH 12 DEGR.

DEC. 1970 BERLIN, RATE N GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
0	N							E								S							W							
0- 1										2	2	4	4	5	8	4	5	5	9	8	13	11	13	46	39	13	3			
1- 2																														
2- 3											3	5	3	3	7	10	6	9	10	7	20	8	10	32	36	13	2			
3- 4										2	3	4	2	3	9	5	5	11	11	8	17	8	8	26	34	17	2	1		
4- 5	1									2	3		4	2	5	8	8	12	15	13	15	8	9	25	25	14	2			
5- 6											1		1	1	5	7	6	11	16	14	17	10	10	24	27	13	1			
6- 7											1	2	2		5	8	7	18	23	19	19	14	15	27	29	10				
7- 8														1	3	8	5	6	9	14	11	12	15	25	27	9	1			
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9-10													3	2	5	2	5	6	3	7	4	2	5	8	12	5				
10-11													2	1	3	3	3	6	6	6	4	3	3	2	6	1				
11-12													4	2		2	3	4	6	6	4	4	4	2	6	2				
12-13													3	1	2	3	4	4	6	6	4	2	4	3	5	2				
13-14	1											2	4	2	5	3	6	4	5	6	2	3	2	1	3	2				
14-15												3	4	2	9	3	6	3	5	6	3	3	4	3	6	2				
15-16			1								4	4	6	5	9	4	6	6	6	5	3	4	2	3	7	2				
16-17											5	4	8	4	9	6	8	5	7	6	4	7	2	3	8	3				
17-18											4	5	9	8	7	5	8	6	8	9	5	3	5	5	10	4				
18-19											3	5	6	4	8	9	7	5	7	10	13	14	8	10	12	4				
19-20											2	1	6	4	5	6	7	6	8	10	25	36	14	14	14	8				
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21-22											1	3	4	4	7	6	5	6	7	9	25	49	62	51	29	10				
22-23		1									1	4	6	5	8	8	5	5	10	8	18	29	49	67	40	13	2			
23-24											3	5	5	8	9	6	5	6	9	8	10	15	22	51	31	11	4			

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AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING DEC. 1970
PULS RATE (NUMBER/MIN). SECTOR WIDTH 12 DEGR.

DEC. 1970 BERLIN,RATE FN GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
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9-10															1					2			2	5	10	5				
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11-12																	1	1		2		2	4	1	5	2				
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14-15															1		1		1	1		2	3	3	6	2				
15-16													1		1				1	1		1	2	2	6	2				
16-17													2		1		1	1	1	3		1		2	8					
17-18													1				3	2	3	4	1	1	2	4	9	2				
18-19													2		1		2		3	5	4	8	6	8	10	4				
19-20																		2	3	5	14	28	11	10	10	6				
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AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING DEC. 1970
PULS RATE (NUMBER/MIN). SECTOR WIDTH 12 DEGR.

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AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
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PULS RATE (NUMBER/MIN). SECTOR WIDTH 12 DEGR.

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8- 9									7			2	6	8		4	1	2	2	5	3	5	7	10	12	12				
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AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING JAN. 1971
PULS RATE (NUMBER/MIN). SECTOR WIDTH 12 DEGR.

JAN. 1971 BERLIN, RATE FN GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
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8- 9													1	1					2	5	2	2	5	6	8	11				
9-10													1	1						2				2	10	8				
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11-12													1											2	4	2				
12-13													1	1										2	4					
13-14																2								2		2				
14-15													1	1	2	1									2					
15-16													1		1	1									4					
16-17														1	1	1	4	4							3	2				
17-18													2	1	2			4	5	4		2			4	3				
18-19													3	7	3		1	3	5	4	5	10	3	3	6	4				
19-20													1	4	3		3	4	7	5	20	32	8	6	6	4				
20-21													2		2		3	4	4	6	31	65	16	11	9	6				
21-22															1	1		1	3	5	22	50	24	29	9	5				
22-23													3	4	2			2	4	4	12	25	21	46	15	9	3			
23-24													1	1	1		1	2	4	5	8	10	8	26	19	13	1			

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AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING JAN. 1971
PULS RATE [NUMBER/MIN]. SECTOR WIDTH 12 DEGR.

JAN. 1971 BERLIN, RATE AN GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
	N							E								S							W							
0- 1													5	4	3	4	3	4	7	5	8	10	8	12	11	8	4			
1- 2																														
2- 3												4	6	5	2	5	4	4	6	5	6	9	7	12	15	10	2			
3- 4					3							1	6	4	3	1	3	5	7	7	5	8	7	11	10	9	2		1	
4- 5									1				9	3	1	3	4	6	6	8	6	9	6	12	11	8	1			
5- 6													6	3	1	4	4	5	6	8	7	10	7	11	13	10	3			
6- 7									1		1		4	2	1		4	6	6	6	4	10	9	11	11	11	3			
7- 8													4	3		1	3	3	2	5	4	10	6	12	12	11	1			1
8- 9									1				6	9		1	1	2	2	5	2	3	5	5	6	10				2
9-10													4	2		2				3	2		2	3	7	7				
10-11													3	3		1	1					3	6	4	5	5				
11-12													4	2	1	1							1	2	3	2				
12-13													5	5		1							1	3	4					
13-14											1		3	2		1								2	2	2				
14-15											1	2	3	4	3	2							1		2					
15-16													6	1	3	3	1						1	1	3	2				
16-17													5	3	1	1	4	4					1		3					
17-18												2	6	5	2	1	4	5	4	2		4			4	3				
18-19													9	6	2		1	3	4	4	6	12	3	4	4	3				
19-20												1	4	6	4	2	4	5	6	6	17	28	8	7	5	5				
20-21												3	3	3	2	1	4	4	5	6	23	46	15	11	6	5				
21-22													4	2	1	2	2	1	3	6	24	42	19	16	5	3				
22-23												1	5	4	2		1	2	5	5	14	28	20	25	8	6				
23-24													3	1	3	1	3	4	5	5	10	11	8	17	10	9	1			

EXIT

AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING FEB. 1971
PULS RATE [NUMBER/MIN]. SECTOR WIDTH 12 DEGR.

FEB. 1971 0
BERLIN, RATE N

GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
	N							E								S							W							
0- 1											4	5	10	10	13	10	9	8	8		8	19	16	41	21	30	8			
1- 2																														
2- 3												5	11	11	12	8	11	9	8	5	7	13	15	36	22	35	3			
3- 4											3	3	11	9	11	9	9	9	9	6	9	15	16	31	18	36	7			
4- 5													9	8	10	9	10	9	9	8	13	17	17	33	18	35	6			
5- 6												2	8	8	10	9	9	8	12	7	19	22	23	34	17	25	4		7	
6- 7													7	6	7	5	5	9	11	7	22	24	21	31	14	30	5			
7- 8													5	6	4	5	3	2	7	4	10	21	12	22	14	16				
8- 9													2	5	8	3	1	1	2	3	5	8	7	13	9	12		1		
9-10													2	4	5	6	5	1	2		4	6	3	7	3	4				
10-11													7	5	4	4	2				5	4		3	3					
11-12													4	4	5	5	3	1	1		2	3		3	1	1				
12-13												2	2	7	5	5	3		1		3	3		2	1					
13-14													3	5	10	3						3	2	1						
14-15													6	5	5	6	1				4	4	4	1						
15-16											2	5	9	9	6	5	1	1		2	4	4	4	3	1					
16-17									1		5	3	10	9	8	6	4	5	4	6	5	7	8	2	2		1			
17-18									2	4	5	5	11	10	9	8	8	9	6	5	5	7	6	4	2	1				
18-19										1	4	6	13	12	9	9	7	18	22	7	7	13	7	7	4	1				
19-20									1		4	6	10	11	10	10	8	12	13	8	26	37	13	8	6	1				
20-21											2	4	10	10	9	10	8	10	12	7	53	109	30	16	7	20	1			
21-22												6	9	7	9	6	8	9	11	6	14	79	43	37	10	11				
22-23										2	2	6	8	11	10	6	8	9	8	5	12	32	47	72	15	19	5		1	
23-24											3	5	8	7	9	8	8	6	5	3	10	22	24	54	22	23	5			

EXIT

AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING FEB. 1971
PULS RATE (NUMBER/MIN). SECTOR WIDTH 12 DEGR.

FEB. 1971 BERLIN, RATE FN GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
	N							E								S							W							
0- 1													3	1	2	2	2	1	5		5	12	10	33	13	23	5			
1- 2																														
2- 3													3			1	6	3	1	2	5	10	6	25	18	28	1			
3- 4													2		2	1	5	4	6	5	5	12	9	22	11	30	2			
4- 5													1		1	2	7	5	5	6	8	11	9	22	11	28	5			
5- 6																2	3	4	11	6	12	14	12	24	10	20	3		6	
6- 7																	1	3	8	5	12	19	12	22	10	25	4			
7- 8																1			3	2	7	15	9	15	9	16				
8- 9																					2	4		8	3	12				
9-10																1						3	2	4	3	1				
10-11																	1				3	3		3	2					
11-12																						2		3	1					
12-13																1						3		1	1					
13-14															3							2		1						
14-15															2						2	2	1	1						
15-16															3	1						2	1	1	1					
16-17													1	2	2			1		2	3	3	2	2	2					
17-18									1				1	2			1	3	4	3		5	2	1	2					
18-19													2	3	3	1	1	7	11	3	3	7	2	3	1					
19-20													2	4		1	1	7	11	6	22	30	7	4	3	1				
20-21													3	3	2	1	3	6	8	1	44	92	18	11	3	17				
21-22													4	3	2		3	5	10	3	9	66	33	28	7	9				
22-23													3	3	2	1	1	6	5	2	8	23	34	60	12	17	2			
23-24													4		2	2	2	1	5	1	7	13	13	42	14	17	3			

EXIT

AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING FEB. 1971
PULS RATE [NUMBER/MIN]. SECTOR WIDTH 12 DEGR.

FEB. 1971 BERLIN, RATE AN GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
	N							E								S							W							
0- 1											1	4	5	5	5	2	2	3	6		6	13	9	16	7	11	2			
1- 2																														
2- 3												2	5	4	3	2	4	4	5	3	6	10	6	14	6	13				
3- 4													6	2	2	2	5	7	8	4	7	12	8	13	6	11	1			
4- 5													5	1	4	2	5	5	7	7	8	10	8	13	5	13	1			
5- 6													2	2	4	3	4	6	10	5	9	11	10	13	7	11	3		6	
6- 7													1	1	1			5	9	5	10	14	9	12	5	13	3			
7- 8													3	2		1	1	1	2		6	9	6	8	4	11				
8- 9													2	5	2	2		1	1		4	4		5	2	8				
9-10													2	3	1	2	1					5		2	1	1				
10-11													7	4	1	3	1				3	5		3	1					
11-12													4	6	3	3	1		1		2	4		3	1					
12-13												3	2	6	2	3	1		1		3	4		1	1					
13-14													3	5	5	2						4	2	1						
14-15		2											4	4	3	3	1				3	4	1	1						
15-16											2	3	5	5	4	2	1				3	2	1	2	1					
16-17											2		5	4	4		1	1	2	3	4	4	5	1	2					
17-18									1		3	4	6	5	4	1	3	6	4	3	3	4	1	1	1	1				
18-19											3	3	4	4	5	1	2	11	11	3	5	8	2	3	1	1				
19-20											2	3	5	6	3	2	3	8	10	5	19	22	7	4	2	1				
20-21												3	4	4	3	3	4	7	7	3	26	50	14	8	2	15				
21-22												2	4	4	4	1	3	6	10	4	10	47	18	15	2	5				
22-23													5	4	3	3	2	6	6	5	10	23	22	23	3	8			4	
23-24													5	4	2	2	2	2	6	1	9	17	11	19	4	8				

EXIT

AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING MAR. 1971
PULS RATE [NUMBER/MIN]. SECTOR WIDTH 12 DEGR.

MAR. 0 1971 BERLIN, RATE N GMT	N 0	12	24	36	48	60	72	E 84	96	108	120	132	144	156	168	S 180	192	204	216	228	240	252	W 264	276	288	300	312	324	336	348
0- 1							1			2	5	6	9	9	7	7	6	11	11	7	9	13	9	54	35	26	6	2		
1- 2																														
2- 3												9	10	7	8	6	6	8	13	6	6	6	9	32	31	34	11			
3- 4	2											6	12	7	10	7	8	10	10	5	5	6	7	34	32	28	7			
4- 5												4	9	7	11	7	5	9	9	5	6	9	8	29	38	26	8			
5- 6													6	6	6	4	5	5	10	5	6	10	11	25	27	21	2			
6- 7												1	6	6	4	4	4	7	10	5	8	10	9	16	17	15	1	1		
7- 8												1	4	5	5	3	2	4	8	7	6	9	5	10	13	8				
8- 9												1	1	5	6	5	1	4	4	3	4	4	3	8	11	5				
9-10												1	4	4	6	4		2	1		1	1	2	5	3	1				
10-11												1	4	4	6	4	1		1	2	2	1		2	3					
11-12												2	2	4	5	5			1	1	2	1								
12-13												1	3	4	7	5	1	2	1	2	1	1		2						
13-14									1			1	4	5	8	2	1	1	1	2	1	1			1					
14-15											1	1	3	5	5	3	3	2	3	2	2		2	2	4	1				
15-16							1			1	4		6	6	6	2	5	4	4	2	2			1	1					
16-17						1	1		2	1	6	7	8	16	8	2	4	5	5	5	3			2						
17-18							1		3	2	7	11	10	8	7	5	13	14	10	11	6	2		1	2			1		
18-19					1	1			1	4	6	11	14	10	9	7	7	23	34	14	7	5	1	3	3	1	1			
19-20										1	2	8	11	8	10	7	7	20	22	13	23	20	5	6	6	3				
20-21						1				2	5	7	9	9	9	5	9	17	19	12	43	57	17	12	10	4				
21-22	1										1	3	11	8	9	5	7	18	17	7	13	35	34	41	11	7				
22-23				1		3					4	5	7	9	7	6	6	12	15	9	13	16	28	82	34	15	4			
23-24					1		1			2	2	2	6	8	8	5	8	12	13	8	10	14	15	66	41	25	5			

EXIT

AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING MAR. 1971
PULS RATE (NUMBER/MIN). SECTOR WIDTH 12 DEGR.

MAR. 1971 BERLIN, RATE FN GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
0	N							E								S							W							
0- 1													4	4		3	3	4	6	4	6	11	7	45	27	19	5			
1- 2																														
2- 3												2	4	2	3	2	3	5	6	4	3	5	7	26	21	25	8			
3- 4	2												2	3	3	4	3	5	6	5		6	5	24	22	21	5			
4- 5													3	3	2	3	4	5	5	3	5	6	6	22	26	21	3			
5- 6													2	2			2	5	7	4	5	7	9	19	17	15	2			
6- 7													3	2			3	5	6	4	5	8	7	15	12	13				
7- 8																		2	5	6	5	7	5	6	10	8				
8- 9																				1	2	2	3	4	9	3				
9-10															2									3	1					
10-11															2															
11-12														2	2															
12-13															3									2						
13-14															2															
14-15																														
15-16													2																	
16-17											1		2	12	2		2		1											
17-18										1	1		2	2	2	3	5	7	5	4										
18-19													2	3	3		4	9	17	6	5	4				1				
19-20												2	4	5	6	4	4	10	8	8	18	14	2	4	4	3				
20-21												2	2	4	5	3	6	10	10	8	36	49	12	9	7	3				
21-22													7	3	2	2	4	10	10	5	9	33	30	34	7	6				
22-23														3	3	3	4	8	7	6	11	13	24	71	25	14	1			
23-24													1	3	3	2	4	6	5	5	6	10	12	55	29	21	5			

EXIT

AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING MAR. 1971
PULS RATE (NUMBER/MIN). SECTOR WIDTH 12 DEGR.

MAR. 1971 BERLIN, RATE AN GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
	N							E								S							W							
0- 1												1	5	5	3	3	4	6	6	6	7	11	6	22	12	10				
1- 2																														
2- 3												3	5	4	2	2	2	5	6	6	3	7	6	18	11	14	1			
3- 4	2											1	9	4	3	4	3	6	6	5	3	5	5	15	10	10	2			
4- 5													5	4	4	3	5	5	6	5	5	7	8	16	11	12	2			
5- 6													3	2	2		4	5	6	5	6	10	10	15	10	10				
6- 7												1	4	2			3	4	5	5	7	8	7	9	6	8				
7- 8												1	3	3	3		1	3	5	5	5	6	4	6	6	6				
8- 9												1		3	3	2		3	3	3	4	3	3	4	5	2				
9-10												1	2	2	5							1	2	4	1					
10-11												1	3	2	4	1					2				2					
11-12												2	2	3	4	1				1	1	1								
12-13												2	3	3	5							1		2						
13-14												2	3	3	5			1	1	1	1	1			1					
14-15											1	1	2		5				3	1	1		2	2	3					
15-16											2		3	3	3		3	1	2		1									
16-17									2	1	1	2	4	3	4	2	3	5	2	2	1									
17-18									3	1	1	3	3	4	4	3	6	5	6	4	3	1								
18-19										3	4	2	5	5	4	2	4	12	19	6	6	4			1	1	6			
19-20												3	3	4	5	4	5	10	9	7	18	15	3	5	2	1				
20-21												4	4	5	4	3	5	10	10	8	23	27	10	10	5	3				
21-22													4	4	4	3	4	10	10	6	10	26	16	20	5	3				
22-23												1	4	5	4	3	3	8	8	7	10	12	14	30	9	6				
23-24													3	4	4	2	4	6	6	7	9	10	8	22	13	10				

EXIT

AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING APR. 1971
PULS RATE (NUMBER/MIN). SECTOR WIDTH 12 DEGR.

APR. 1971 BERLIN, RATE N GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
0	N							E								S							W							
0- 1								1	4	5	10	9	10	8	7	6	9	11	11	10	8	10	13	82	83	34	8	2		
1- 2																														
2- 3										3	11	8	9	8	6	7	9	12	13	9	9	10	10	48	77	49	9			
3- 4										1	8	9	10	8	6	6	8	12	18	8	9	10	10	37	71	57	7	1		
4- 5											2	4	6	5	6	6	7	10	13	9	10	9	9	24	50	35	2			
5- 6					1					1	1	2	4	4	3	2	5	5	6	7	6	9	7	13	33	16				
6- 7							1		1	1			2			4	5	5	11	6	5	3	6	10	22	8				
7- 8									1			2		1	2	2	3	2	6	4	2	3	4	5	11	3				
8- 9												1	1	1	1	4		2	1	5	2	1	1	3	7	2				
9-10												2	2		1	4	1	3	2	4		1	1	1	3		2			
10-11											1	4	4	1	2	5	5		3	1		1		2	3					
11-12								1		2	4	6	5	2	5	5	7	4	1	4		4			1			2		
12-13							1	1	2	3	2	7	6	3	5	5	6	5	2	7	10	4			2					
13-14							1	4	5	3	5	7	7	4	7	8	7	7	6	11	10	9			1					
14-15								5	6	7	5	9	6	2	9	8	7	7	7	10	13	11	4		2		1			
15-16							3	4	5	7	5	9	6	3	6	8	6	5	9	12	16	11	5	2	2					
16-17						1	3	5	6	4	10	12	6	3	6	6	7	6	8	14	14	11	3	2	2					
17-18					2	2	1	3	7	8	18	21	10	7	7	6	6	8	13	15	15	7	3	3	3					
18-19				1	1	2	1	3	9	7	19	20	11	8	9	6	10	34	42	18	12	8	4	4	5					
19-20					1	1	2	4	13	7	14	16	13	9	11	9	12	35	53	24	23	15	5	8	7					
20-21							1	3	13	7	12	12	10	8	9	7	12	26	39	21	34	39	13	14	13	1				
21-22								2	7	6	10	11	7	6	7	7	8	15	26	15	15	28	30	36	24	5				
22-23									6	6	10	11	8	7	6	7	7	11	18	12	14	20	25	85	50	13				
23-24							1	1	5	6	9	9	8	7	8	7	7	13	15	7	9	12	21	95	72	19	2			

EXIT

AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING APR. 1971
PULS RATE [NUMBER/MIN]. SECTOR WIDTH 12 DEGR.

APR. 1971 BERLIN,RATE FN GMT	0	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
	N							E								S							W							
0- 1										2	2	3	5	4	4	2	4	8	8	4	3	6	9	68	63	24	6	2		
1- 2																														
2- 3											5	3	4	1	1	1	5	6	9	5	4	7	8	36	52	39	7			
3- 4											2	1	2	3	3	3	5	8	12	5	4	7	6	28	51	48	5			
4- 5																	4	8	11	5	5	5	6	19	35	31	2			
5- 6																		4	4	5	4	3	5	11	24	15				
6- 7																		5	7	1	2		4	7	17	7				
7- 8																			3	3			1	2	7	1				
8- 9																								3	3	2				
9-10																		2					1		2					
10-11																														
11-12												1	2				2								1					
12-13												3	2				2			2	1				2					
13-14									1			3	2		2		2	1			1	1			1					
14-15									3			3	2		2		3	1		2	4	3			1					
15-16								2				3				2	1			4	6	3			2					
16-17								1				2			2		2		2	3	3	3			2					
17-18							1	1	1		4	6			2		5	6	5	5	3			2	1					
18-19							1		1	1	7	6	5	2	3		6	14	23	7	5	2	2	4	3					
19-20							1	1	5	2	6	6	5	5	5	5	7	19	26	12	14	12	3	3	5					
20-21									5	3	3	5	3	5	3	2	8	16	24	12	22	34	12	8	7					
21-22								1	4	2	4	4	2	1	1	4	5	10	17	10	8	24	24	30	14	3				
22-23									2	2	4	4	3	3	2	3	6	7	11	6	8	14	20	69	36	10				
23-24									1		4	4	2		3	1	5	7	8	4	4	8	14	80	55	16	2			

EXIT

AZIMUTH DISTRIBUTION OF ATMOSPHERICS RATES,
PERIOD OF AVERAGING APR. 1971
PULS RATE (NUMBER/MIN). SECTOR WIDTH 12 DEGR.

APR. 0
1971
BERLIN, RATE AN

GMT	N 0	12	24	36	48	60	72	E 84	96	108	120	132	144	156	168	S 180	192	204	216	228	240	252	W 264	276	288	300	312	324	336	348
0- 1								1	2	2	5	7	7	4	4	4	5	8	8	5	6	6	6	31	22	12	3			
1- 2																														
2- 3											6	4	5	2	3	3	5	7	8	5	5	8	5	22	24	18	3			
3- 4											3	2	4	4	3	4	5	8	11	6	4	9	6	17	23	20	1			
4- 5											1	1	2			2	5	8	11	6	6	5	6	11	19	15				
5- 6												1	2	2			3	4	4	5	5	4	4	7	11	11				
6- 7													2			1	2	5	7	2	2		4	5	12	7				
7- 8												2		1			1	2	5	3		1	1	3	6	1				
8- 9												1	1	1		2		2		4	1	1		1	3	2				
9-10												2	1		1			2		1		1	1	1	2					
10-11												2	4	1	2	1	2		1						2					
11-12											3	3	4		2	3	3			2		1			2					
12-13											1	5	4	2	4	1	3	2		4	4	1			3					
13-14								1	1	2	2	5	5	2	2	4	3	4	5	6	6	4			1					
14-15								2	3	1	5	6	5		4	4	4	4	5	5	9	6	2		4					
15-16								2	1	2	4	5	4		2	5	3	1	4	6	9	6	2		2					
16-17								1	2	1	5	8	2		3	1	4	2	5	7	9	5		2	4					
17-18							1	1	2	1	8	10	4	2	4	1	5	8	8	6	8	4		2	2					
18-19								1	2	2	9	10	5	3	4	3	7	16	20	6	6	4	2	2	3					
19-20								2	4	2	8	9	5	5	5	5	8	24	26	10	11	7	3	3	4					
20-21									4	3	7	7	4	4	5	4	8	14	22	11	17	18	7	6	6					
21-22									5	3	6	5	3	3	3	5	5	10	15	11	12	19	13	17	9	2				
22-23									3	2	5	6	3	2	5	3	6	8	11	6	8	15	15	24	13	5				
23-24									2	2	6	5	4	2	2	3	5	7	9	5	6	10	10	36	20	9				

EXIT