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Climatology of 24-Hour North Atlantic Tropical Cyclone Movements
Climatology of 24-Hour North Atlantic Tropical Cyclone Movements

by

George W. Cry

Office of Climatology, U. S. Weather Bureau, Washington, D. C.

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CLIMATOLOGY OF 24-HOUR NORTH ATLANTIC TROPICAL CYCLONE MOVEMENT

George W. Cry
Office of Climatology, U.S. Weather Bureau, Washington, D.C.
[Manuscript received July 22, 1960; revised October 17, 1960]

ABSTRACT
Tropical cyclone movements are an important aspect of hurricane forecasts and warnings. Summaries of 24-hour changes of tropical cyclone (hurricane and tropical storm) center positions in Δ latitude-Δ longitude groupings for 68 selected areas of the North Atlantic region during the period 1886-1958 are presented. The month and year of tropical cyclone origin or detection and the total frequency of individual tropical cyclone passages through each area are included. Points of recurvature, portions of tropical cyclone tracks containing complete loops, and tables of mean speeds in various latitudes are also shown.

1. INTRODUCTION
The variations in tropical cyclone movement, together with other features of these destructive storms, have been of continuing interest to the hurricane forecaster in his problem of predicting areas likely to be affected by a particular storm. Several methods for forecasting tropical cyclone motion, considering various features of the state of the surrounding atmosphere have been developed in recent years [1, 2, 3, 4, 5]. These objective, statistical, and numerical techniques, while employing several directions of attack, all require a more or less complete knowledge of the atmospheric pattern over a considerable area surrounding the storm circulation. Despite a continually improving observational network providing an increased quantity and quality of data, as well as improved aircraft and radar observations, complete information necessary for the utilization of such techniques is not always available over rather extensive areas of the hurricane region. When this situation exists the application of a climatological approach, considering the behavior of past tropical cyclones in certain locations and seasons, may profitably be utilized.

The purpose of this paper is to furnish climatological data on tropical cyclone movement in the North Atlantic region. This type of information, useful primarily to the hurricane forecaster, may also find utility in related studies of hurricane probabilities in various areas. Some previous studies along this line have included Mitchell's[6] which presented average tropical cyclone movements in tabular and graphic forms for 2-1/2° areas in the region 10°N.-60°N., 50°W.-100°W. covering the years 1887-1923, inclusive, and Colón's [7] which gave an abundance of useful information on tropical cyclone motion, including persistence computations and modal recurvature locations, and on
frequency and regions of formation for the years 1887-1950, inclusive. Mook [8] constructed charts of hurricane positions as a function of storm locations within given 5° latitude-longitude areas 24, 48, and 72 hours earlier. His data consisted of published hurricane tracks for the years 1887-1951 and a hurricane position punched card deck prepared in connection with the 1899-1939 Northern Hemisphere maps series.

2. DATA AND METHOD

The data in this paper have been taken from a recent summary [9] of North Atlantic tropical cyclones for the years 1886-1958. The most accurate determination of the track of each hurricane and tropical storm was attempted, after a review of all available information. The 1200 or 1230 GMT positions of all the hurricanes and tropical storms shown in that publication were tabulated to the nearest 0.1° and differences (Δ latitude and Δ longitude) between succeeding 24-hour positions for each storm were calculated and grouped by area and by month. Areas selected are shown on index chart on page 24. The storm movements were tabulated in the area from which the storm moved. When two or more positions were located within a single area, each of the resulting movements was included in that area.

Consolidation of these storm movements was made for each of the 68 areas in 1° class intervals of latitude and longitude. For example, all movements in the range 0° to 0.9° latitude - 1.0° to 1.9° longitude were grouped. These monthly and annual movement summaries were then plotted on a series of charts (pages 25 - 92). The region from which movement originated is shown in the upper left of each chart. The monthly and annual frequency of 24-hour movements is shown immediately below the appropriate title. This total does not always reflect the number of tropical cyclones passing through each area. Differences are noted in most areas because of multiple 24-hour observations for those storms which remained in an area for more than one day, and the movement of other storms over portions of an area between observations. Therefore, the total number of individual tropical cyclone tracks touching each area in each month is shown in the lower right of each chart together with the years of tropical cyclone origin or detection in each area.

A sample monthly movement summary (for the area 15°-20°N., 50°-60°W. during September), with an explanation of the information on these portions of each chart, is shown in figure 1.

3. 24-HOUR MOVEMENT

All movements have been tabulated in degrees of latitude and longitude. Distances (or speeds) represented by a movement through one degree vary considerably at different latitudes. Calculations of mean speeds were made to provide convenient reference tables at various latitudes. The procedure used, adapted from the middle latitude navigation method outlined on pp. 225-227 of Bowditch's [10] "American Practical Navigator," is shown on page 19. The complete range of storm movements, or any portion of the movement distribution in each summary area, may be estimated by using the speed tables. For example, in figure 1 the maximum speed is 19.8 knots (one case at 3.5°N., 7.5°W.); the minimum speed is 5.2 knots (four cases at 1.5°N., 1.5°W.). The speed to the
most frequent location (six cases at 1.5°N., 3.5°W.) is 9.1 knots. Of the 56
24-hour movements in figure 1, 37 (or 66 percent) fall within the boundary
drawn between the mid-points 1.5°N.-2.5°N., 1.5°W.-5.5°W. The range of speeds
to these points is from 5.2 knots to 14.4 knots. A close estimation of the
rate of movement to any point can be easily obtained, giving a complete pic-
ture of the range of speeds of all 24-hour movements. These tables (pages 20
-23) should be useful for estimating speeds of storm movement in any situation
where this information may be desired.

A detailed discussion of movement characteristics in each of the 68 areas
will not be attempted since details are shown on the charts. A general sum-
mmary of the eastward and westward components of 24-hour tropical cyclone
motion at various latitudes is given in table 1.

Westward movement, generally with a slight northward component, is strong-
ly predominant below 20°N., with a few movements northeastward from the western
Caribbean by storms developed there. The majority of movements between 20°N.

Figure 1. - Example of monthly movement summary charts, area 15°-20°N., 50°-
60°W., for September.
Table 1. - Tropical cyclone movement characteristics by month in specified latitudinal bands for the North Atlantic region for the period 1886-1958. "E" indicates a component of motion toward the east and "W" a component of motion toward the west.

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<td>48</td>
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and 30°N. is still westward, but a greater northward component is usual, and an increasing number of northeastward motions are noted as a result of recurvatures in or south of the region. North of 30°N. a sharply increasing percentage of northeastward movements is noted as storms come under the influence of stronger steering currents in the higher latitudes. Many tropical cyclones gradually acquire the structure and organization of extratropical cyclones and become major features of the general circulation in the northern portion of
Table 2. - Tropical cyclone origins by month for areas in the North Atlantic region for the period 1886-1958.

<table>
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<tr>
<th>Month</th>
<th>East of 50°</th>
<th>50°-60°</th>
<th>60°-70°</th>
<th>70°-80°</th>
<th>80°-90°</th>
<th>90°-100°</th>
<th>Total</th>
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<td>5</td>
<td>12</td>
<td>1</td>
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<td>8</td>
<td>3</td>
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<td>2</td>
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<td>Aug.</td>
<td>28</td>
<td>37</td>
<td>12</td>
<td>14</td>
<td>16</td>
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<td>20</td>
<td>32</td>
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<td>Oct.</td>
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<td>2</td>
<td>3</td>
<td>10</td>
<td>7</td>
<td></td>
<td>23</td>
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<tr>
<td>Nov.-May</td>
<td>63</td>
<td>111</td>
<td>35</td>
<td>53</td>
<td>72</td>
<td>13</td>
<td>347</td>
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Origins South of 20°N.

<table>
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<th>60°-70°</th>
<th>70°-80°</th>
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<td>Aug.</td>
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<td>12</td>
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<td>5</td>
<td>54</td>
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<td>Nov.-May</td>
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<td></td>
<td>18</td>
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<tr>
<td>Total</td>
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<td>38</td>
<td>54</td>
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<td>37</td>
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Origins North of 20°N.

The ocean [11]. Others, particularly those over the continent, decrease rapidly in intensity due to the effects of increased surface friction and movement away from their main energy source - the warm tropical ocean. Many of these storms dissipate, or become only minor circulations from the standpoint of winds, within a short time after moving inland. The latter portions of a number of storm tracks, usually in the middle latitudes from the central Atlantic eastward, have a southeastward component - indicative of motion partially around large high pressure areas often present in that region.

4. TROPICAL CYCLONE ORIGINS

Table 2 is a general summary of seasonal variation in regions of tropical cyclone origin or detection. The well known seasonal shift of origins [12,13] is readily seen. The progression is from a June concentration in the Gulf of Mexico and western Caribbean to increased origin frequencies in the Bahamas and just east of the Lesser Antilles in July, and in the lower latitudes of the tropical Atlantic in August and September. Slightly greater numbers of origins than in earlier months are noted in the western regions in these two months. In October a pronounced increase occurs in the western Caribbean when almost 40 percent of all storms during the month are first noted south of 20°N. between 70°W and 90°W. Other origins are scattered throughout most of the development region. This general scatter continues in the off-season months.
Figure 2. - Schematic diagram of tropical cyclone recurvature types.

5. RECURVATURE AND ERRATIC MOVEMENTS

Tabulations of resultant motion do not reflect all characteristics of most tropical cyclone tracks. Since the storm path is not always a straight line between two points, recurvatures are major features in many tracks and the rarer complete loops in the storm path are also important.

a.) Recurvatures. - Several types of upper-level flow patterns have been associated with tropical cyclone recurvature [14]. Riehl [15] has stressed the major role of planetary waves in affecting recurvature, and several others [16, 17, 18] have demonstrated that events in distant portions of the hemisphere can be important in the development of long wave patterns which, in turn, control tropical cyclone movements in the Atlantic.

If recurvature is considered as a change in the longitudinal direction of motion of a storm center, four types may be differentiated:

1) eastward or regular recurvature - change in the direction of movement from a westward component through north to eastward (clockwise). This is by far the most frequent type.

2) westward recurvature - a change in the direction of movement from an eastward component through north to westward (counterclockwise).

A small number of tropical cyclones have changed the sense of longitudinal direction while also on an equatorward track. Again two types may be distinguished:

3) a change in the direction of movement from a westward component through south to eastward (counterclockwise).

4) a change in the direction of movement from an eastward component through south to westward (clockwise).

Recurvature points have been determined as the most westerly locations (types 1 and 3) or the most easterly locations (types 2 and 4) reached by storm centers during each recurvature. Multiple recurvatures, including two
eastward points with a westward point between, have been noted infrequently.
Dates and geographic locations of eastward recurvature points are shown on
figures 3-8 and westward recurvatures on figure 9. Multiple recurvatures of
the same type for an individual storm are indicated by "A", "B" or "C", and
the equatorward types are distinguished by "S". A diagram of each type is
shown in figure 2.

Early season eastward recurvatures are confined to the Gulf of Mexico
in June, to the Gulf and the extreme western Atlantic off Florida in July.
Following the increased area covered by tropical cyclones in August, a pri-
mary concentration of recurvatures is from the southeastern United States
cost between 27°N. and 35°N. eastward to near 72°W. Lesser concentrations
are noted in eastern Texas and southwest of Bermuda. No marked concentra-
tion of recurvature locations is found in September as a large expansion of the
recurvature area occurs. The most frequent recurvatures are southwest of
Bermuda. Most storms recurve between 25°N. and 35°N. but a number are noted
both north and south of this band. The wide latitudinal variation continues
in October, but the favored location is in the western Caribbean between 17°N.
and 20°N., west of 80°W. Off-season eastward recurvatures are widely
scattered.

Westward recurvatures are most frequent between 25°N. and 35°N. over a
wide longitudinal area, with several occurrences also at high latitudes over
the eastern Atlantic and late season occurrences in the western Caribbean.

b.) Loops. - When tropical cyclones move into areas of light and vari-
able ambient winds where an organized steering current is absent, irregular
motions of the storm center may occur. In extreme cases complete loops in the
storm path have been tracked. Two classes of these loops - clockwise and
clockwise - have been compiled and are shown on figures 10 and 11.

The counterclockwise group is located in two general areas: over the
Atlantic north and east of 25°N., 50°W.; and from the western Caribbean and
Gulf of Mexico northeastward to the Carolina coast and near Bermuda. Early
and late season occurrences predominate: 6 in May and June, 4 in September,
10 in October, and 3 in November. The slightly less frequent clockwise group
is more widely scattered - in the Gulf of Mexico, over the Atlantic between
25°N. and 40°N. from 30°W. to 75°W., and in the south-central Atlantic. These
are generally a midseason occurrence: 3 in August-September, 9 in September,
4 in October, and 1 in November.

Each loop contains at least two recurvature points. These are not shown
on the recurvature charts.

6. SUMMARY

Seasonal distributions of 24-hour changes of position, origins, recurva-
tures, and some of the irregular movements of 581 tropical cyclones in the
North Atlantic area during a 73-year period were studied.

The general pattern of tropical cyclone motion is predominantly westward
at slow to moderate speeds in the region south of 25°N. Between 25°N. and
Figure 3. - Eastward recurvatures, June.
Figure 5. - Eastward recurvatures, August.
Figure 6. - Eastward recurratures, September.
Figure 7. - Eastward recurvatures, October.
Figure 8 - Eastward recurvatures, November-May.

October, February, May 18, 1887

Flirt recurvatures
Steered recurvatures
North to south

November-May Eastward Recurvatures

March 10-14, 1887
First recurvatures
Second recurvatures
North to south
Figure 9. - Westward recurvatures, all months.
Figure 10. - Clockwise loops in tropical cyclone tracks.
Figure 11. Counterclockwise loops in tropical cyclone tracks.
30°N. northeastward motions become more frequent, and are progressively more usual, with increasing speeds, in the northern sections of the hurricane region.

The primary tropical cyclone formation areas tend to show a definite longitudinal shift during the year, from the western portion of the ocean early in the season to the southeastern Atlantic in August and September, then back to the Caribbean late in the season.

The variability of areas of recurvature tends to be greatest during September. Two types of extreme short-period changes in the direction of storm movement (loops) were found to be primarily concentrated over rather definite areas within certain portions of the tropical cyclone season.

ACKNOWLEDGMENTS

The author is indebted to Dr. H. E. Landsberg, Messrs. W. H. Haggard, R. C. Gentry, H. F. Hawkins, A. I. Cooperman, and H. C. Sumner for their interest and suggestions, and to Mr. C. F. Kambic and Mrs. E. A. Lepp for their assistance in calculations, figures, and manuscript.

REFERENCES

Example of the procedure used to calculate the mean speeds shown in Tables 3-10:

Base Latitude 17°13' (Area 15°-20°N), Longitude 67°30'. To find the distance to the midpoint of the 1° area centered at 21°N, 72°W

\[ d = L_2 - L_1 \text{ (Minutes)} \]

\[ = 21°00' - 17°30' \]

\[ = 3°30' \]

\[ d = 210' \]

\[ \log d = 2.32222 \]

\[ L_M = L_1 + \frac{d}{2} \]

\[ = 17°30' + 1°45' \]

\[ = 19°15' \]

\[ \log \cos L_M = 9.97501 \]

\[ D_{Lo} = \lambda_1 - \lambda_2 \text{ (Minutes)} \]

\[ = 72°00' - 67°30' \]

\[ = 4°30' \]

\[ = 270' \]

\[ \log D_{Lo} = 2.43136 \]

\[ \log \tan C = \log D_{Lo} + \log \cos L_M - \log d \]

\[ = 2.43136 + 9.97501 - 2.32222 \]

\[ = 0.08415 \]

\[ \log \sec C = 0.19664 \]

\[ \log D = \log d + \log \sec C \]

\[ = 2.32222 + 0.19664 \]

\[ = 2.51886 \]

\[ D = 330.26 \text{ Nautical Miles} \]

Mean Speed = 13.76 or 13.8 knots.

[Adapted from the middle-latitude sailing distance computation technique given on pages 225-227 of American Practical Navigator (Bowditch), 1958.]
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<td>33.5</td>
<td>34.2</td>
<td>35.0</td>
<td>35.9</td>
<td>37.0</td>
<td>38.1</td>
<td>39.3</td>
<td>40.6</td>
<td>42.0</td>
<td>43.4</td>
<td>44.9</td>
<td>46.5</td>
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<td>30.2</td>
<td>30.7</td>
<td>31.8</td>
<td>32.9</td>
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<td>36.3</td>
<td>37.5</td>
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<td>43.7</td>
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<td>31.5</td>
<td>32.7</td>
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<td>35.3</td>
<td>36.7</td>
<td>38.2</td>
<td>39.9</td>
<td>41.8</td>
<td>43.7</td>
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<td>48.0</td>
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<tr>
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<td>27.0</td>
<td>27.7</td>
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<td>30.5</td>
<td>32.0</td>
<td>33.6</td>
<td>35.2</td>
<td>36.9</td>
<td>38.8</td>
<td>40.8</td>
<td>43.0</td>
<td>45.3</td>
<td>47.9</td>
<td>50.6</td>
</tr>
</tbody>
</table>
### SPEED IN KNOTS BETWEEN SPECIFIED COORDINATES, BASE LATITUDE 37°30'

#### Lat. 0.5

| Long. 0.5 | 1.5 | 2.5 | 3.5 | 4.5 | 5.5 | 6.5 | 7.5 | 8.5 | 9.5 | 10.5 | 11.5 | 12.5 | 13.5 | 14.5 | 15.5 | 16.5 | 17.5 | 18.5 | 19.5 | 20.5 | 21.5 | 22.5 | 23.5 | 24.5 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|

#### Long. 0.5

| Lat. 0.5 | 1.5 | 2.5 | 3.5 | 4.5 | 5.5 | 6.5 | 7.5 | 8.5 | 9.5 | 10.5 | 11.5 | 12.5 | 13.5 | 14.5 | 15.5 | 16.5 | 17.5 | 18.5 | 19.5 | 20.5 | 21.5 | 22.5 | 23.5 | 24.5 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
SPEED IN KNOTS BETWEEN SPECIFIED COORDINATES, BASE LATITUDE 47°30'
Index to areas selected for tropical cyclone movement tabulations. Numbers refer to pages on which summary for each area may be found.
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADeD AREA.

- JUNE
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER-MAY
- JUNE
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER-MAY

FREQUENCY OF 4-10° CENTRAL PRESSURE THROUGH EQUIPOTENTIAL LINES FROM A SHADeD AREA.

- JUNE
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER-MAY

FREQUENCY OF 4-10° CENTRAL PRESSURE THROUGH EQUIPOTENTIAL LINES FROM A SHADeD AREA.
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA.
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHAPED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHAD ED AREA

[Diagram showing annual and monthly frequency distributions of cyclone motion components within the shaded area.]
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

- 10°-20°N, 80°-85°W.
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER-MAY

Frequency plots showing the movement of tropical cyclones over 24-hour increments for each month from June to May.
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADOED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADEd AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

15°-20°N.
50°-60°W.

LONG/24 HOURS

ANNUAL

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

LONG/24 HOURS

JUNE

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

NUMBER OF CYCLONES CROSSING PASSING THROUGH THE AREA AND YEARS OF PASSING IN AREA

| MONTH  | 1960 | 1961 | 1962-63 | 1964 | 1965-
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</thead>
<tbody>
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<td>15</td>
<td>10</td>
<td>5</td>
<td>7</td>
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<tr>
<td>JULY</td>
<td>8</td>
<td>4</td>
<td>3</td>
<td>2</td>
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<tr>
<td>AUGUST</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SEPTEMBER</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
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</tr>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>NOVEMBER-MAY</td>
<td>2</td>
<td>1</td>
<td>1</td>
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</table>
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHARED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

LONG./24 HOURS
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

FREQUENCY

Δ LONG/24 HOURS

FREQUENCY

Δ LONG/24 HOURS

FREQUENCY

Δ LONG/24 HOURS

FREQUENCY

Δ LONG/24 HOURS

FREQUENCY

Δ LONG/24 HOURS
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

- OCTOBER
- JUNE
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER-Nov-May

<table>
<thead>
<tr>
<th>MONTH</th>
<th>JUNE</th>
<th>JULY</th>
<th>AUGUST</th>
<th>SEPTEMBER</th>
<th>OCTOBER-Nov-MAY</th>
</tr>
</thead>
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<tr>
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<td>3</td>
<td>9</td>
<td>3</td>
<td>53</td>
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<th>OTHER CYCLES</th>
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<th>1947</th>
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<td>4360</td>
<td>2825</td>
<td>1550</td>
<td>310</td>
<td>116</td>
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</table>
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

20°-25°N,
15°-30°W.

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

<table>
<thead>
<tr>
<th>MONTH</th>
<th>FREQUENCY</th>
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<tbody>
<tr>
<td>JUNE</td>
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<td>JULY</td>
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<td>AUGUST</td>
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<td>SEPTEMBER</td>
<td>0</td>
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<tr>
<td>OCTOBER</td>
<td>0</td>
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<tr>
<td>NOVEMBER-MAY</td>
<td>0</td>
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</table>
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

A LONG/24 HOURS

DECEMBER

JANUARY

FEBRUARY

MARCH

APRIL

MAY

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADeD AREA

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

FREQUENCY

20°-26°N
40°-45°W

MARCH

APRIL

MAY

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

JUNE

SEPTEMBER

JULY

OCTOBER

AUGUST

SEPTEMBER

MAY
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHAPED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHATED AREA

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

ANNUAL
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADIED AREA

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

JUNE 4

JULY 15

AUGUST 26

SEPTEMBER 06

OCTOBER 66

NOVEMBER-MAY 06

MONTHS DECADES

1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915

JUNE JUNE JUNE JUNE JUNE JUNE JUNE JUNE JUNE JUNE JUNE JUNE JUNE JUNE JUNE

LONG./24 HOURS

LAT./24 HOURS

LONG./24 HOURS

LAT./24 HOURS

LONG./24 HOURS

LAT./24 HOURS

LONG./24 HOURS

LAT./24 HOURS

LONG./24 HOURS

LAT./24 HOURS

LONG./24 HOURS

LAT./24 HOURS

LONG./24 HOURS

LAT./24 HOURS

LONG./24 HOURS

LAT./24 HOURS
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHAPED AREA

20°-25°N, 65°-90°W.
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

52
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

20°-25°N, 95°-100°W.

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

WINDS OF CYCLONE CENTER PASSING THROUGH THE AREA AND TRACK OF центЕ IN AREA

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

MAK

PRESIDENT

12

12

12

12

12

12
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

25°-30°N, 15°-50°W.
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

MONTH OF CYCLODES CENTERING WITHIN THE AREA AND TIMES OF OCCURRENCE IN AREA

<table>
<thead>
<tr>
<th>JUNE</th>
<th>JULY</th>
<th>AUGUST</th>
<th>SEPTEMBER</th>
<th>OCTOBER-MAY</th>
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<td>5</td>
<td>10</td>
<td>15</td>
<td>30</td>
<td>50</td>
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<tr>
<td>1000</td>
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<td>1000</td>
<td>1918</td>
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<td>1910</td>
<td>1910</td>
<td>1910</td>
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<td>1910</td>
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24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

[Graphs and data points showing the movement patterns of cyclones over different months]
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

25°-30°N.
60°-70°W.

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

LONG./24 HOURS

LONG./24 HOURS

LONG./24 HOURS

LONG./24 HOURS

LONG./24 HOURS

LONG./24 HOURS
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

15°-30°N, 70°-2°W.

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

FREQUENCY

FREQUENCY

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24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

24 HOURS

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

25°-30°N, 100°-150°W

ANNUAL
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER-MAY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

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FREQUENCY

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FREQUENCY
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHARED AREA.

MONTHS:
- JUNE
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER
- DECEMBER

- JUNE
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER
- DECEMBER

- JUNE
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER
- DECEMBER

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- OCTOBER
- NOVEMBER
- DECEMBER

- JUNE
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- NOVEMBER
- DECEMBER

- JUNE
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- AUGUST
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- OCTOBER
- NOVEMBER
- DECEMBER

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- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER
- DECEMBER

- JUNE
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER
- DECEMBER

- JUNE
- JULY
- AUGUST
- SEPTEMBER
- OCTOBER
- NOVEMBER
- DECEMBER
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA.
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

ANNUAL

FREQUENCY

JUNE

FREQUENCY

JULY

FREQUENCY

AUGUST

FREQUENCY

SEPTEMBER

FREQUENCY

OCTOBER

FREQUENCY

NOVEMBER-MAY

FREQUENCY

NUMBER OF CYCLONE CENTER PASSING THROUGH THIS AREA AND YEARS OF CENTER 24 HOURS

JULY 15 20 15

AUGUST 20 40 10 10

SEPTEMBER 20 15 10 5

OCTOBER 15 5 10

NOVEMBER-MAY 10 10 20

STORM YEARS 1960 1961 1965 1966
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADEN AREA

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

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FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

20
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADeD AREA

20°-25°N,
60°-80°W.
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

NUMBER OF CYCLONES PERIOD PASSING THROUGH AREA AND YEARS OF CYCLES IN AREA


STORM CRITERIA

FREQUENCY 0 0 0 0 0
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

30°-35°N
93°-100°W

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

ANNUAL

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

FREQUENCY

\( \Delta \text{LONG/24 HOURS} \)

\( \Delta \text{LAT/24 HOURS} \)
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHAD ED AREA

35° 47' N
12° 35' W

ANNUAL

FREQUENCY

JUNE

FREQUENCY

JULY

FREQUENCY

AUGUST

FREQUENCY

SEPTEMBER

FREQUENCY

OCTOBER

FREQUENCY

NOVEMBER-MAY

FREQUENCY
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHAPED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 Hour Components of Motion of Tropical Cyclones Initially Located Within the Shaded Area
24-HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADING AREA

JUNE

SEPTEMBER

AUGUST

OCTOBER

NOVEMBER-MAY

ANNUAL

1/2 HUR/{HOUR}

1/2 HOUR

X

Y

LONGITUDE [HOURS]

LATITUDE [DEGREES]
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA

40°-45°N.
50°-60°W.

JUNE

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

MONTHS OF CYCLES CENTERS PASSING THROUGH THIS AREA AND YEARS OF SHEEREST IN AREA

JUNE 1 7 15 20 26
JULY 6 4 10 16 22
AUGUST 15 10 20 26
SEPTEMBER 10 16 22
OCTOBER 16 22
NOVEMBER-MAY 22

FREQUENCY
24 HOURS COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHAPED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADEd AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHAPED AREA

- Map of the area
- Graphs for different months:
  - June
  - July
  - August
  - September
  - October
  - November-May
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA
24 Hour Components of Motion of Tropical Cyclones Initially Located Within the Shaded Area
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADED AREA.
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADDED AREA

MAP OF CYCLONE INITIATION LOCATION

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY

JUNE
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHADEd AREA

ANNUAL

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER-MAY
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHAPED AREA
24 HOUR COMPONENTS OF MOTION OF TROPICAL CYCLONES INITIALLY LOCATED WITHIN THE SHAPED AREA

| Month      | Components of Motion | Maps of Motion
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<tbody>
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<td>November-May</td>
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**Key**: 25% 25% 25% ANNUAL

**Features**:
- Grids for each month
- Shaded areas indicating motion components
- Yearly distribution

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**Note**: The diagrams illustrate the movement patterns of tropical cyclones over different months, with shaded regions indicating the areas of initial location.