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ATLANTIC TROPICAL CYCLONE TRACKS BY 5-, 10-, 15-, AND 30-DAY PERIODS

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ABSTRACT

A recent revision of Atlantic tropical cyclone climatology identifies 761 storms which have reached at least tropical storm intensity over the 92-years from 1886 through 1977. This study presents computer plots of these storm tracks for various intraseasonal periods ranging from 5 days to 1 month. A brief assessment on the accuracy of the tracks is also included.

INTRODUCTION

Depending upon their maximum sustained surface windspeeds, tropical cyclones are defined as tropical depressions ($\leq$ 33 kt), tropical storms (34 through 63 kt) or hurricanes ($\geq$ 64 kt). Over the North Atlantic tropical cyclone basin[1], reasonably accurate records extend back into the previous century and, beginning with the year 1886, it is possible to classify storms according to the maximum intensity attained during their life cycle. Over the 92 years from 1886 through 1977, Neumann, *et al.* (1978) identify 761 tropical cyclones which have attained at least tropical storm status and 448, or approximately 59%, of at least hurricane strength. Numerous additional tropical cyclones that never developed beyond the weak tropical depression stage have also occurred, but, until the introduction of weather satellites in the early 1960's, many of these went undetected and records are too fragmented to be of any statistical value. Accordingly, most studies, including the present, concern themselves only with those tropical cyclones which attained at least tropical storm status.

All or portions of the period of record, 1886 through 1977, have been used by various authors and agencies to prepare climatological and engineering studies tailored to specific user requirements. In the reference cited in the preceding paragraph, for example, the presentation of storm track maps, one for each year, 1886 through 1977[2], satisfies a large demand for this type of information. In another study, Crutcher and Quayle (1974)[3] give average motion characteristics and storm frequencies for 5° latitude-longitude "boxes." Hope and Neumann (1969, 1971) do likewise for 2 1/2° spacing.

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[1] The North Atlantic tropical cyclone basin includes much of the North Atlantic Ocean, the Caribbean Sea, the Gulf of Mexico and most adjacent land areas.

[2] The referenced publication also includes storm track maps for 1871 through 1885, but there is no specification of intensity. The reference further includes a list of 116 published and unpublished articles, studies, and data on all aspects of Atlantic tropical cyclones.

[3] The referenced publication also includes statistics for other tropical cyclone basins.

Additional storm motion characteristics in the form of vector statistics are given by Crutcher and Quinlan (1971).

Other available studies focus on Atlantic tropical cyclones that have crossed the United States coastline. These studies include Ho *et al.* (1975), Simpson and Lawrence (1971), and Hebert and Taylor (1975). In the latter, storms crossing the United States coastline are classified according to their Saffir/Simpson (Saffir, 1977) hurricane disaster scale rating.

In Cry (1965), as revised by Neumann *et al.* (1978), tropical cyclone tracks, in addition to being presented for each year, are grouped into trimonthly and monthly periods. Such charts have always been useful in identifying temporal and spatial characteristics of Atlantic tropical cyclones. The present study, with the aid of computer graphics technology, expands on this type of presentation and, in addition to those intraseasonal periods specified above, includes storm tracks grouped by 5-day and bimonthly periods.

2. DATA SOURCES

Data used in the preparation of the various charts and figures contained herein were obtained from a recently revised computer card deck (and magnetic tape) compiled at the National Hurricane Center as described by Jarvinen and Caso (1978). These data were used in the previously cited revision of Atlantic tropical cyclone climatology (Neumann *et al.*, 1978). The reader is referred to either of these two publications for a detailed description of the methodology used in compiling the card deck.

Certain factors should be considered before making further interpretations of the material presented here. The formation of tropical cyclones typically takes place over remote tropical or subtropical waters. Gradual deepening into tropical storms, and perhaps into hurricanes, then occurs, while eventual dissipation or modification can be expected over the colder waters of the North Atlantic or when the storms move over North America and away from the sustaining marine environment. The duration of a tropical cyclone currently averages about 9 days, but, depending upon a number of circumstances, has ranged from less than 1 to 31 days.

The current method of detecting and tracking tropical cyclones - primarily by weather satellites and aircraft reconnaissance - guarantees that even weak, short-duration storms will not go undetected. Such was not always the case. Subsequent to the introduction of routine aircraft reconnaissance in 1944 and before the introduction of weather satellites in the early 1960's, some storms had already reached a degree of maturity upon first being detected by aircraft, ship, or land station. Before the era of aircraft reconnaissance, a surprise encounter with a mature tropical cyclone was even more likely. Even though detection of a tropical cyclone could have occurred several days after initial formation, attempts were made by analysts to extrapolate these storms back to a more likely point of origin. Sometimes, a complete lack of information prevented full attainment of this goal.

Ship traffic has always been active across the Atlantic and the chance of a mature storm going undetected for more than a few days is unlikely. Certainly, some remote, weak, and short-duration storms could have remained undetected.

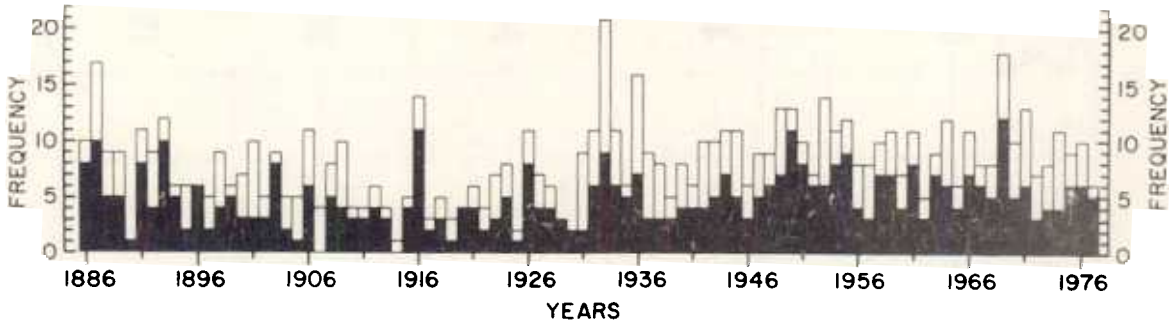


Figure 1. Annual distribution of the 761 recorded Atlantic tropical cyclones reaching at least tropical storm strength (open bar) and the 448 reaching hurricane strength (solid bar), 1886 - 1977. The average annual number of such storms over the period of record is 8.3 and 4.9, respectively.

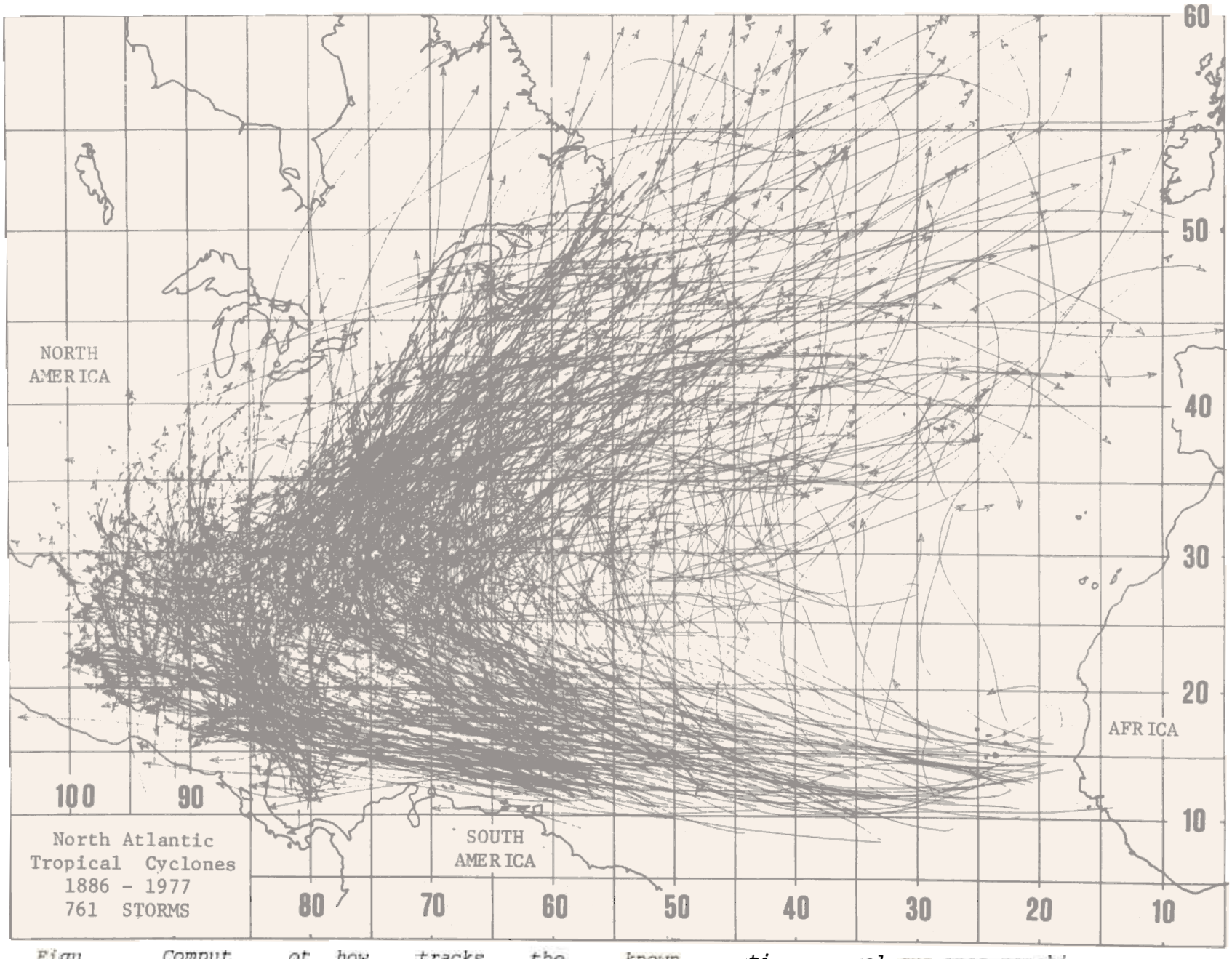
However, as evidenced by figure 1, the occurrence rate of tropical cyclones although having wide year-to-year variation, shows only a slight decline before the introduction of aircraft reconnaissance in 1944. Indeed, a record number of 21 storms was observed in 1933.

In addition to the question of storm detection, the question also arises as to the accuracy of the tracks after initial detection. Today, tropical cyclones are under continuous surveillance by weather satellite; errors in positioning the center (eye) of a storm average less than 20 n.mi. Aircraft can locate and evaluate the center with similar, if not better, accuracy, but the frequency of these aircraft "fixes" is small, averaging four per day for storms threatening populated areas and one per day or none for other distant storms. It is more difficult to determine the center of a tropical cyclone under these latter circumstances than to have continuous weather satellite coverage. Before the era of weather reconnaissance, the center of a tropical cyclone was often estimated on the basis of a few ship reports on the periphery of the cyclones's circulation. Under these circumstances, positioning errors exceeding 100 n.mi. are to be expected. However, even before the use of aircraft, the intersection of a storm with a populated land mass generally guaranteed position accuracy to within 15 n.mi. at the point of landfall.

In summary, the storm tracks presented here are considered reasonably accurate, even back to the previous century. However, the extrapolation of some of these storms backwards in time is a subjective process, subject to large error. Also, it is likely that some weak, short-duration storms could have gone completely undetected. Once detected, the errors in locating the exact center of a storm, although small when storms move over populated areas and small even over remote areas with today's tracking technology, could have exceeded 100 n.mi. with earlier, limited tracking methods.

3. PRESENTATION OF CHARTS

The various charts presented on pages 9 through 57 were produced on the NOAA FR-80 computer graphics system. In Chart Series A, storm tracks are



Figu Comput ot how tracks the known ti al cyc ones reaching
ropi al torm tens ty he od throu 97

presented for monthly periods. For the period May through December, charts are presented for 15- or 16-day periods (Series B); for 10- or 11-day periods (Series C); and finally, for 5- or 6-day periods (Series D). The legend located in the lower left hand corner of each chart specifies the time period and the number of storms plotted. In cases where this latter number is zero, the maps are omitted. Tracks are given only for those storms which attained at least tropical storm strength. Once a storm was found to meet this requirement, all recorded intensity stages, including the tropical depression and subtropical[4] stages, if any, were included in the plot and used to determine the beginning date[5] of the storm. Storms are identified only according to their apparent beginning date. Further labeling would clutter the charts and detract from their essential purpose: the identification of seasonal shifts in the temporal and spatial characteristics of Atlantic tropical cyclones.

A plot of the entire 761-storm sample is shown in figure 2. Because of the large number of storms, this chart has limited utility. However, it does serve to define the limits and the general configuration of the North Atlantic tropical cyclone basin.

Chart Series D was used to prepare figure 3. Here, the seasonal fluctuations in the frequency of tropical cyclones is highlighted and it can be noted that most tropical cyclones (discounting the 6-days of August 25-31)

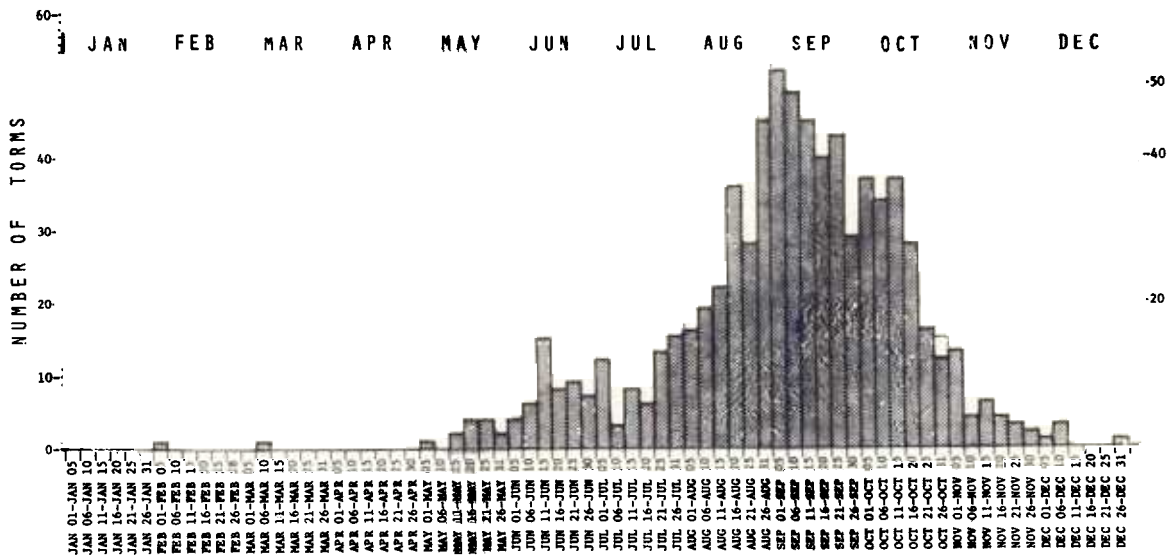


Figure 3. Number of tropical storms and hurricanes beginning in specified 5- or 6-day periods, 1886 through 1977. Those periods containing 6 days have been subdivided into a 5-day total (shaded) and a 1-day total (nonshaded). Total number of storms is 761. Data have been derived from Chart Series D.

[4] For a description of subtropical cyclones, see Hebert (1973).

[5] In the earlier years, observational difficulties, as cited in section 2, may have delayed initial detection of some storms.

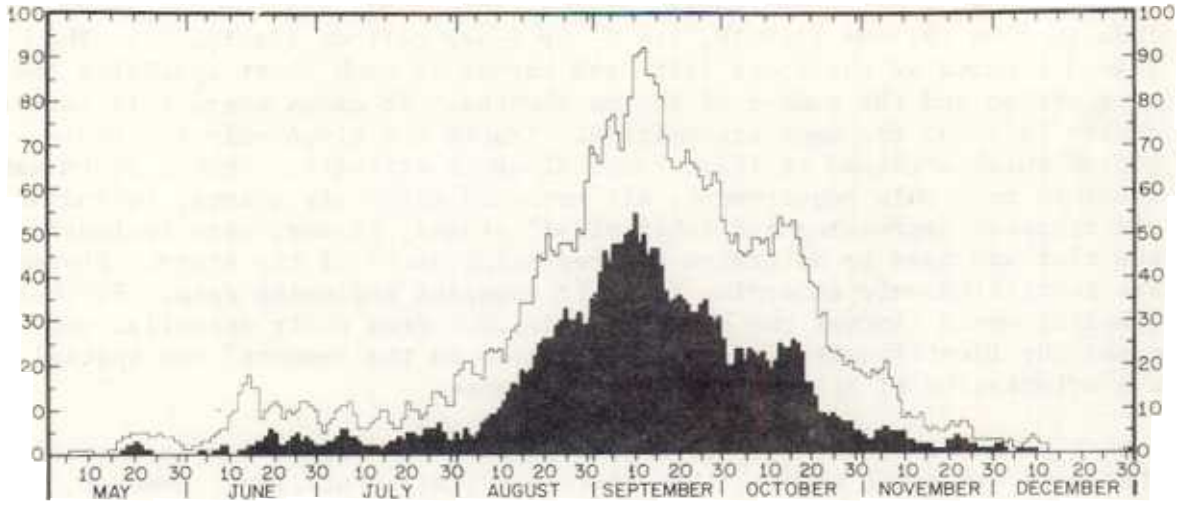


Figure 4. Number of tropical storms and hurricanes (open bar) and hurricanes (solid bar) observed on each day, May 1 - December 30, 1886 through 1977.

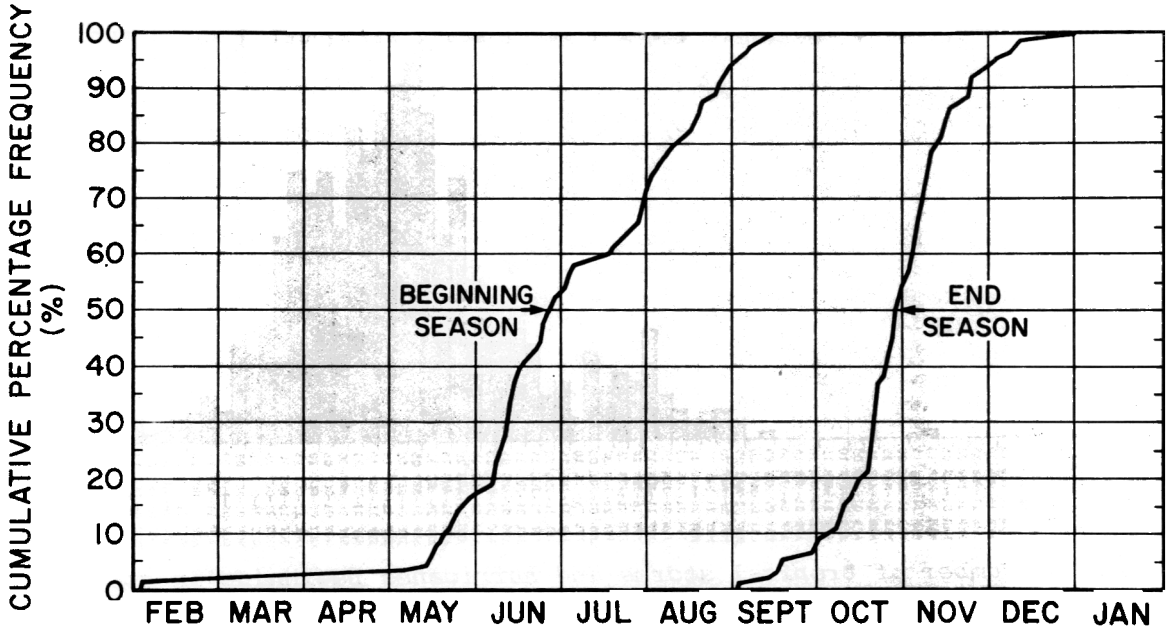


Figure 5. Cumulative percentage frequency distribution of beginning and ending dates of Atlantic tropical cyclone season, 1886 through 1977. (Dates are of first and last recorded position with at least tropical storm strength.)

occur in early September. However, the duration of a tropical cyclone averages a week to 10 days. Accordingly, as shown on figure 4, more tropical cyclones have been in *existence* somewhat later in September, even though the peak starting period is in early September.

The "official" Atlantic hurricane season extends from June 1 through November 30. However, as seen from figure 5 and the various chart series, the season occasionally begins or ends outside of this period. The figure gives a cumulative percentage frequency of the date of detection (see footnote 5) of the first and the date of dissipation of the last tropical cyclone of storm or hurricane intensity for each season from 1886 through 1977. The median (midpoint of the distribution) beginning date is June 26 and the median ending date is October 29.

Detailed discussions on additional features of Atlantic tropical cyclone climatology, as revealed by the Chart Series, are beyond the scope of the present study, being geared more to presentation, rather than interpretation of the data. The Chart Series confirms, of course, the obvious and well-known seasonal shift in the genesis area of Atlantic tropical cyclones; westward both early and late in the season and farther eastward in midseason. However, numerous additional temporal and spatial characteristics of Atlantic tropical cyclone climatology can be determined by study of the Chart Series.

4. REFERENCES

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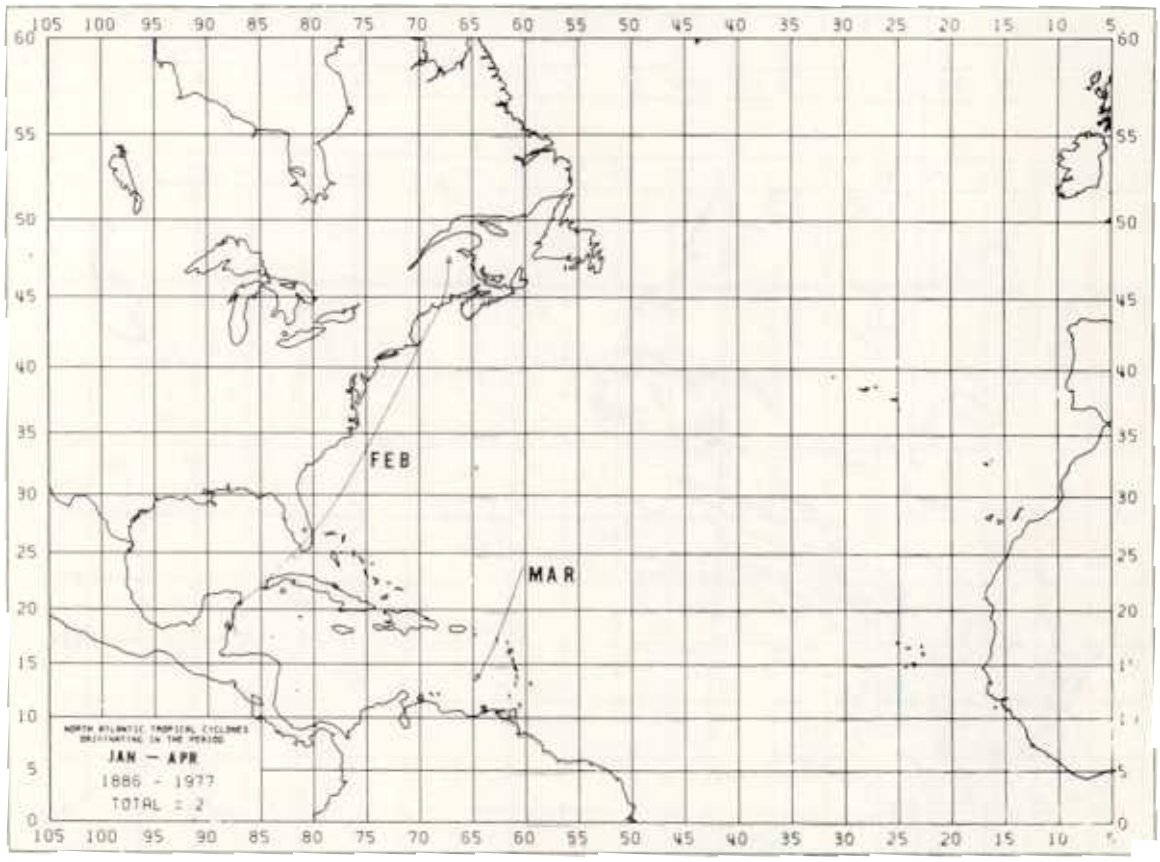
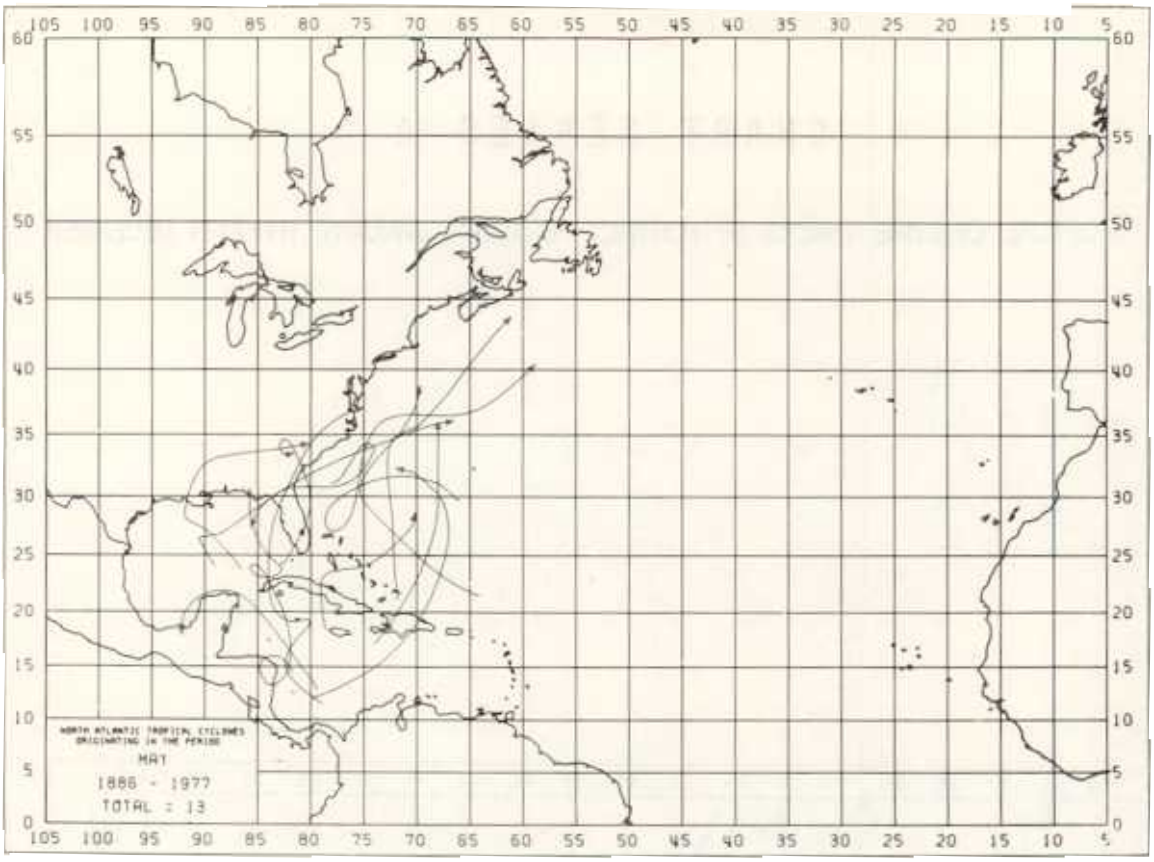
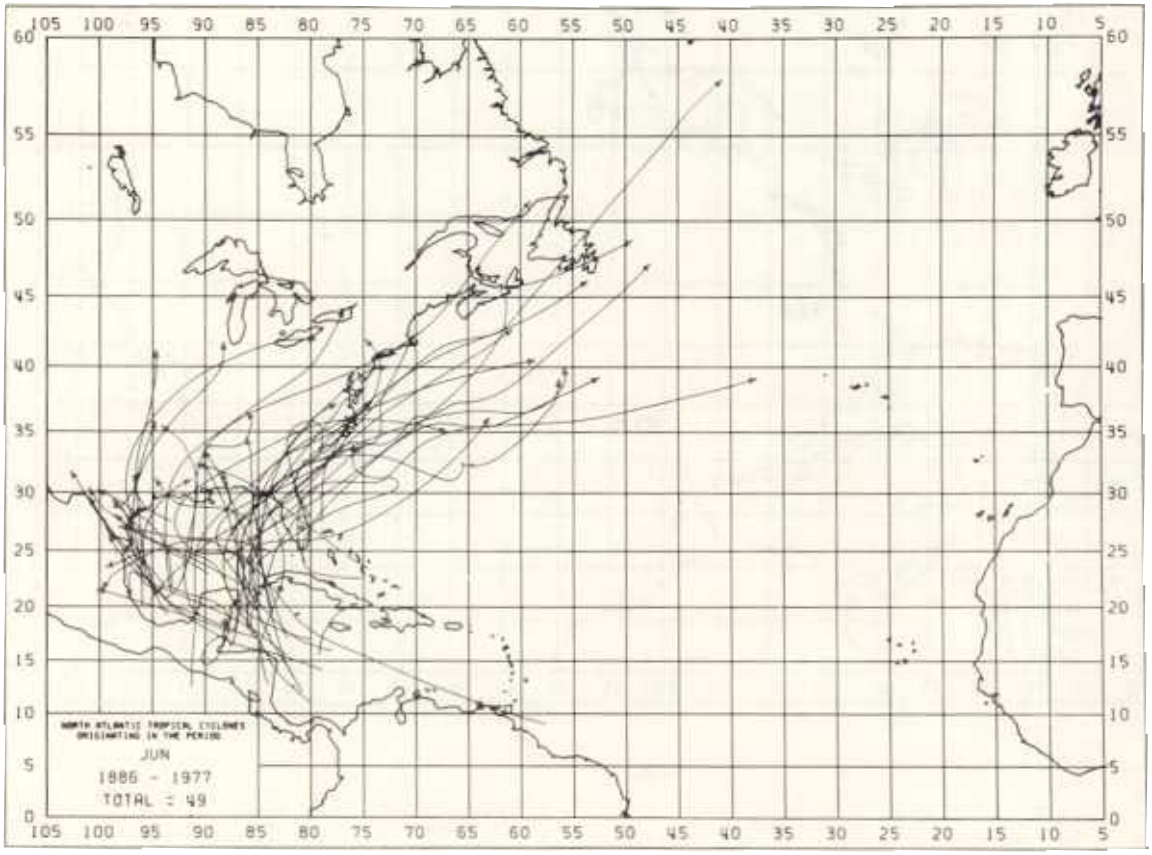
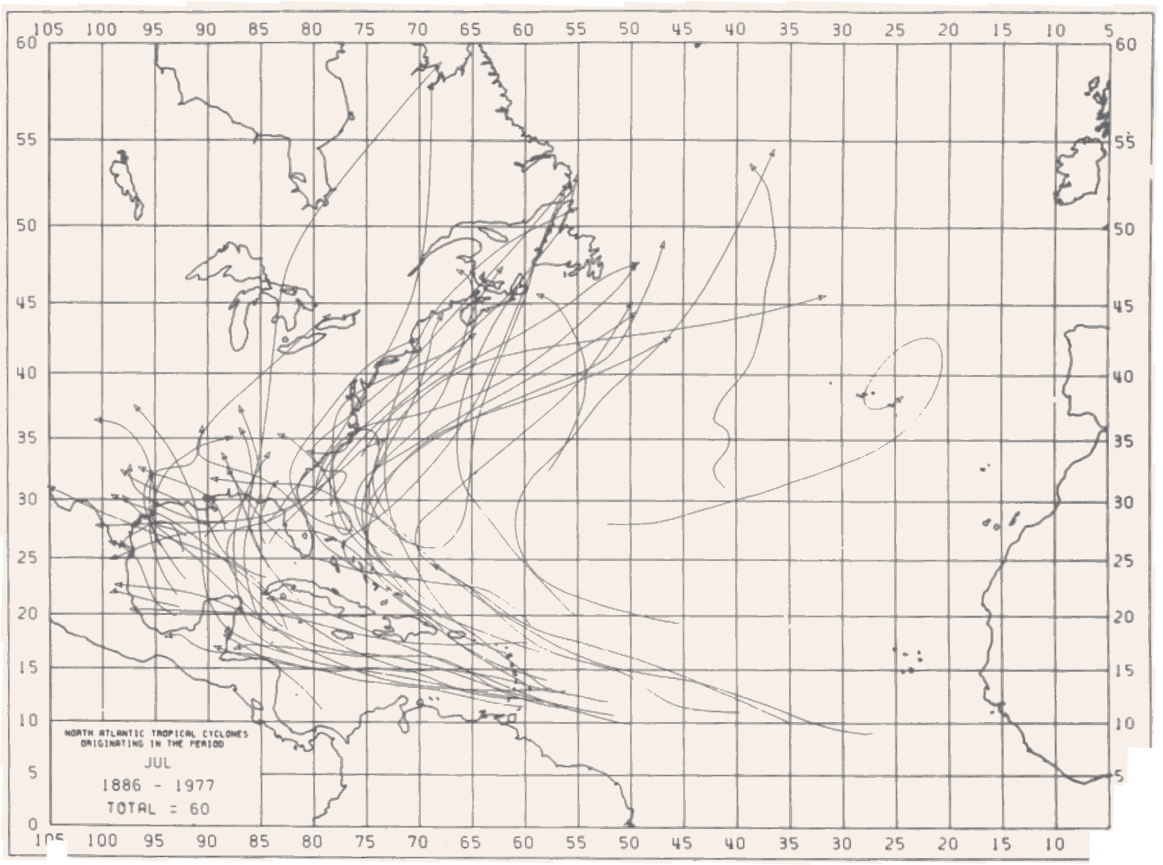
CHART SERIES A

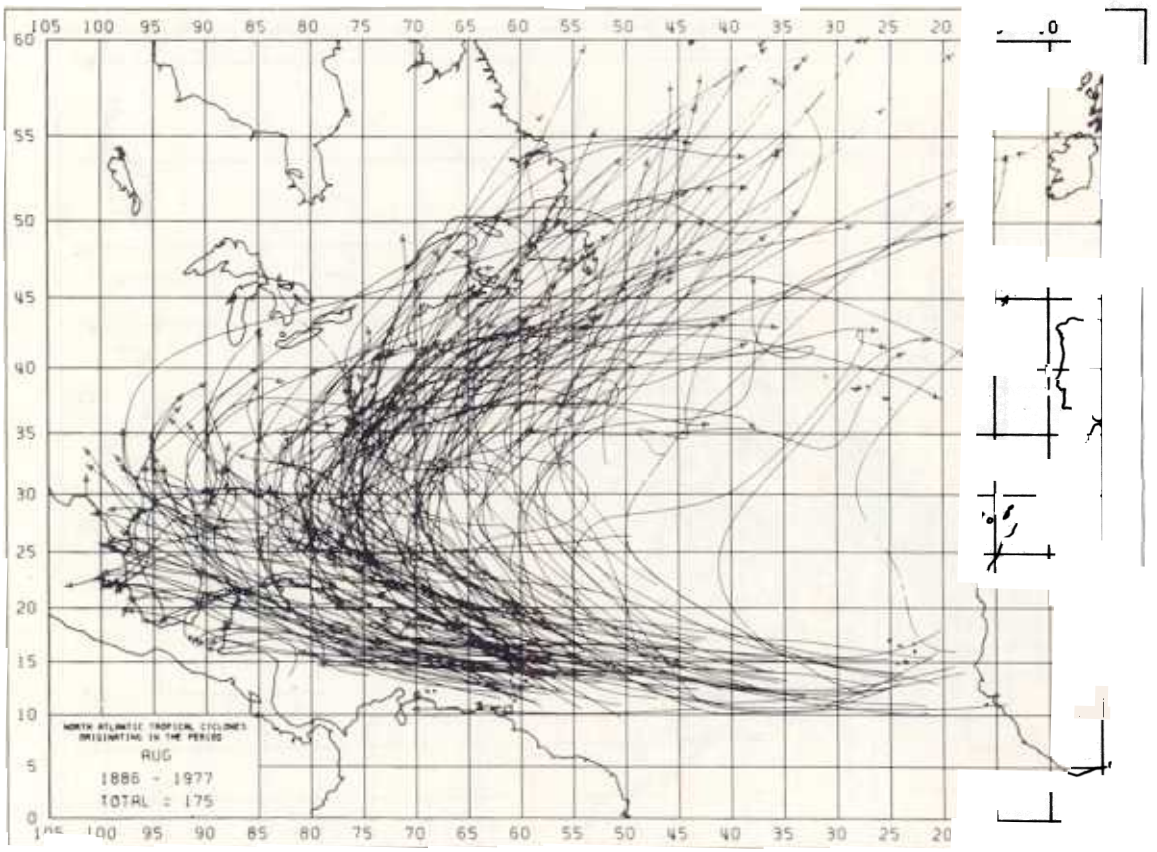
TROPICAL CYCLONE TRACKS BY MONTHLY PERIODS, JANUARY THROUGH DECEMBER

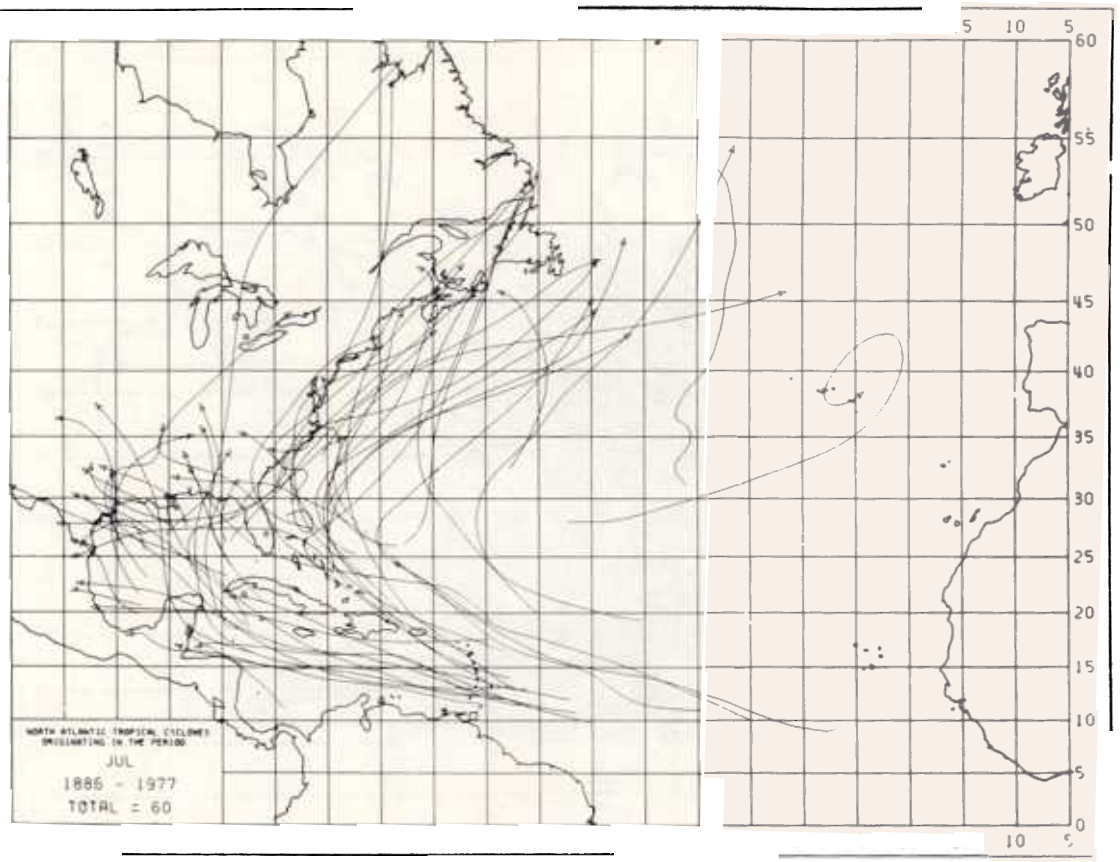


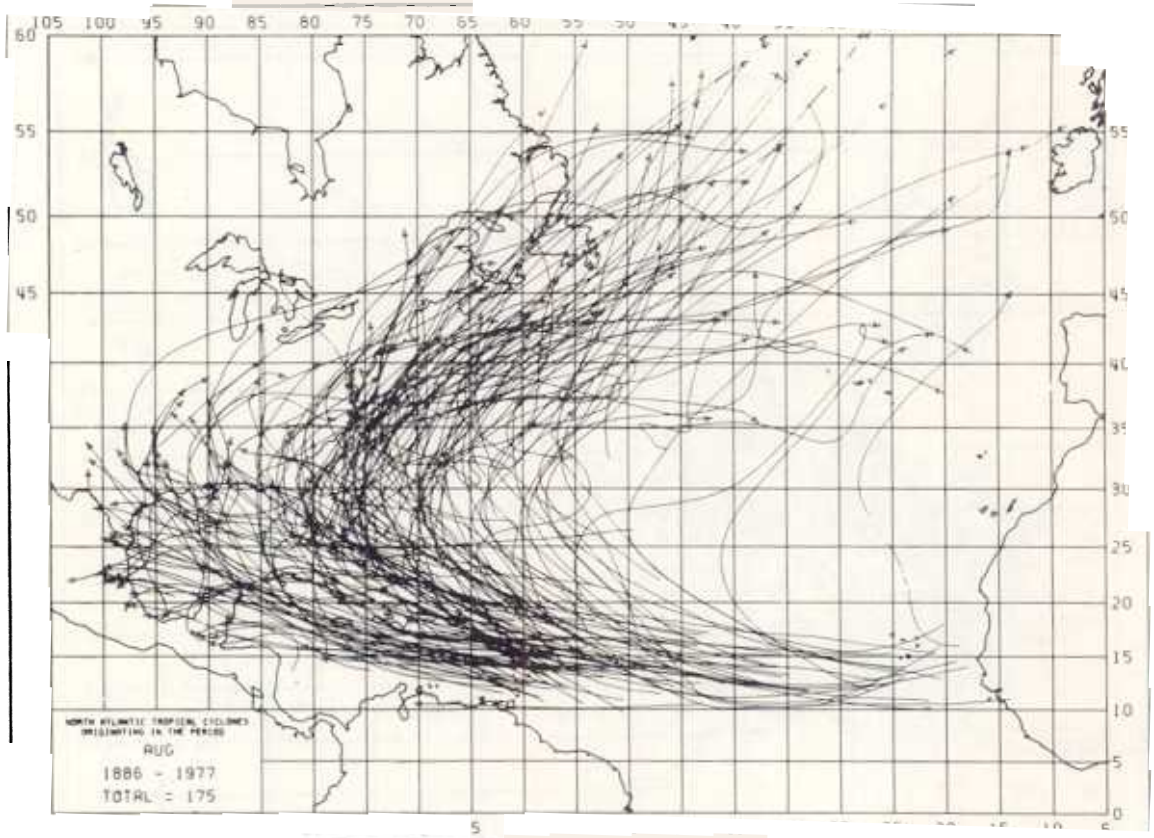

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
MAY
1886 - 1977
TOTAL : 13

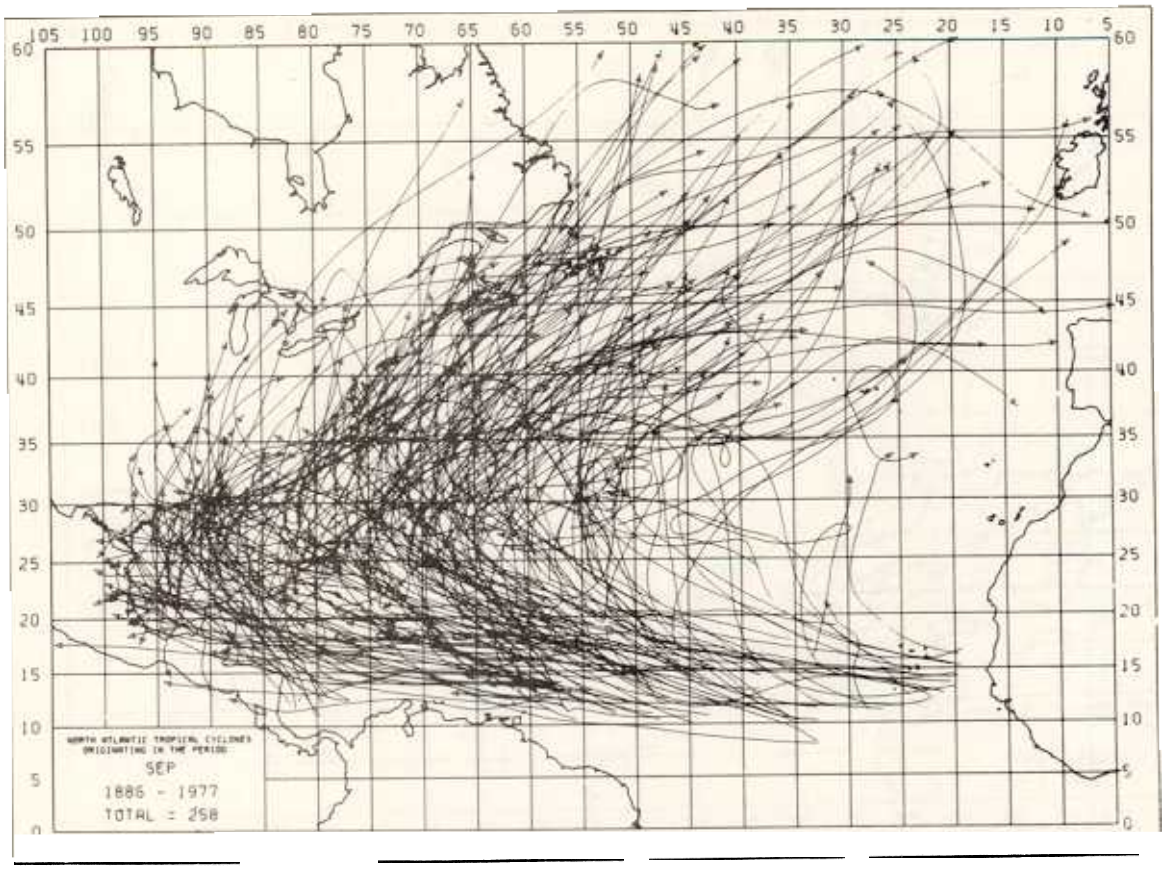

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN
1886 - 1977
TOTAL : 49

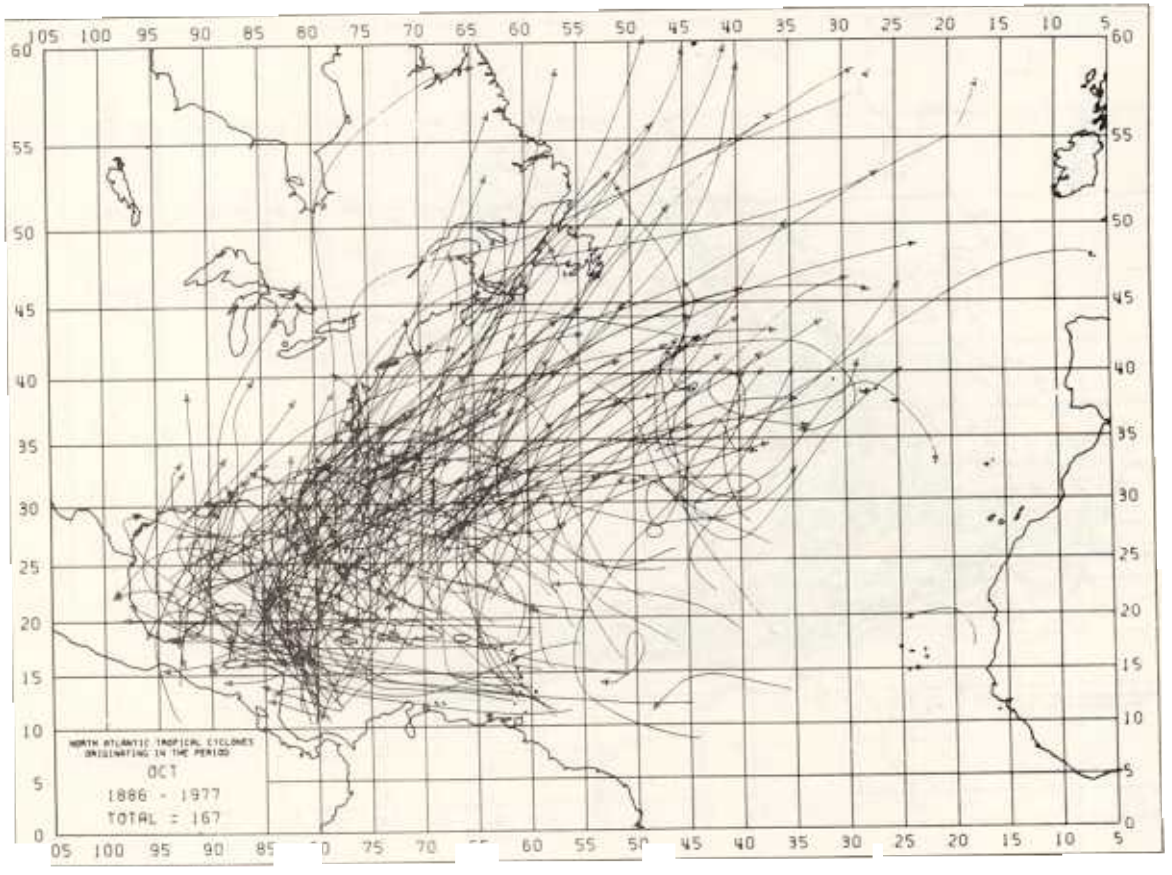

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL
1886 - 1977
TOTAL = 60


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG
1886 - 1977
TOTAL = 175


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL
1886 - 1977
TOTAL = 60


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG
1886 - 1977
TOTAL = 175


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
SEP
1886 - 1977
TOTAL = 258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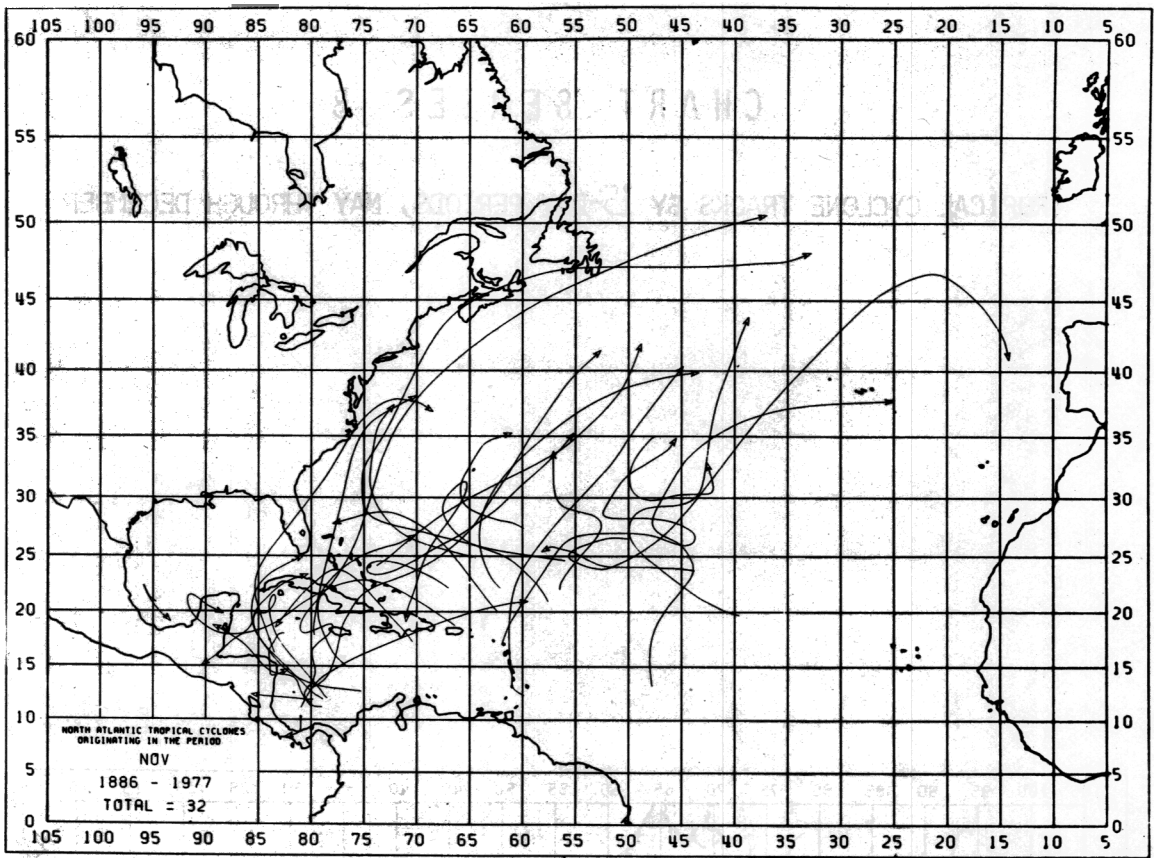
ORIGINATING IN THE PERIOD
OCT
1886 - 1977
TOTAL = 167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ORIGINATING IN THE PERIOD
NOV
1886 - 1977
TOTAL = 32

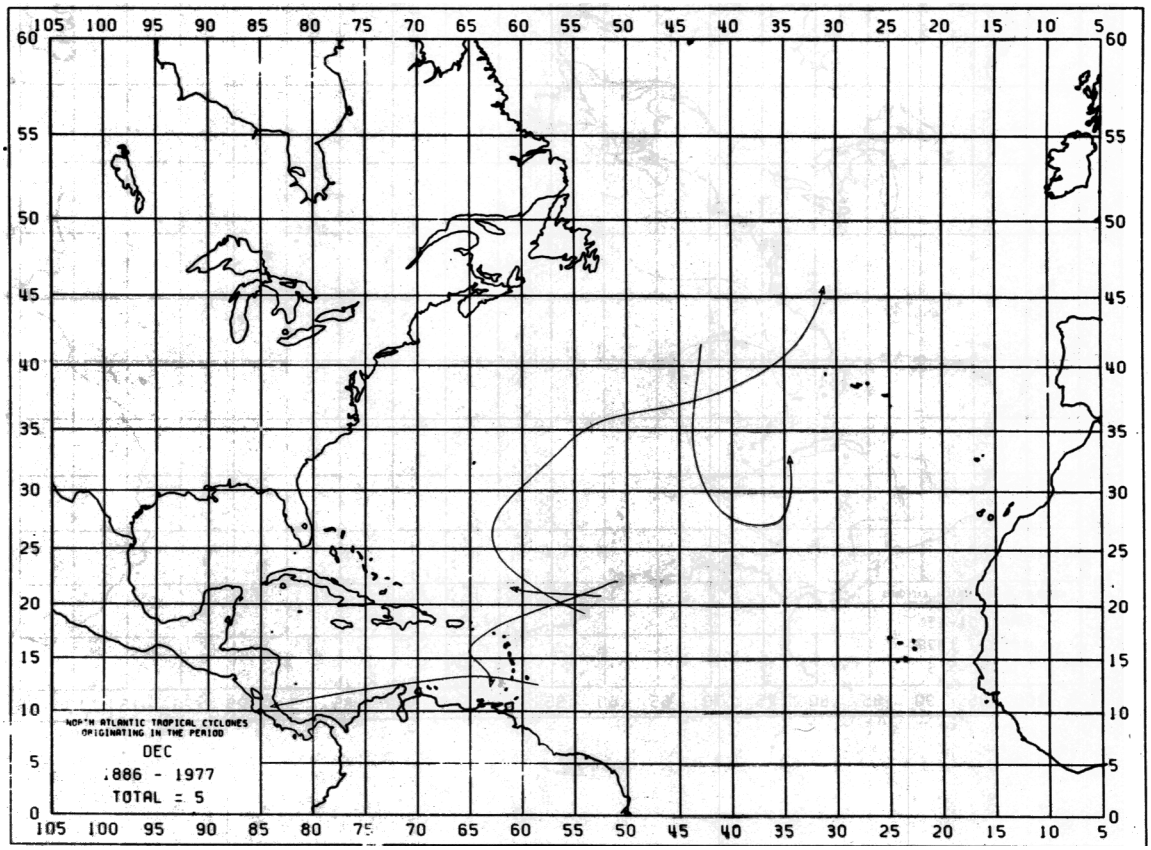
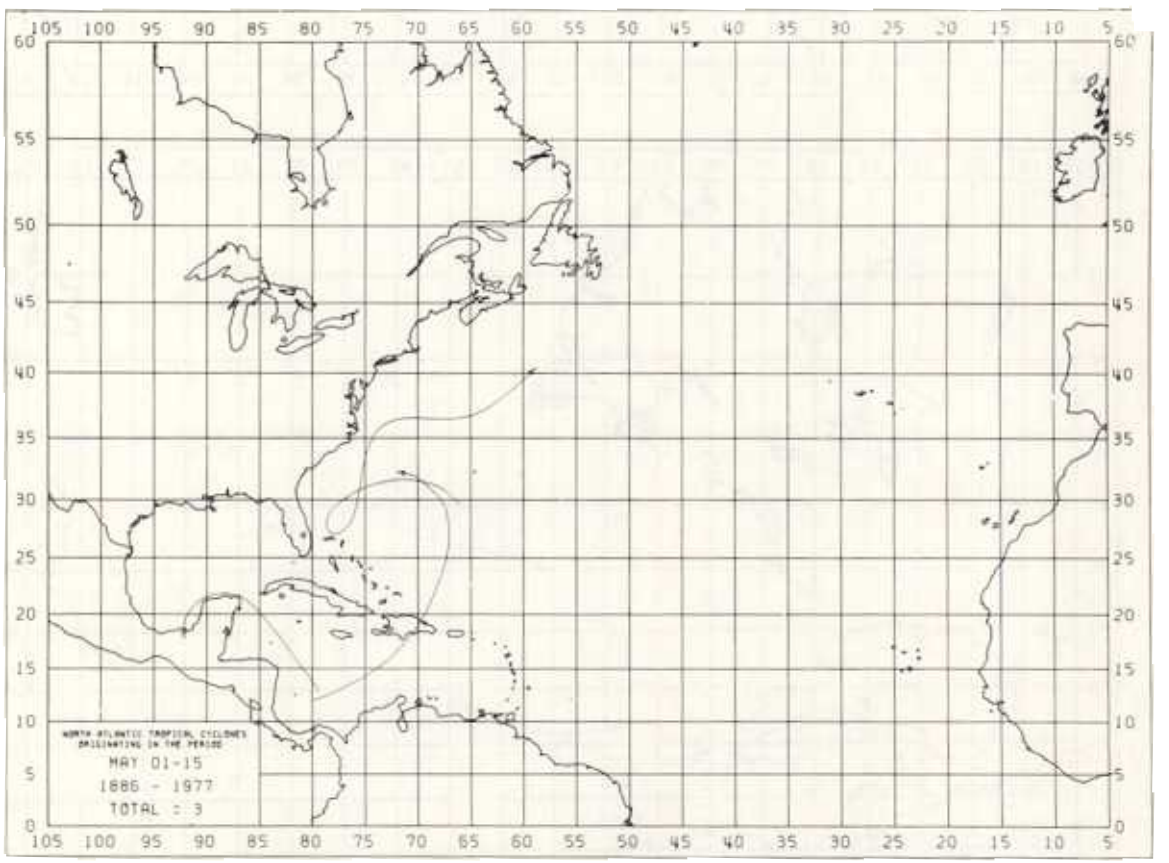
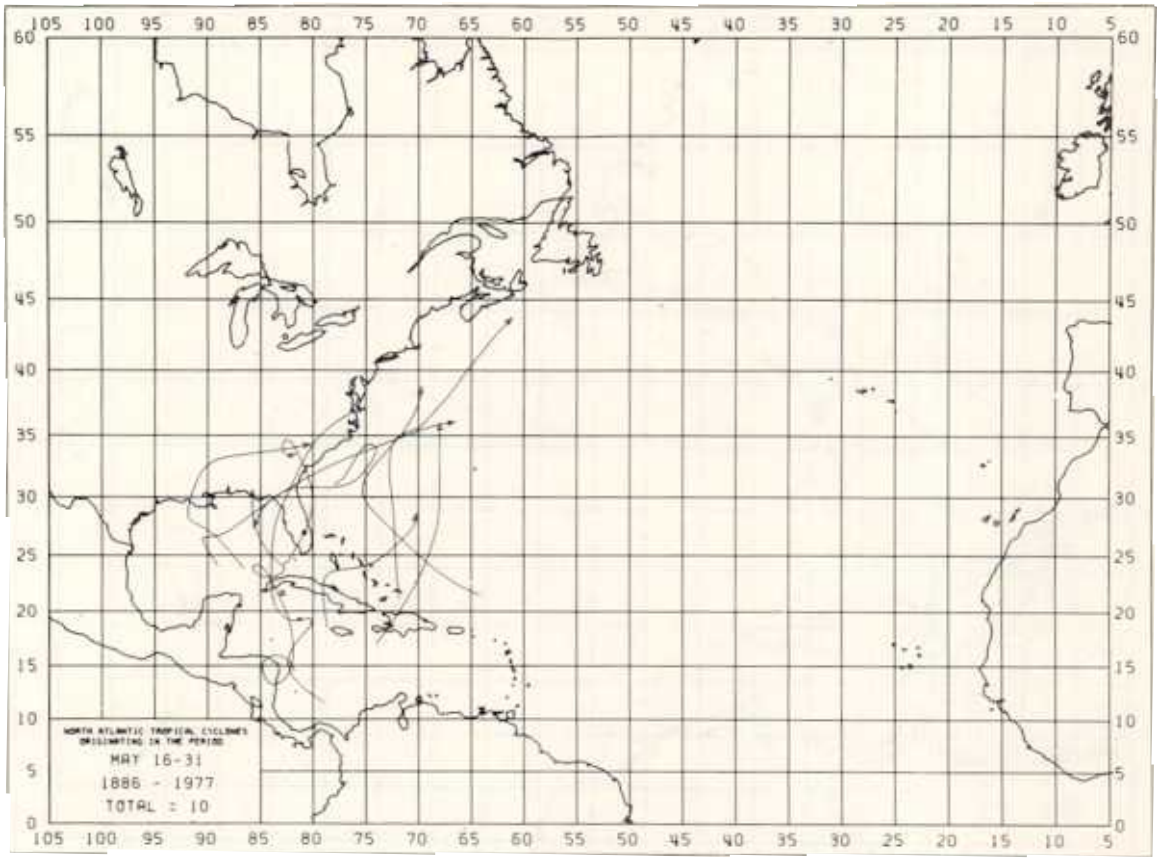
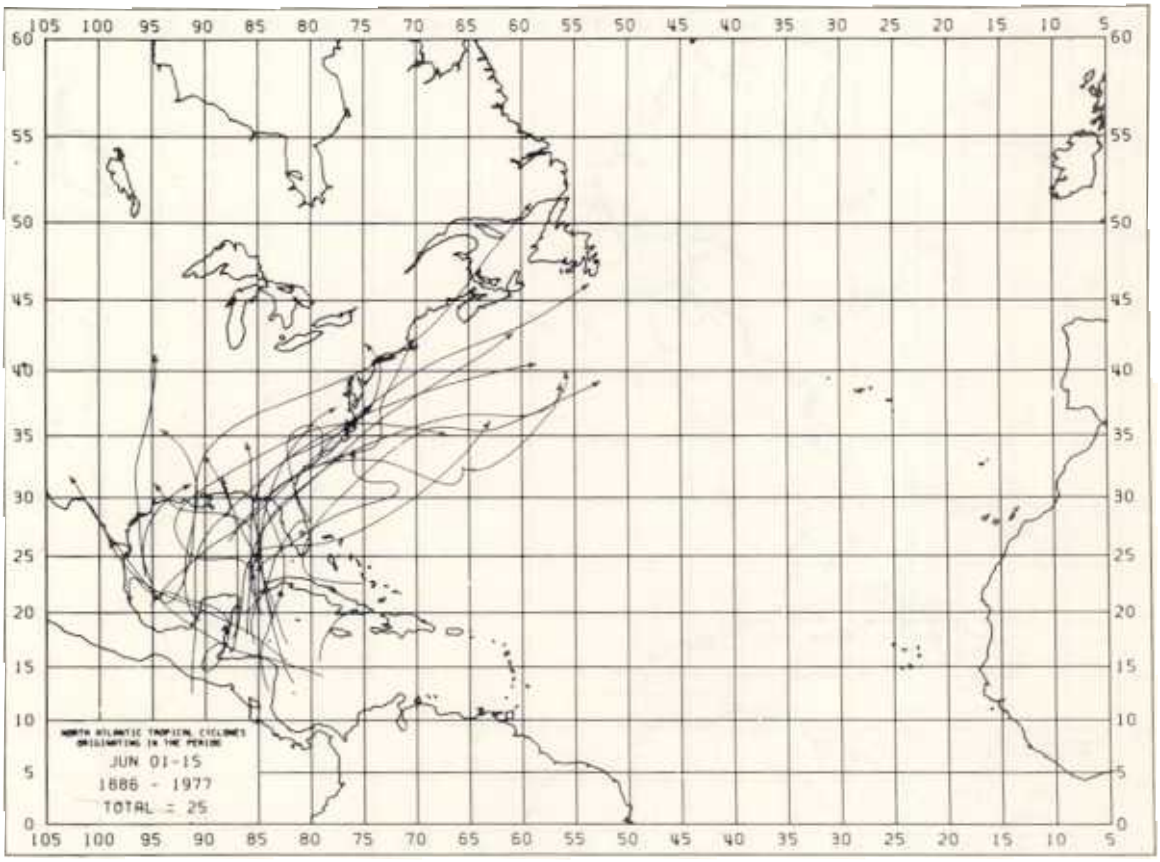

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
DEC
1886 - 1977
TOTAL = 5

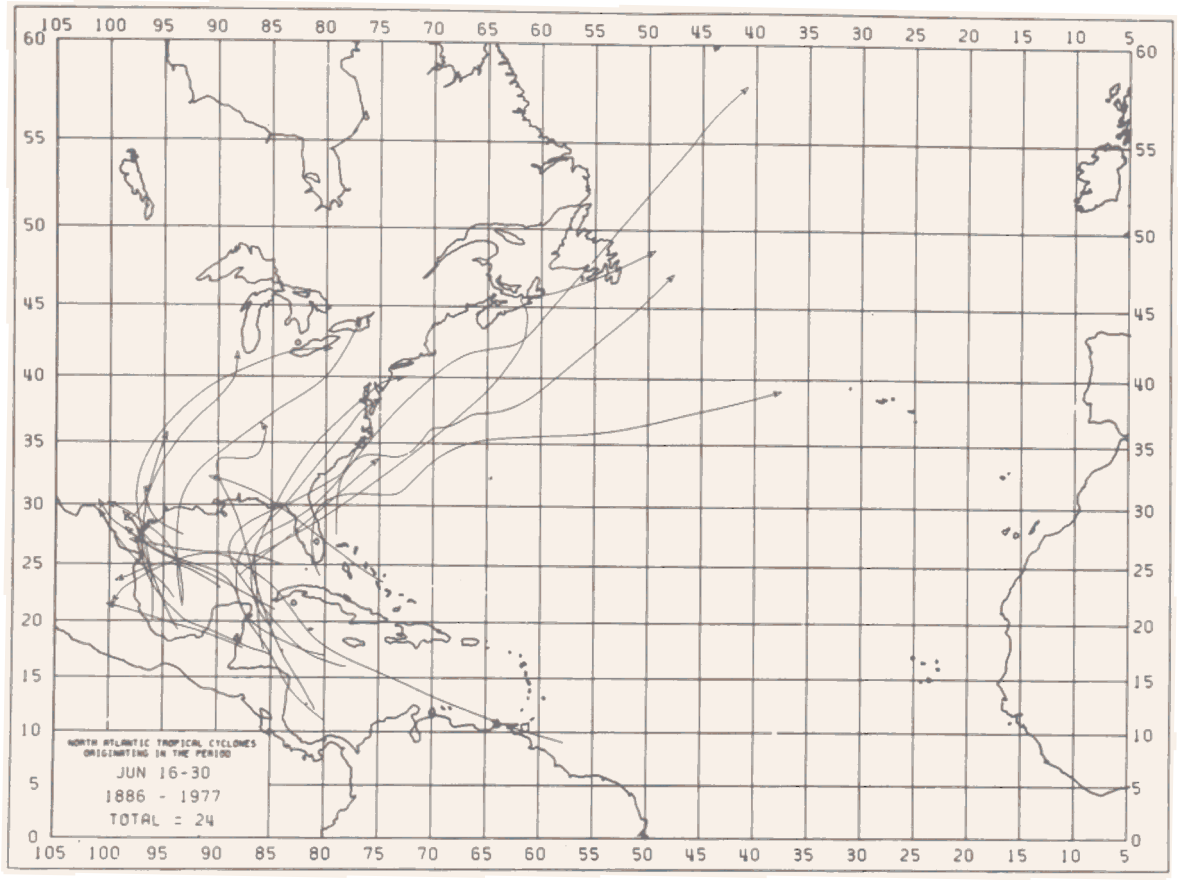
CHART SERIES B

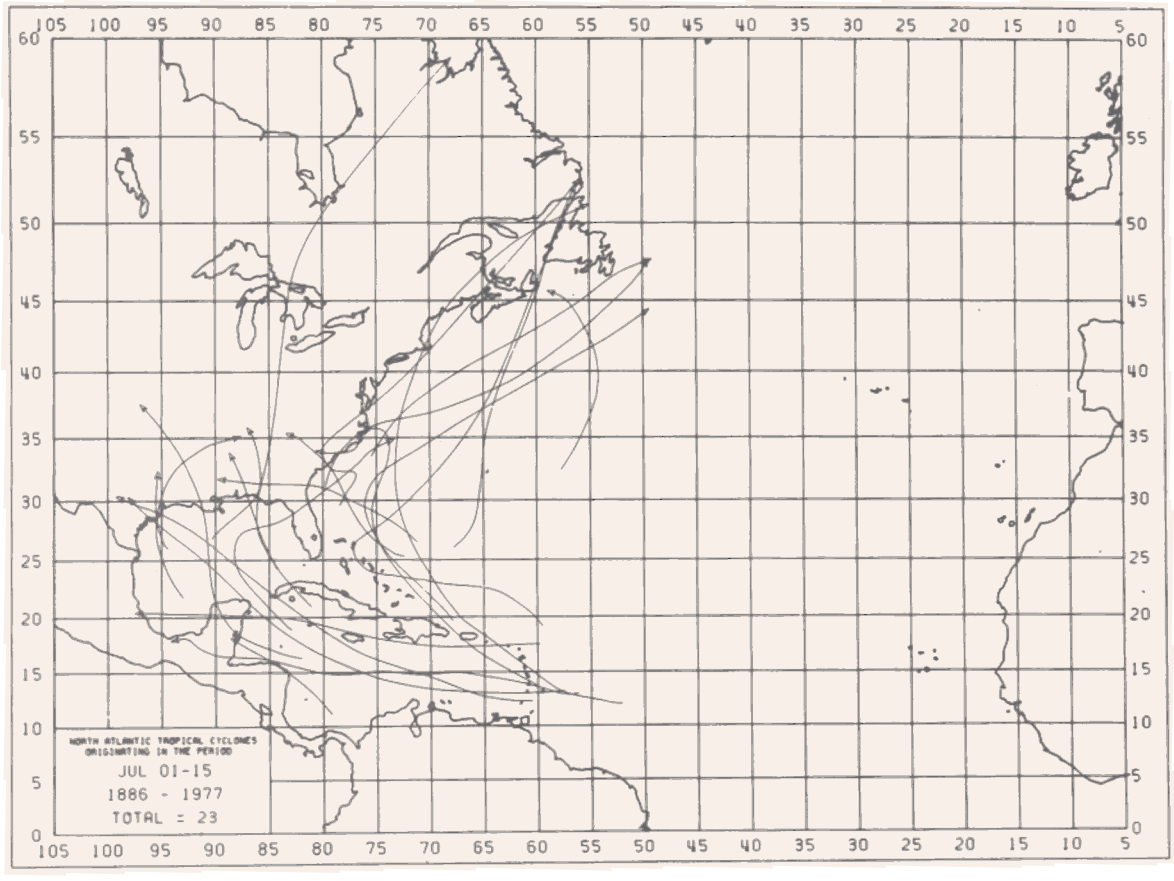
TROPICAL CYCLONE TRACKS BY 15-DAY PERIODS, MAY THROUGH DECEMBER

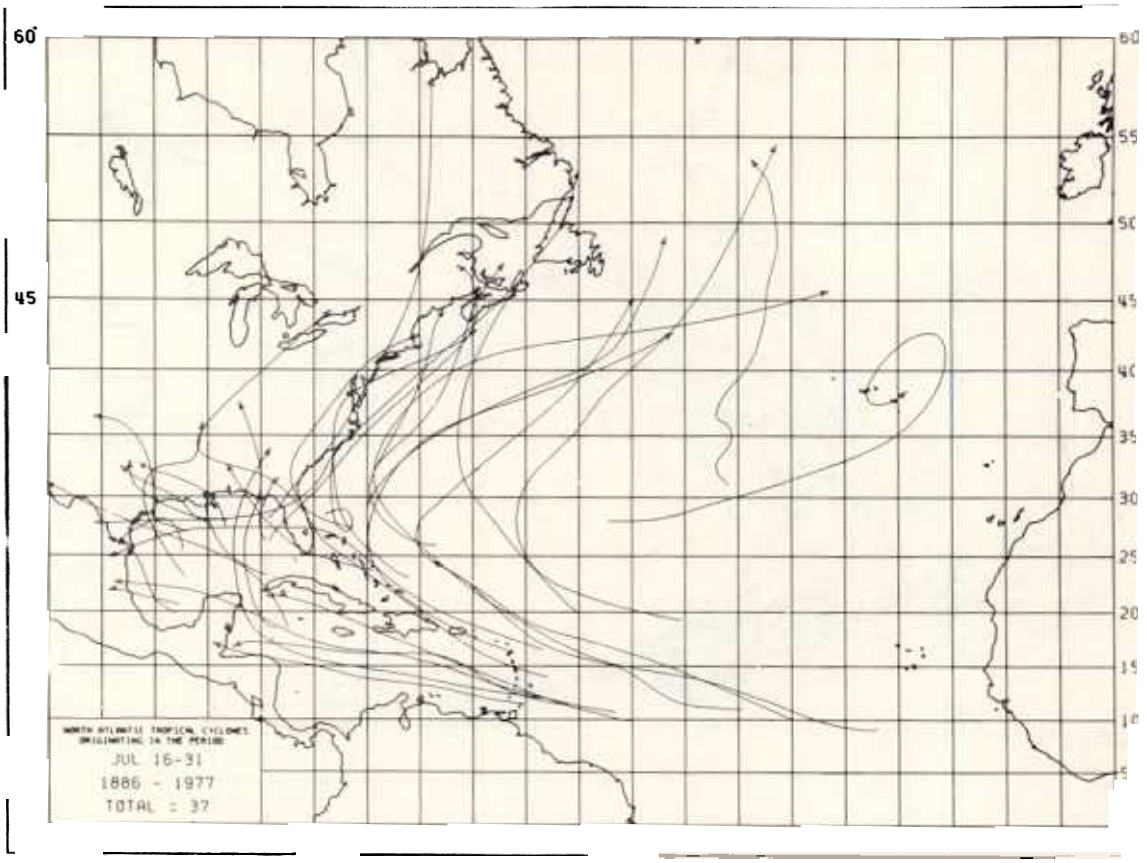


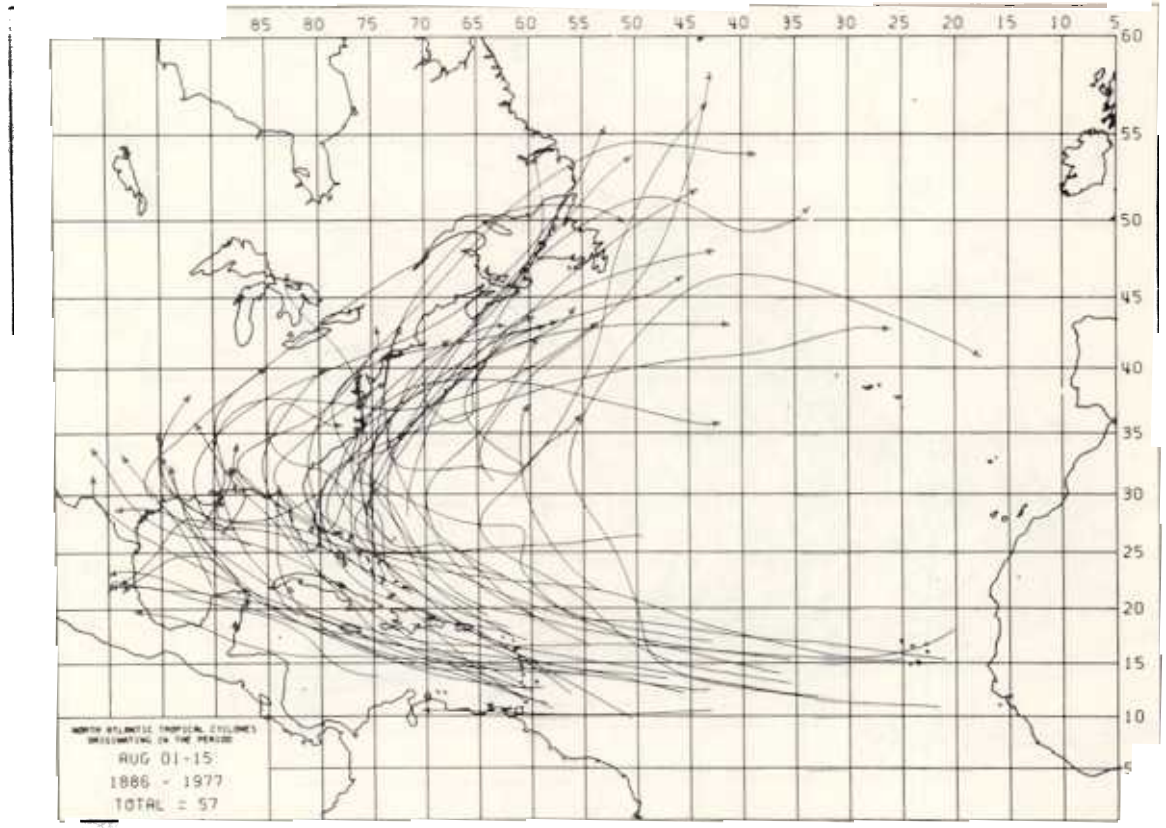

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
MAY 16-31
1886 - 1977
TOTAL = 10

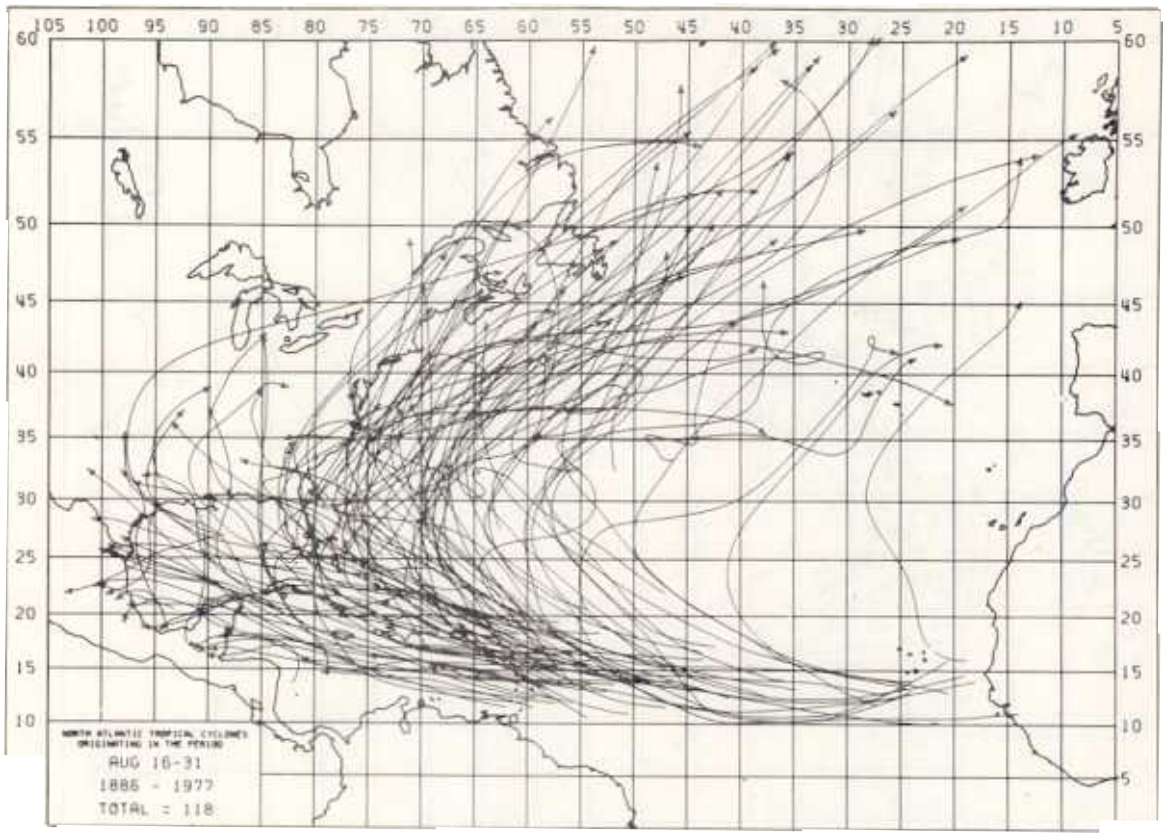

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 01-15
1886 - 1977
TOTAL = 25


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 16-30
1886 - 1977
TOTAL = 24


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 01-15
1886 - 1977
TOTAL = 23


60
45
NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 16-31
1886 - 1977
TOTAL = 37


85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5
60
55
50
45
40
35
30
25
20
15
10
5
NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG 01-15
1886 - 1977
TOTAL = 57


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
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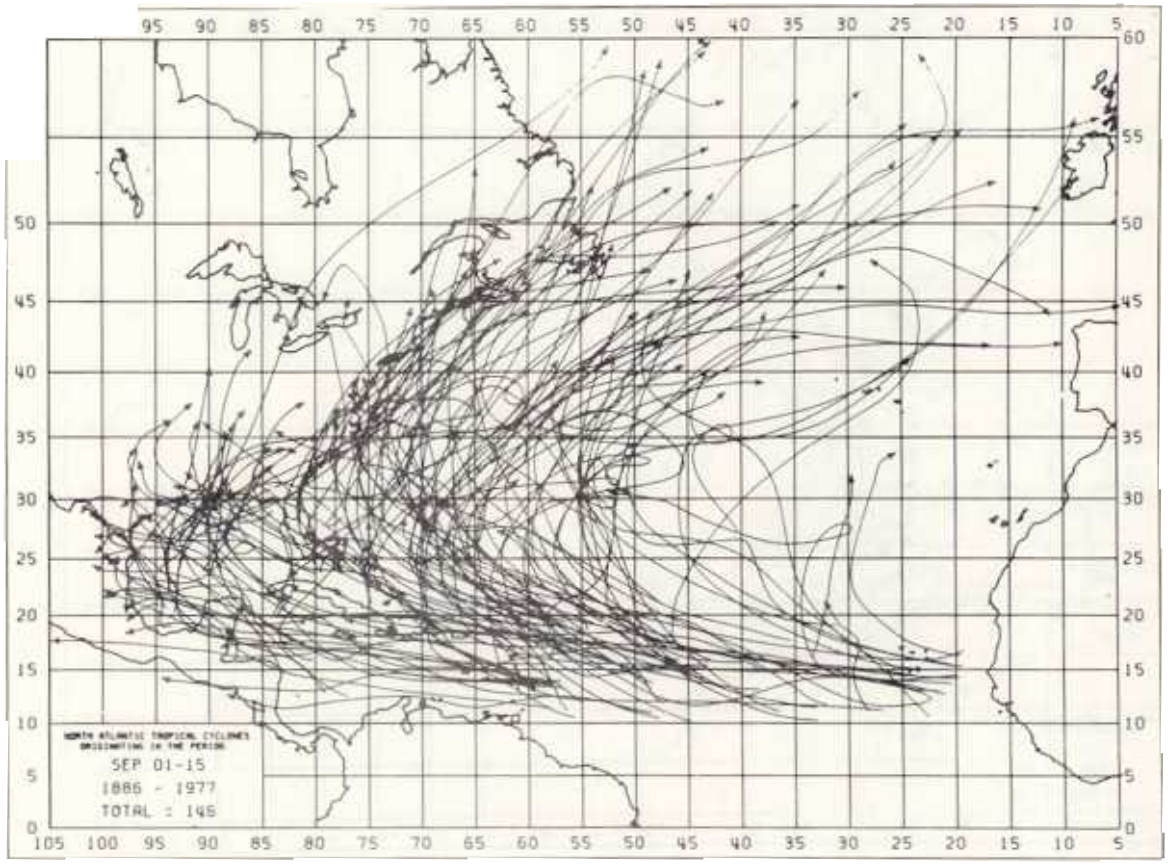
1886 - 1977
TOTAL = 118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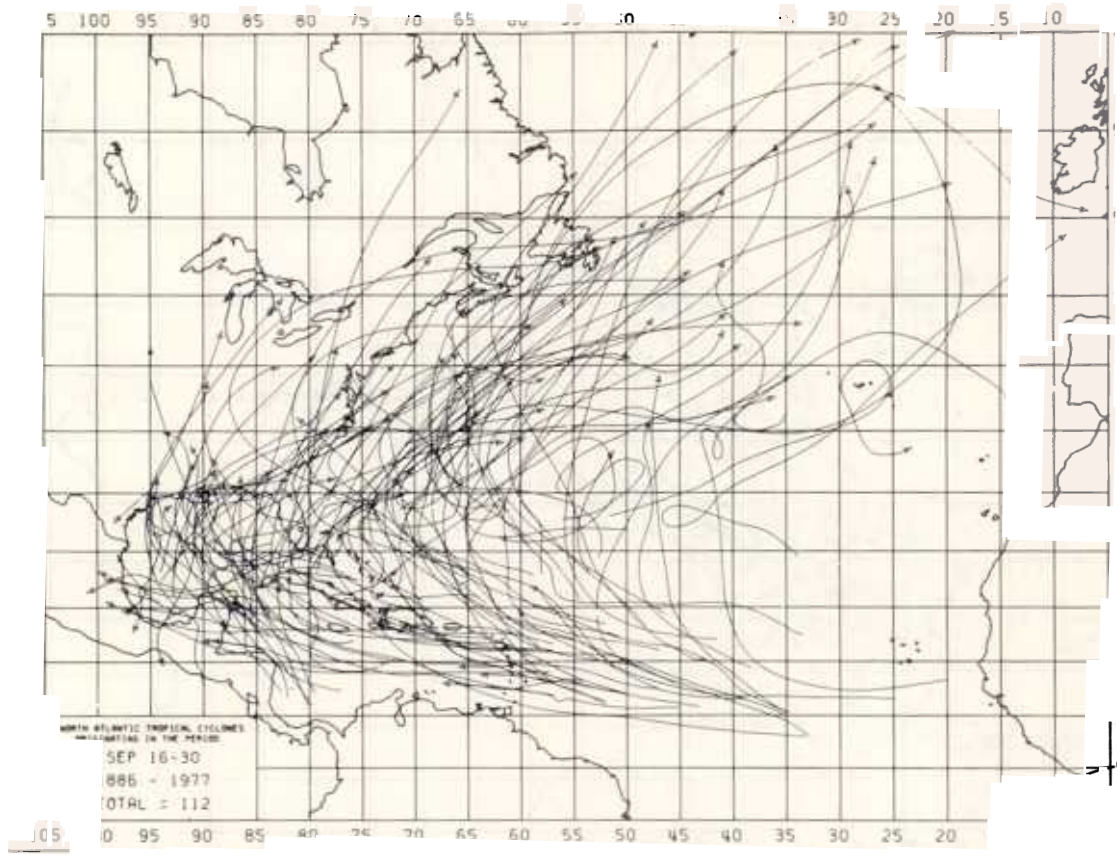
SEP 01-15
1886 - 1977
TOTAL = 146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1886 - 1977
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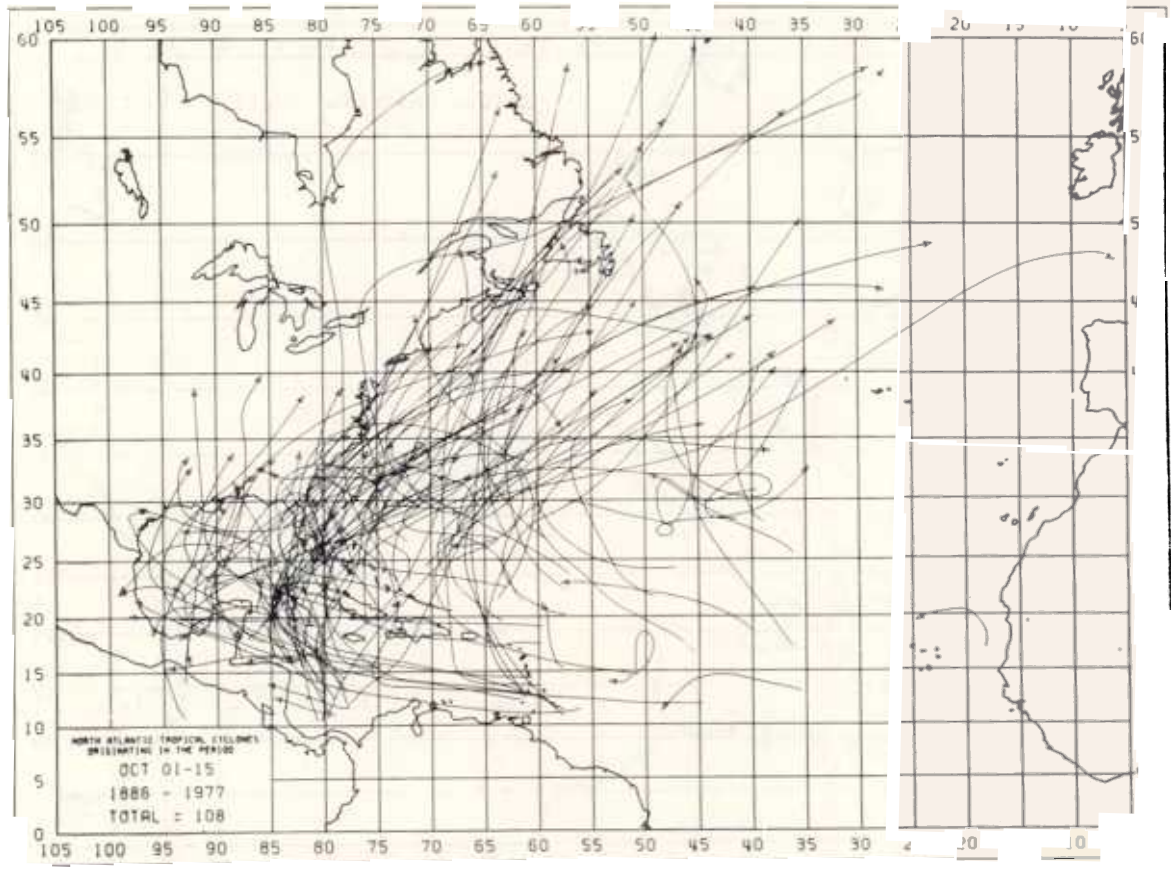
OCT 01-15
1886 - 1977
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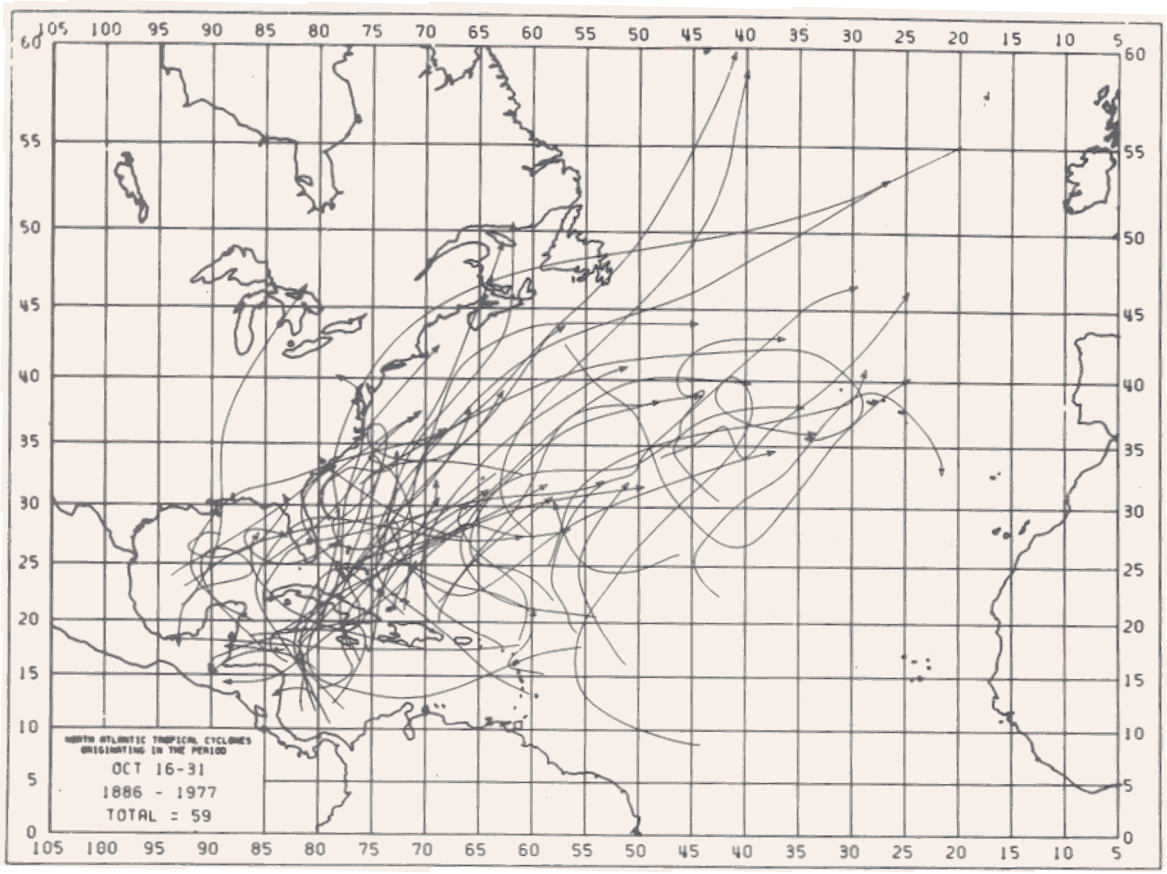
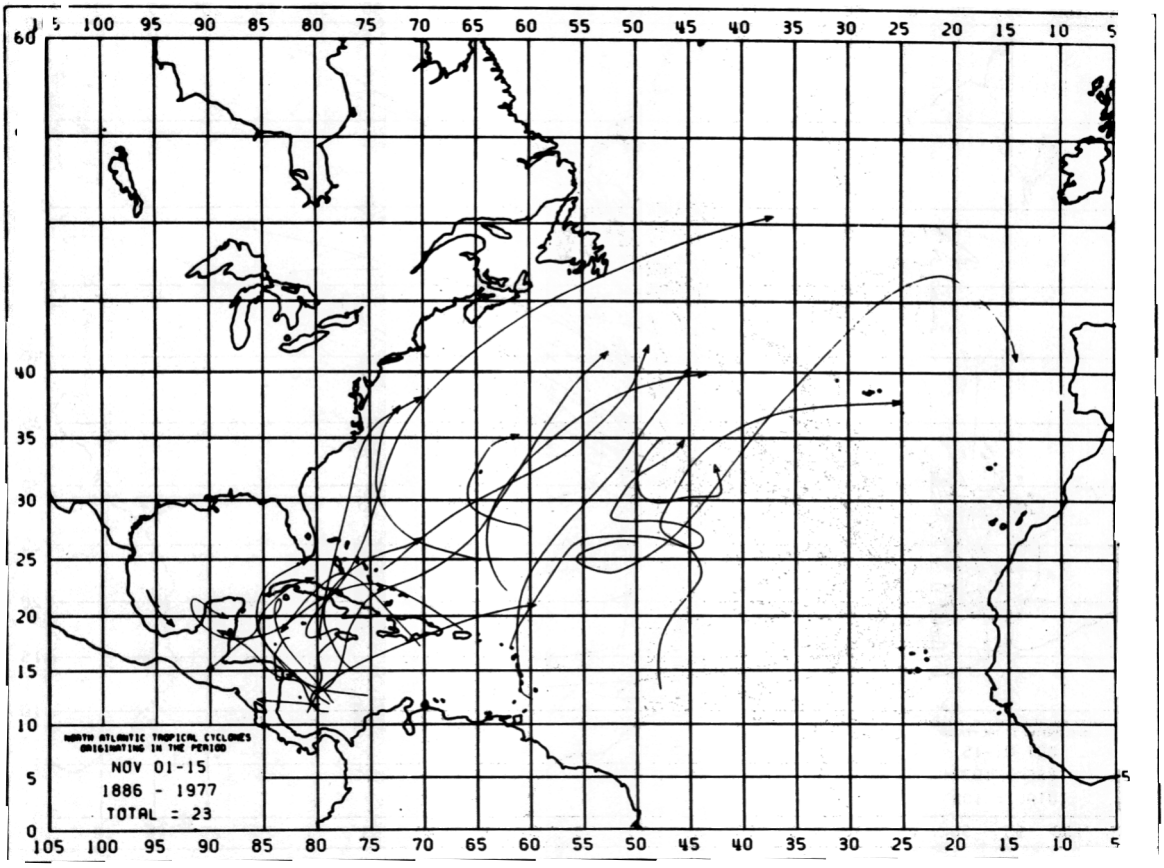
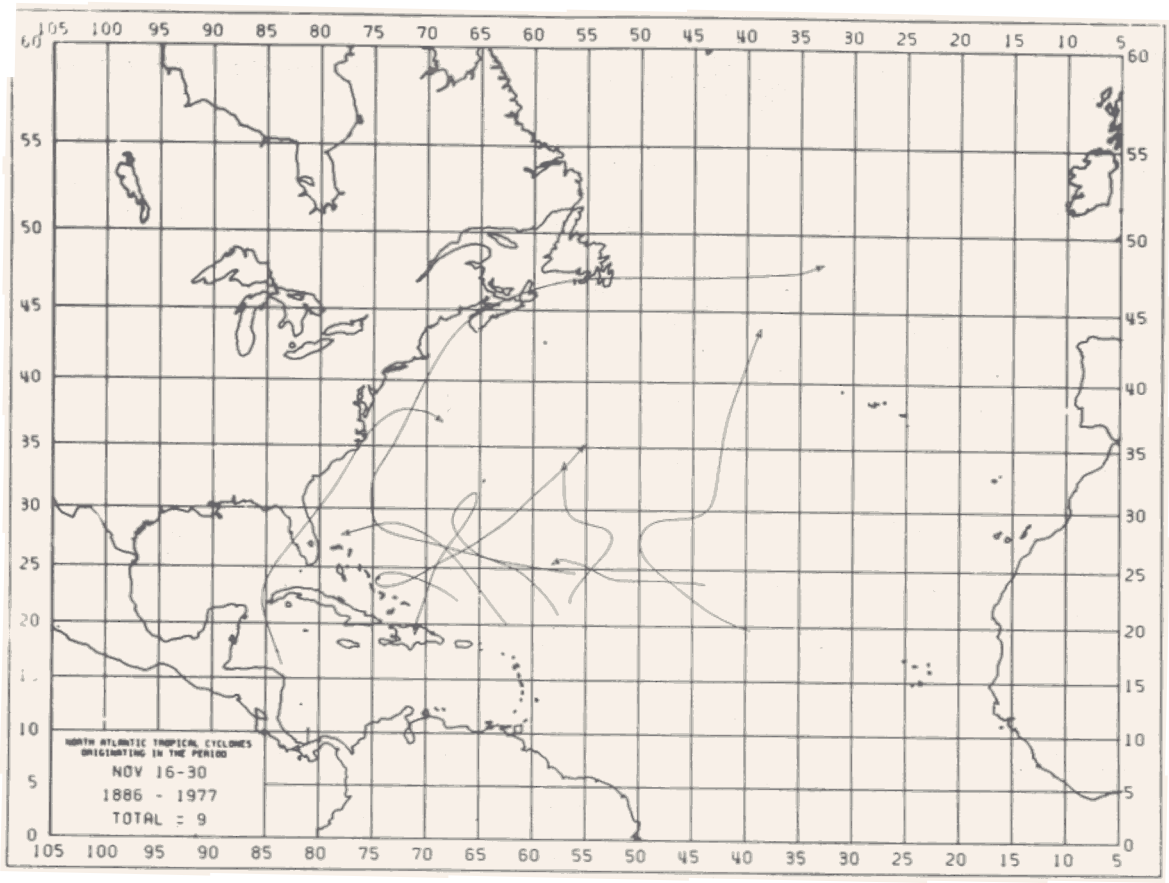
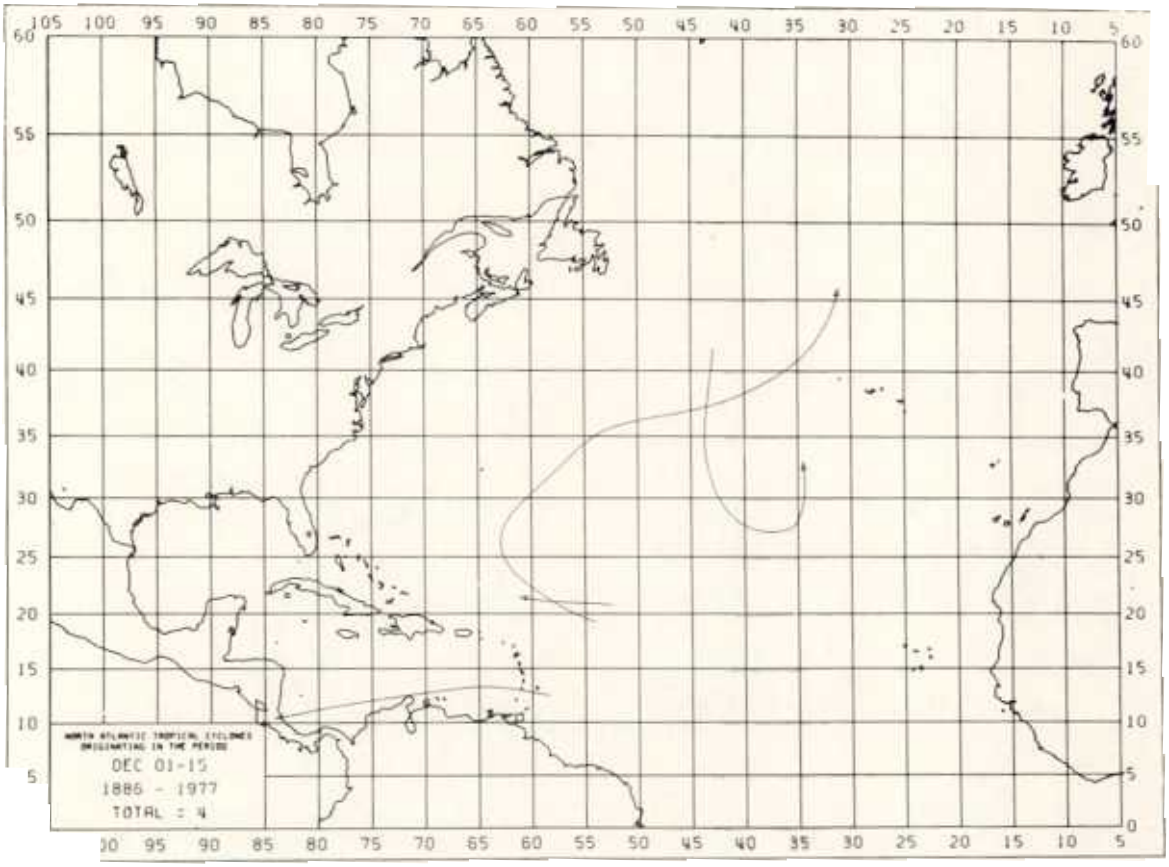

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
OCT 16-31
1886 - 1977
TOTAL = 59


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
NOV 01-15
1886 - 1977
TOTAL = 23


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
NOV 16-30
1886 - 1977
TOTAL = 9


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
DEC 01-15
1886 - 1977
TOTAL = 4

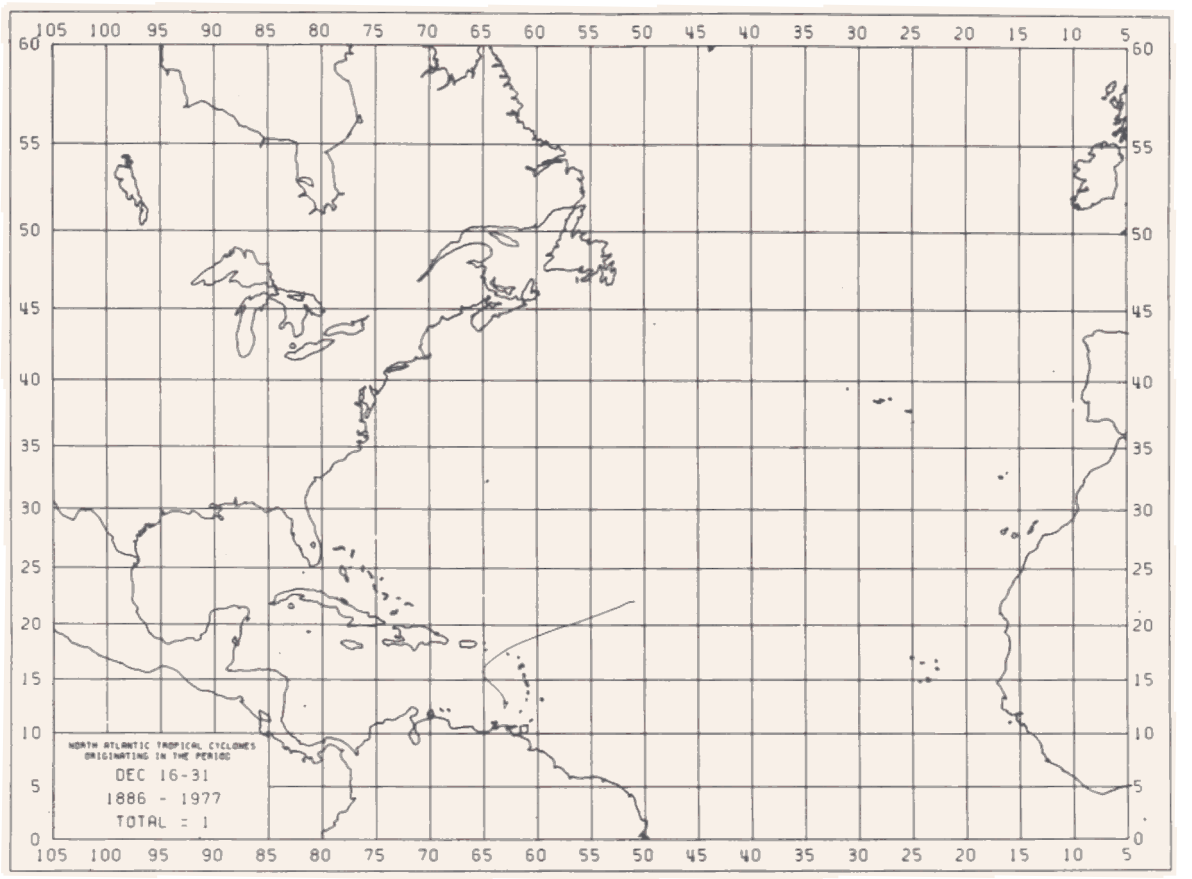
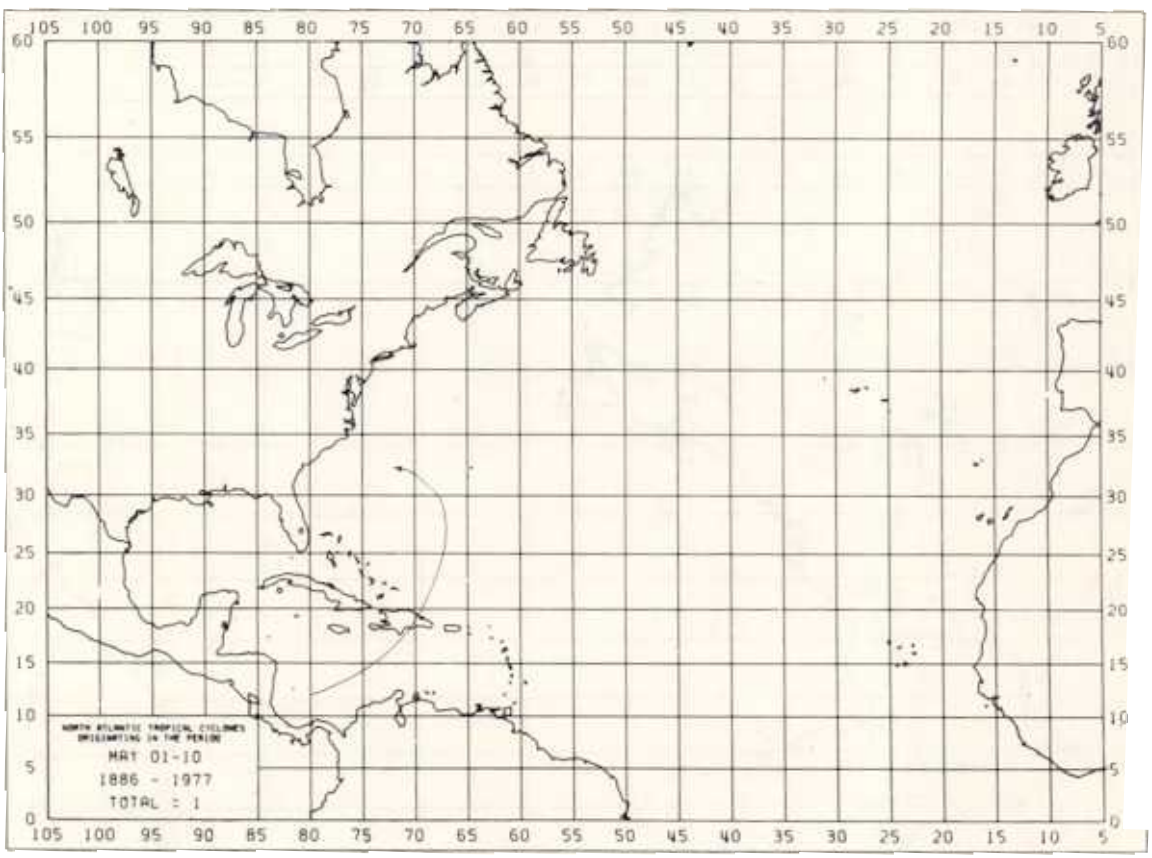
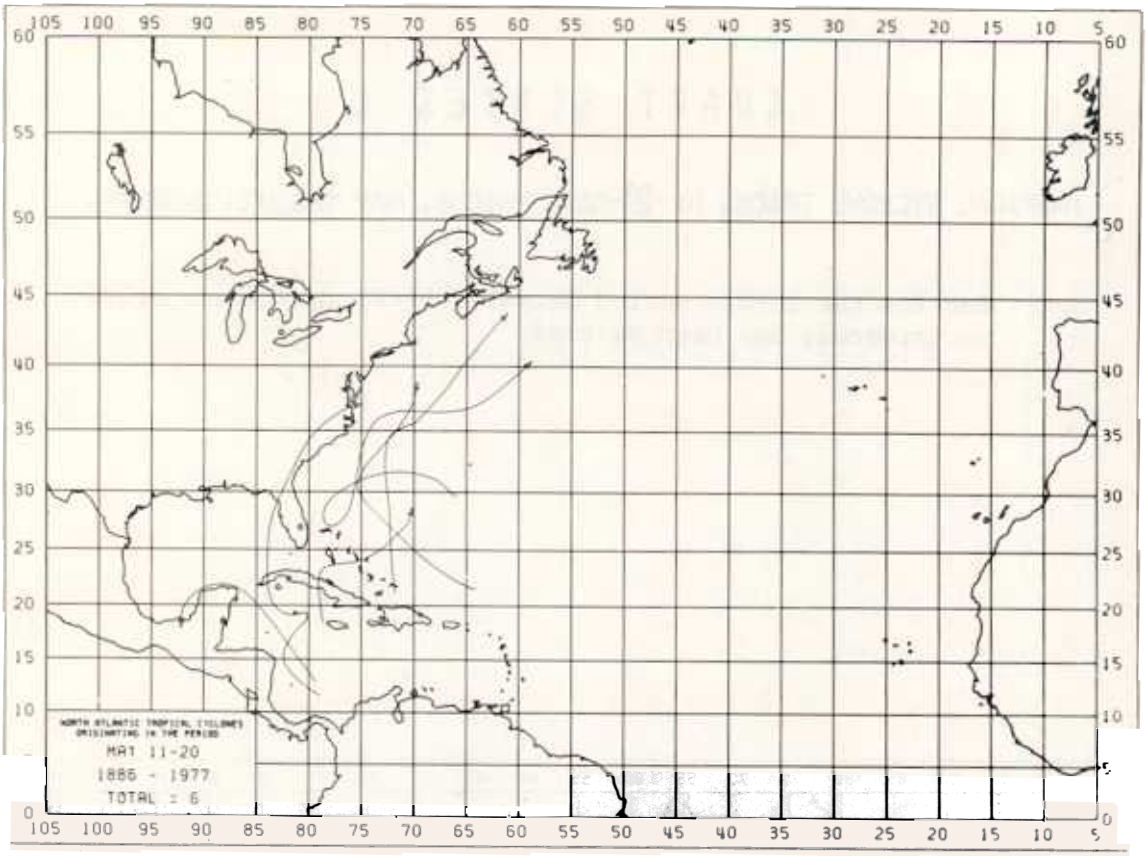

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
DEC 16-31
1886 - 1977
TOTAL = 1

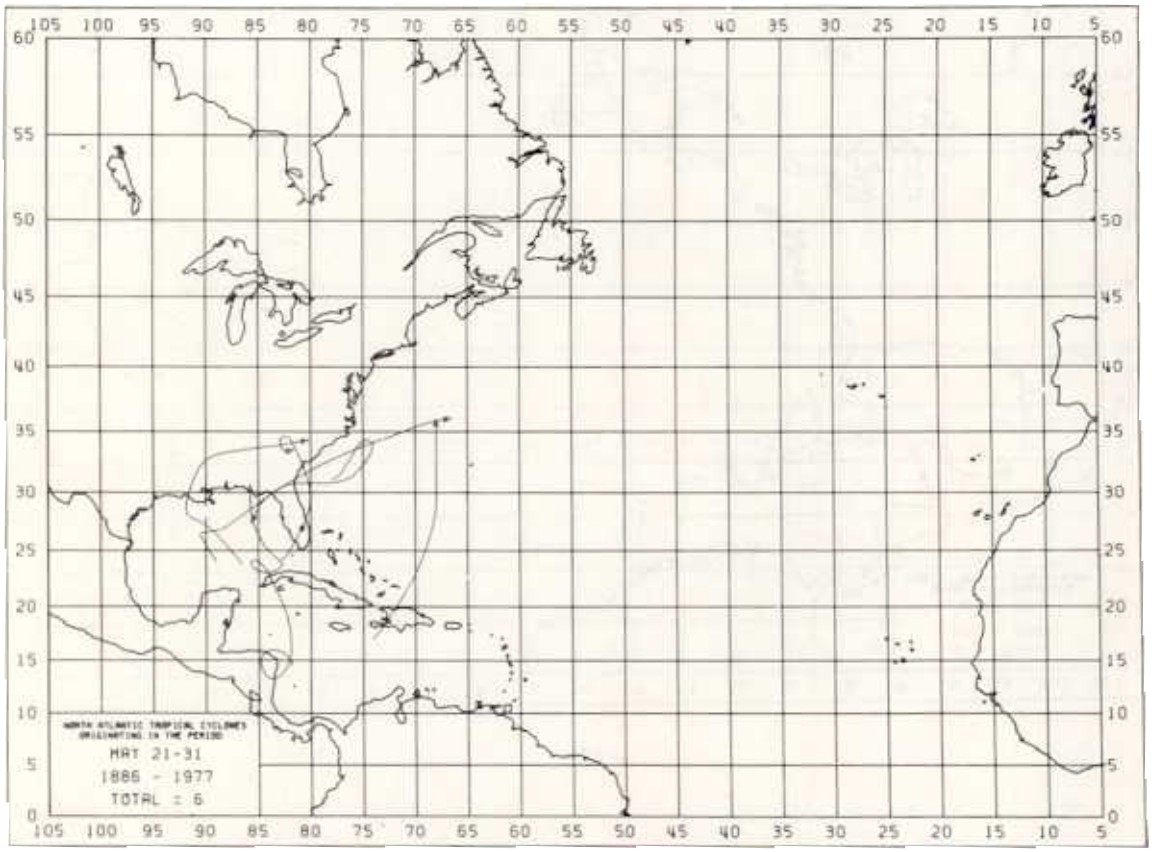
CHART SERIES C

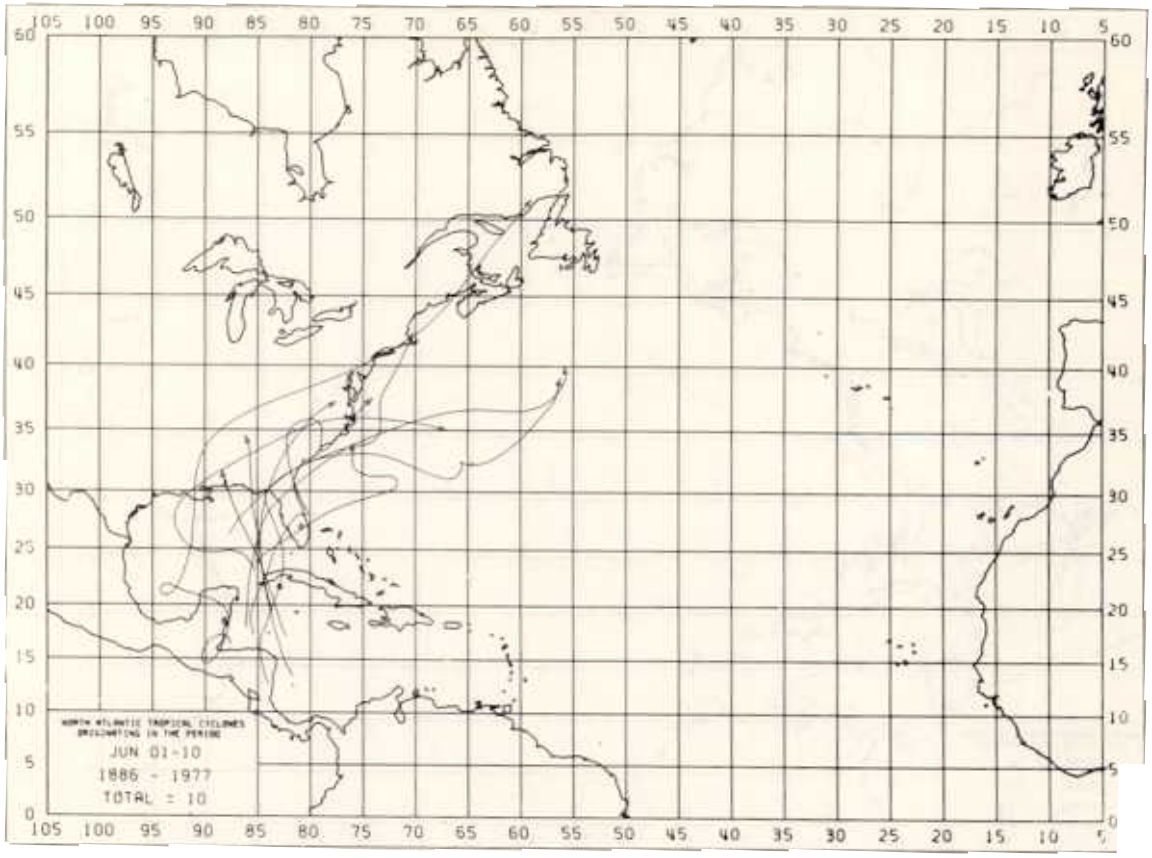
TROPICAL CYCLONE TRACKS BY 10-DAY PERIODS, MAY THROUGH DECEMBER

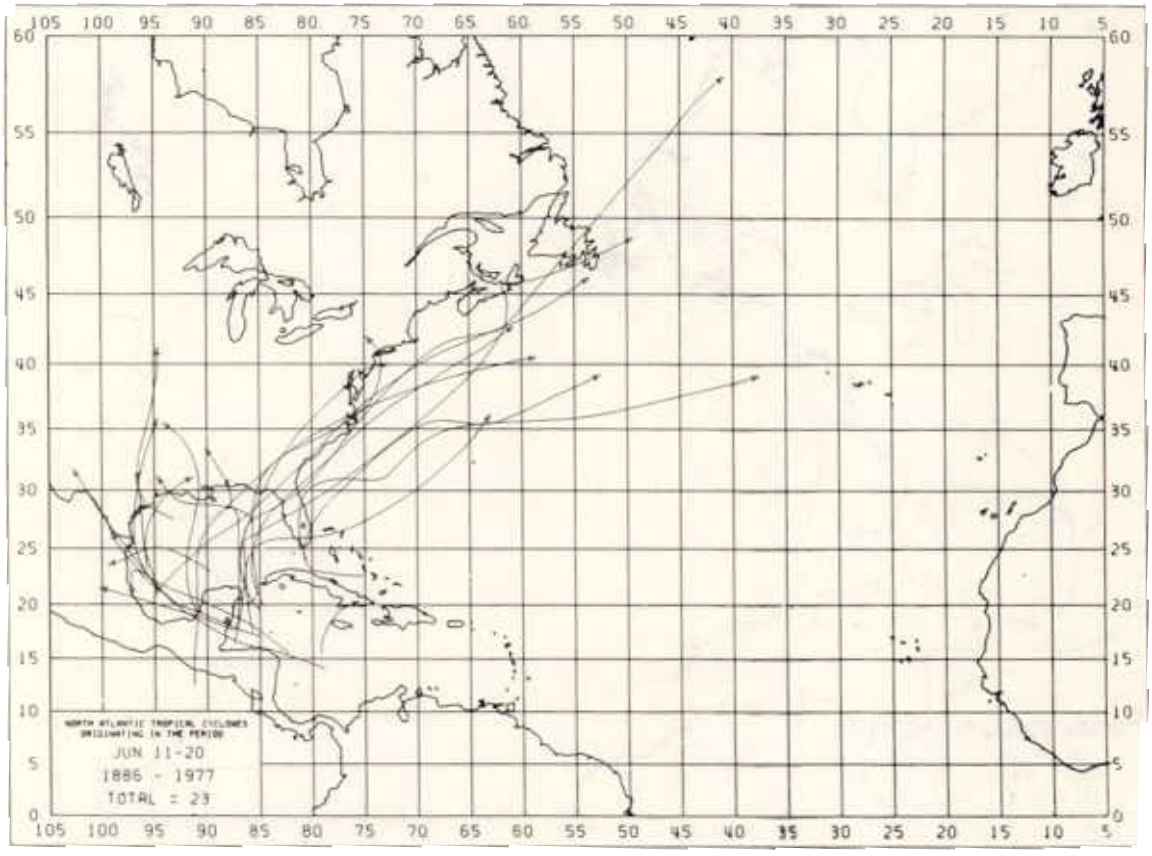
Note: Map for the 10-day period December 11-20, having no storm occurrences, has been omitted.

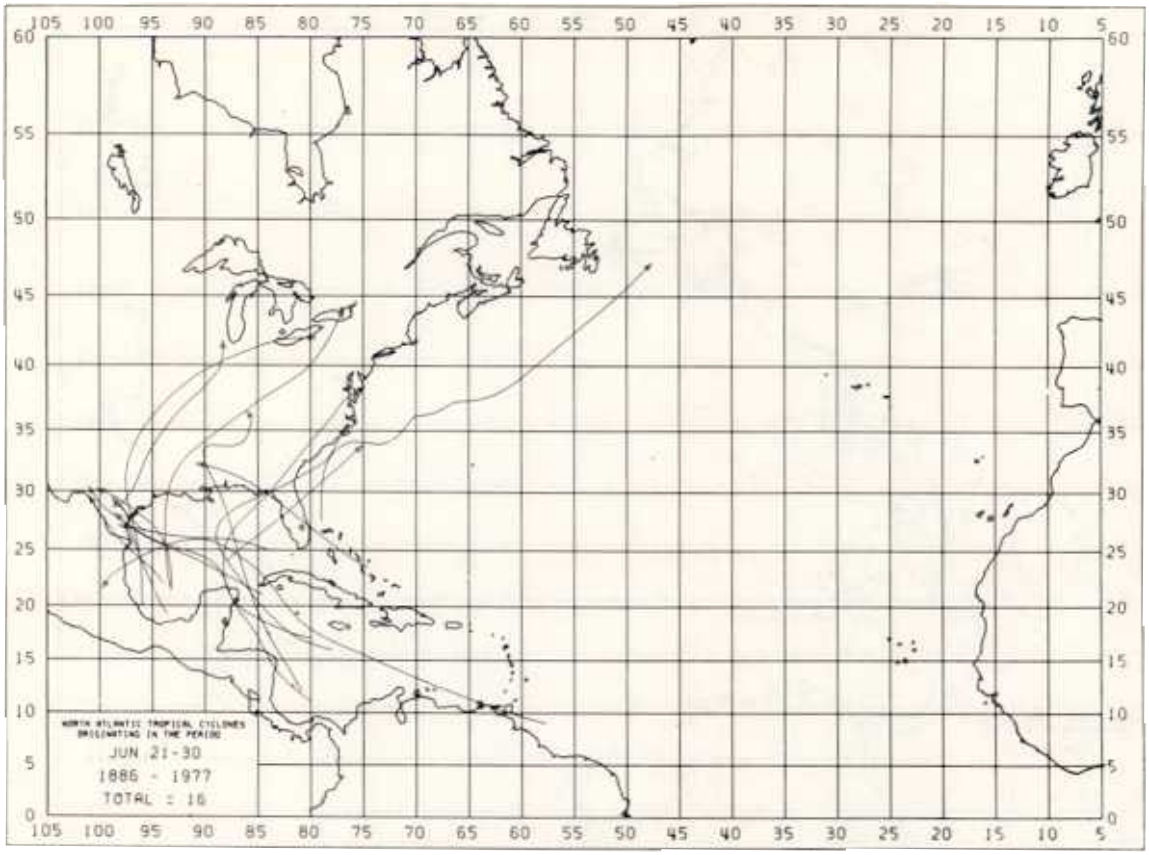


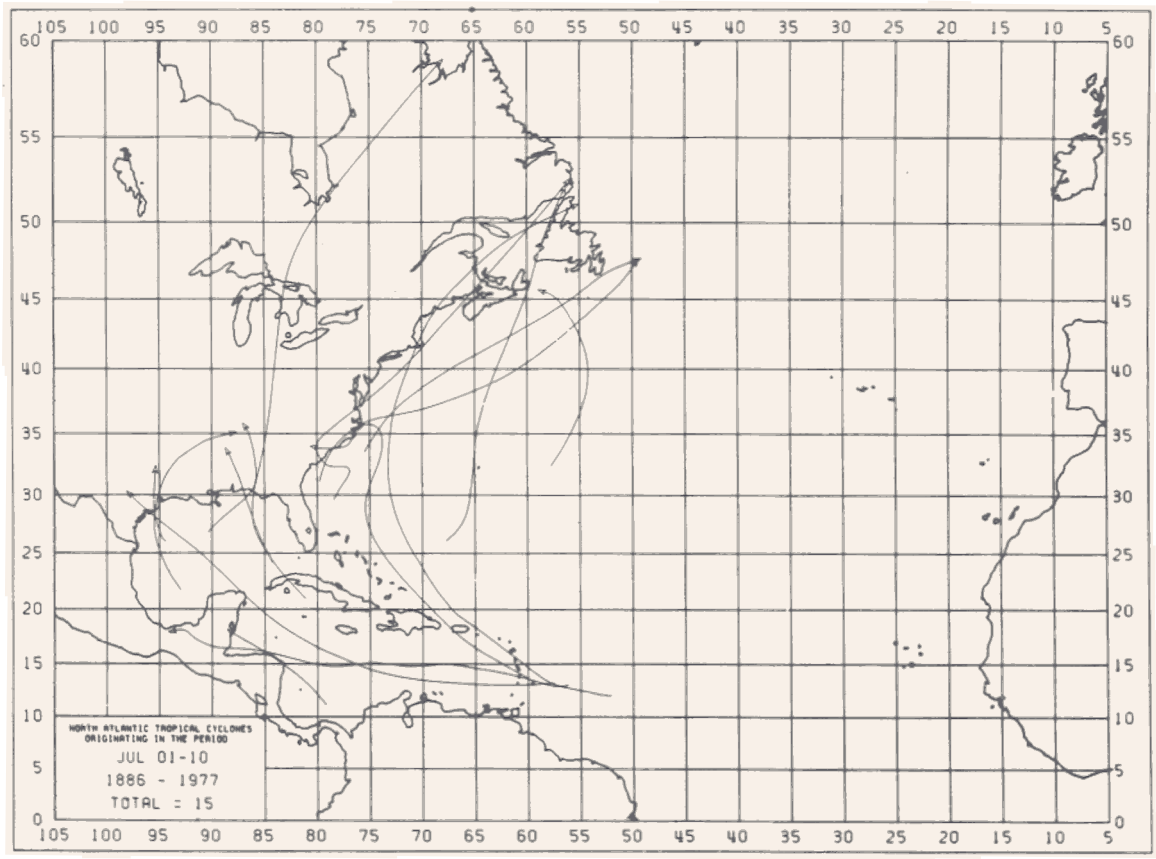

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
MAY 11-20
1886 - 1977
TOTAL : 6

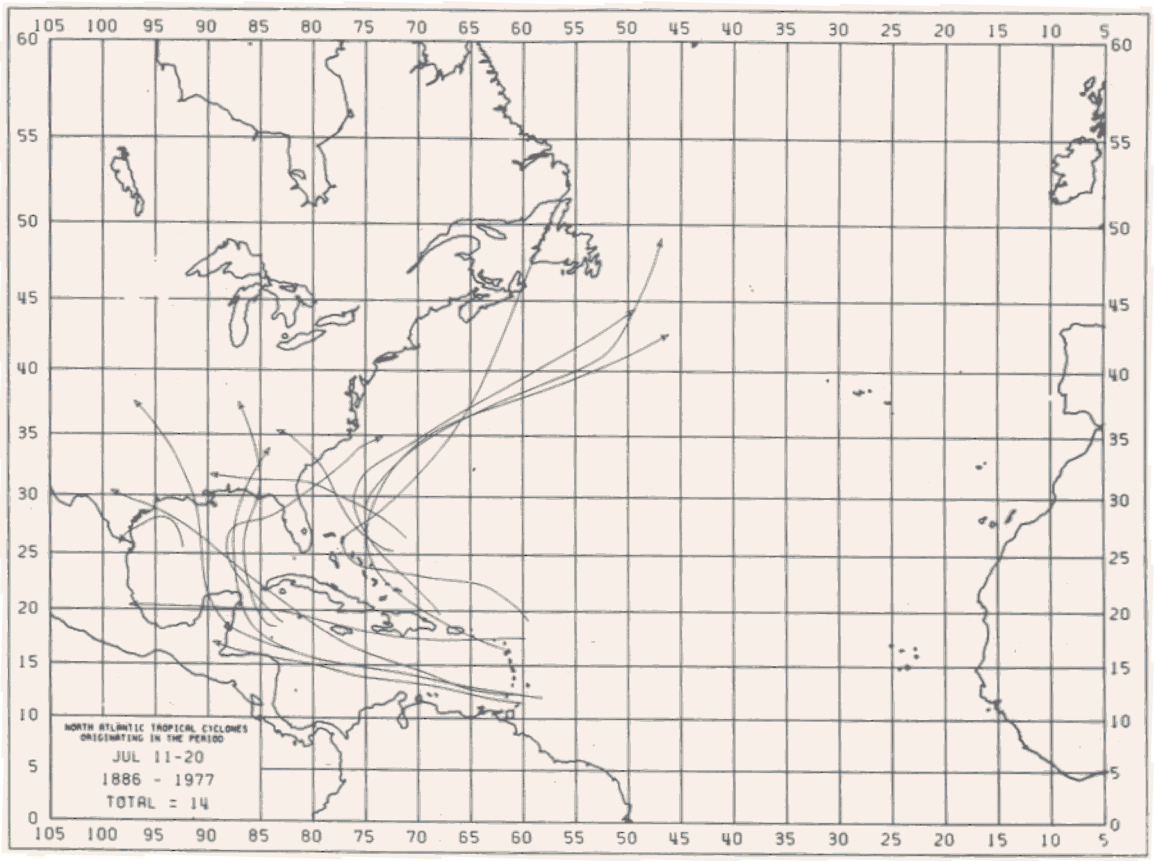

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
MAY 21-31
1886 - 1977
TOTAL : 6

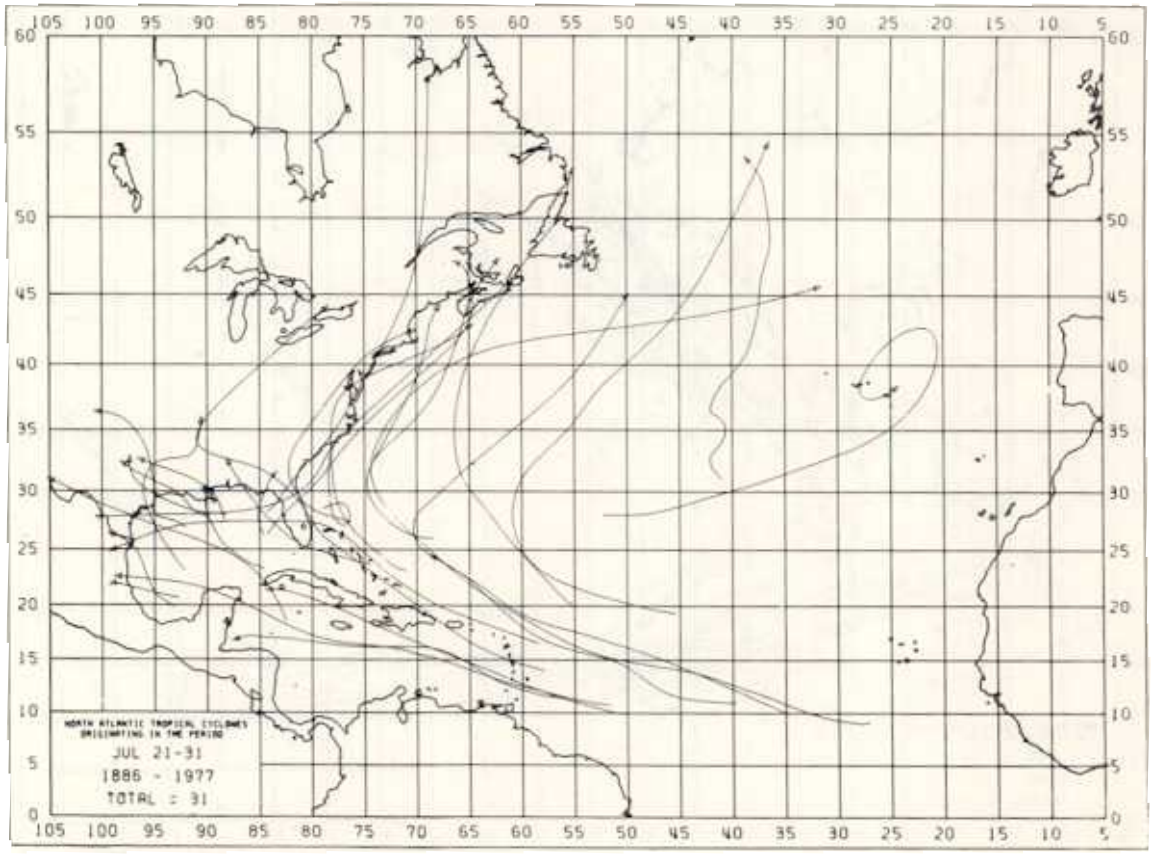

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 01-10
1886 - 1977
TOTAL = 10

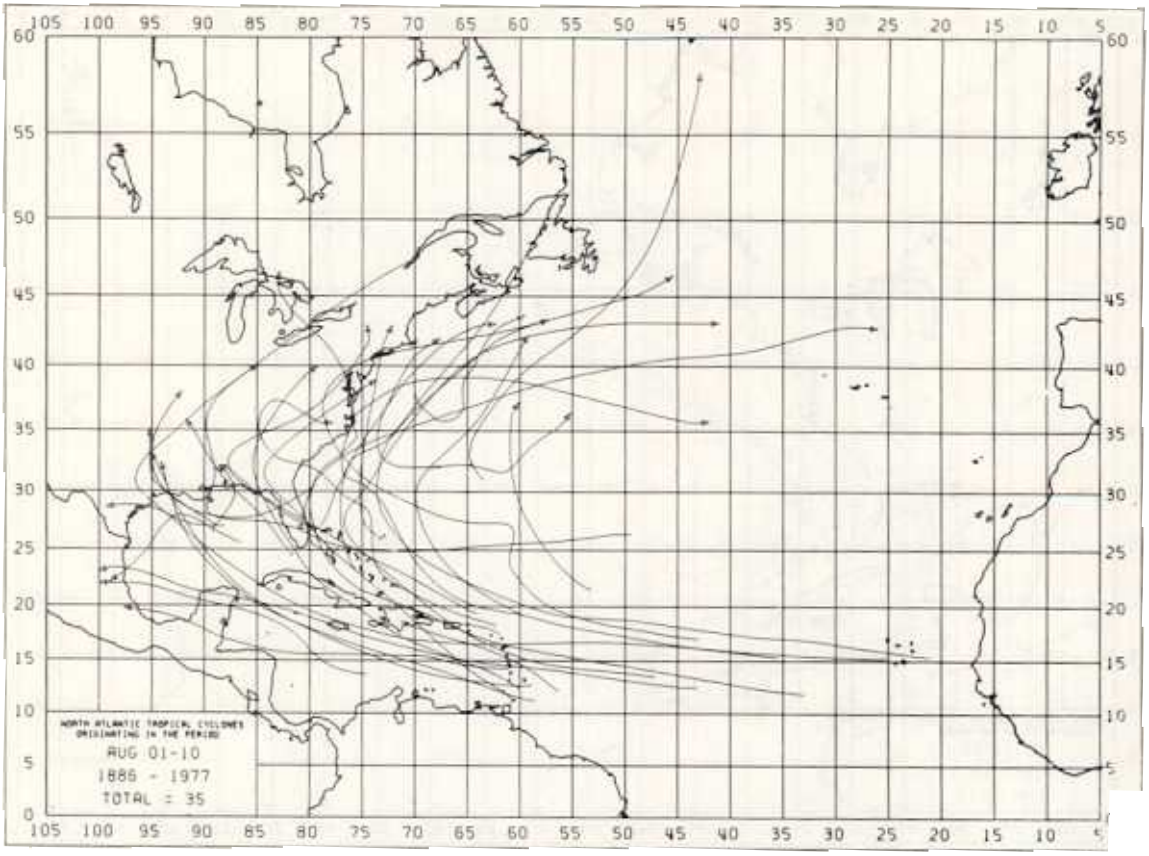

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 11-20
1886 - 1977
TOTAL = 23

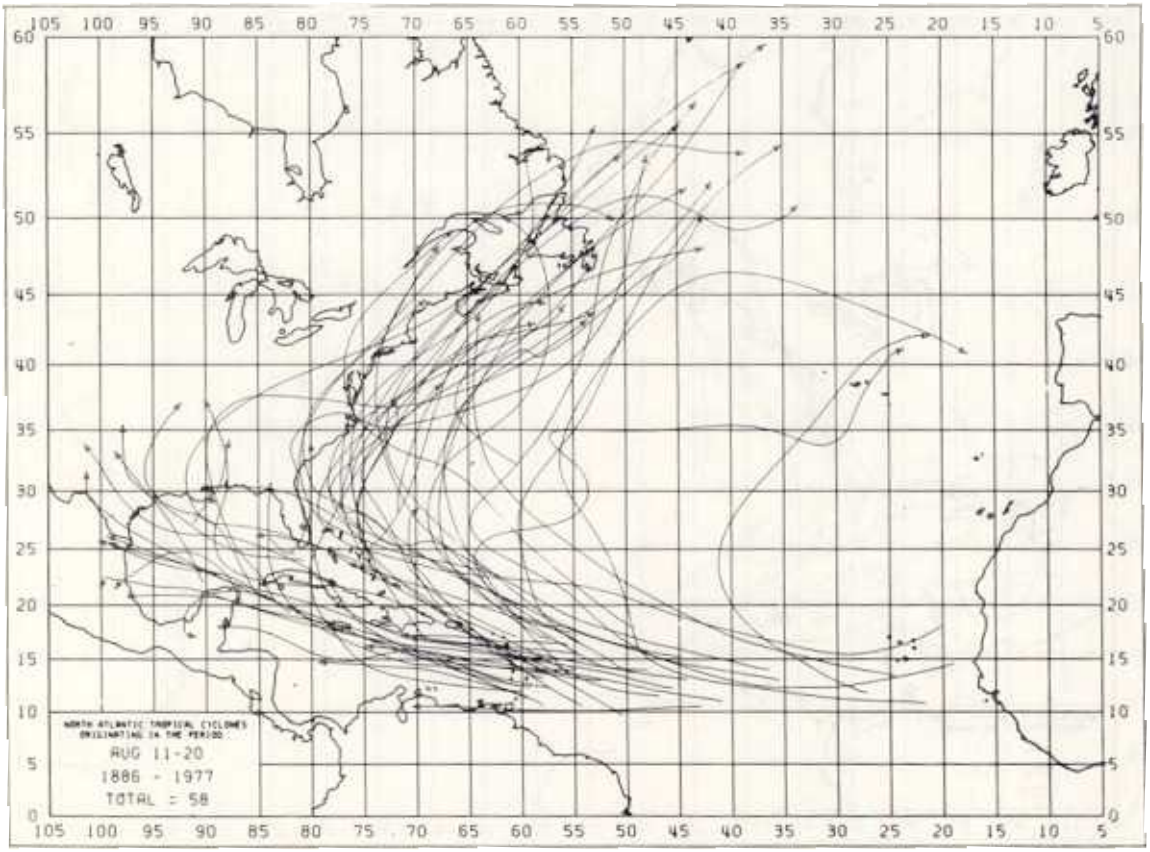

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 21-30
1886 - 1977
TOTAL : 16

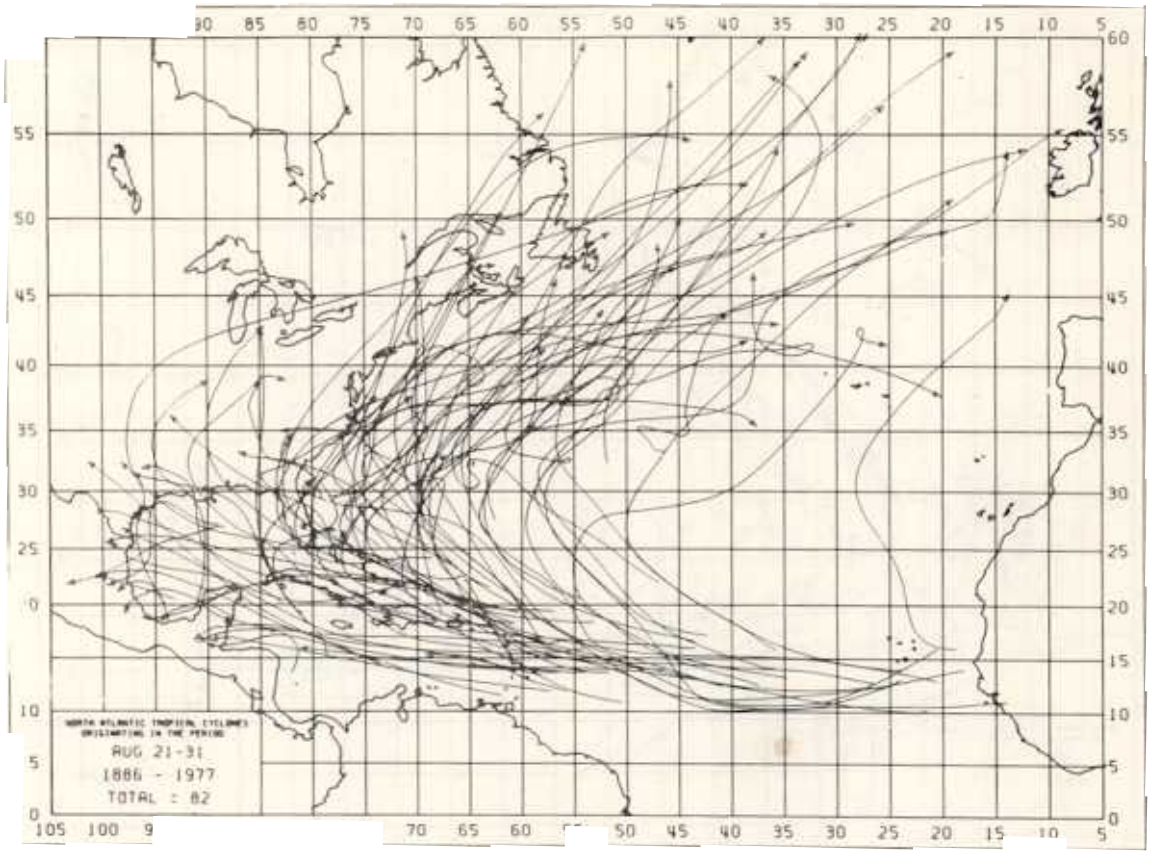

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 01-10
1886 - 1977
TOTAL : 15

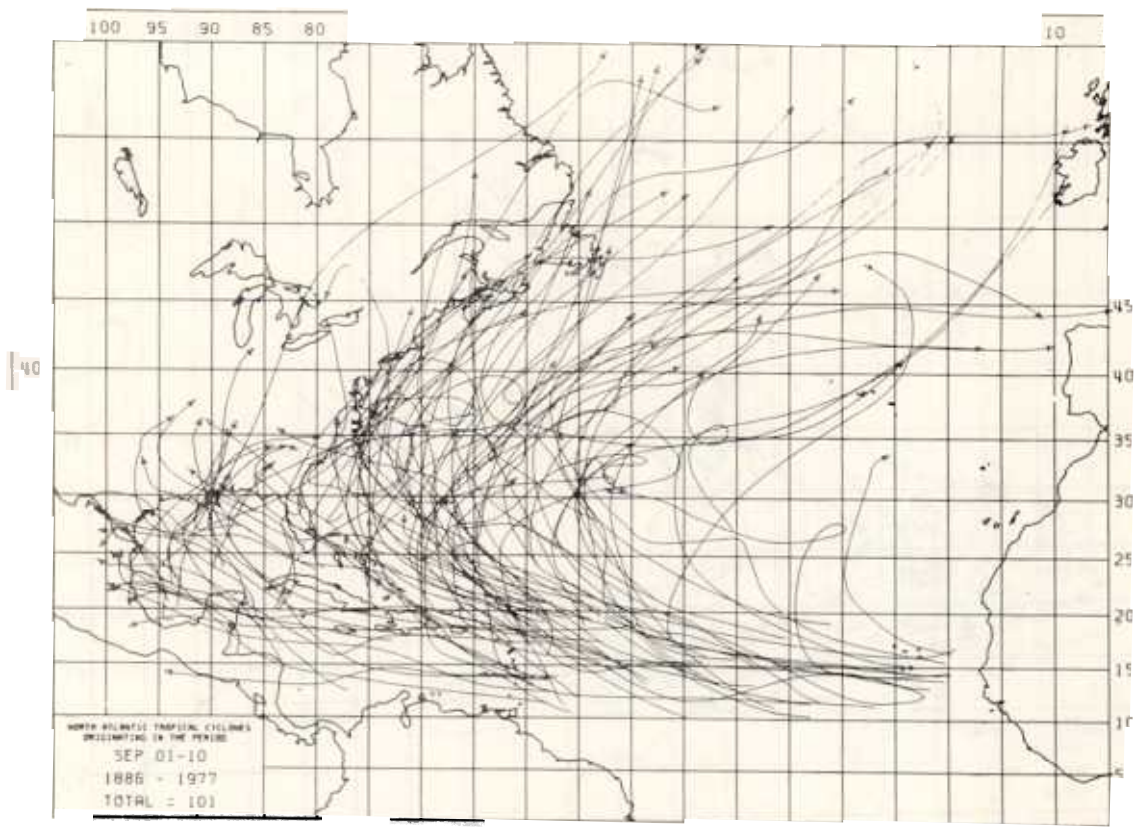

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 11-20
1886 - 1977
TOTAL = 14

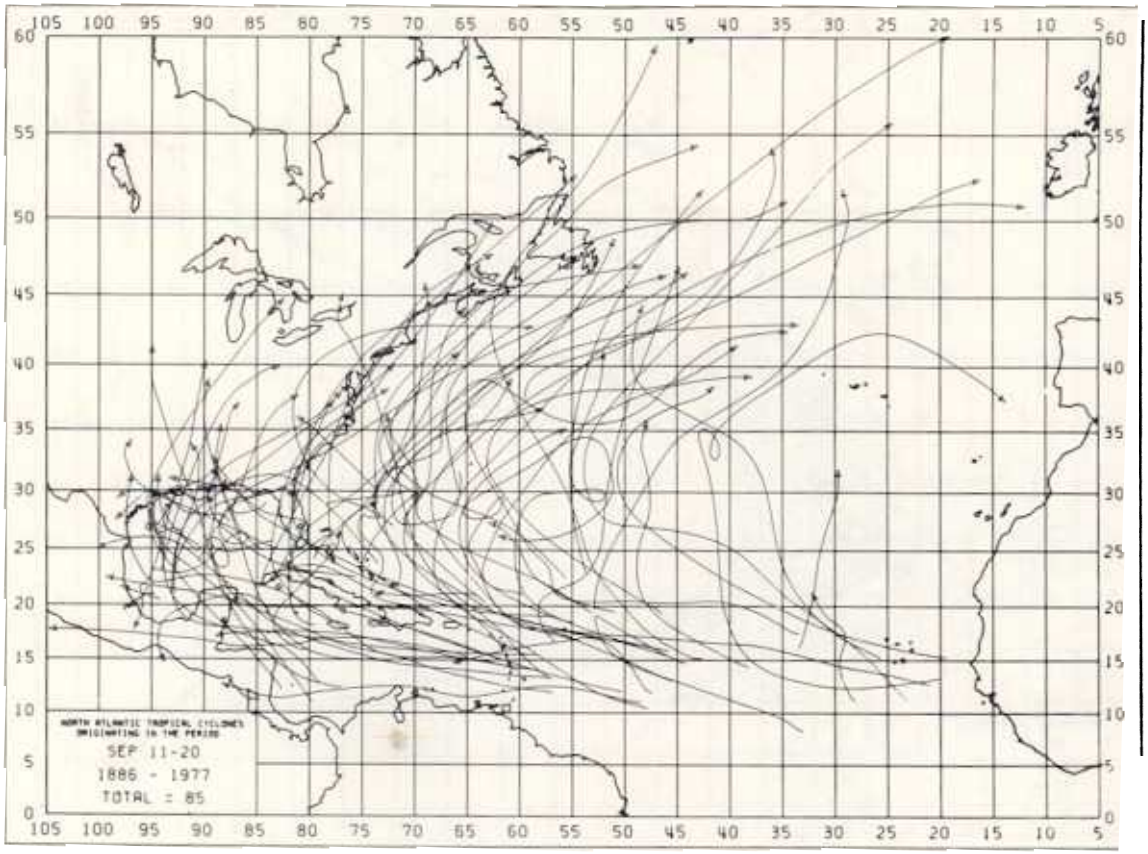

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 21-31
1886 - 1977
TOTAL = 31

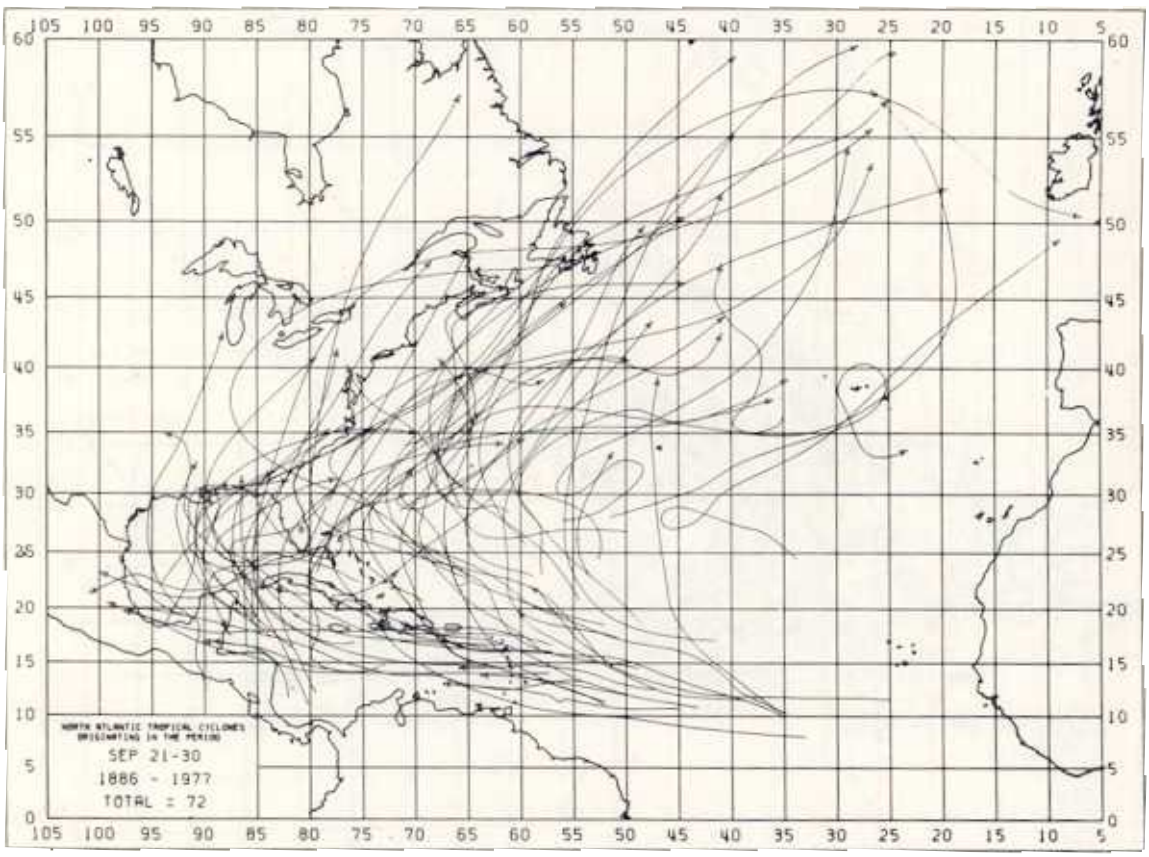

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG 01-10
1886 - 1977
TOTAL = 35

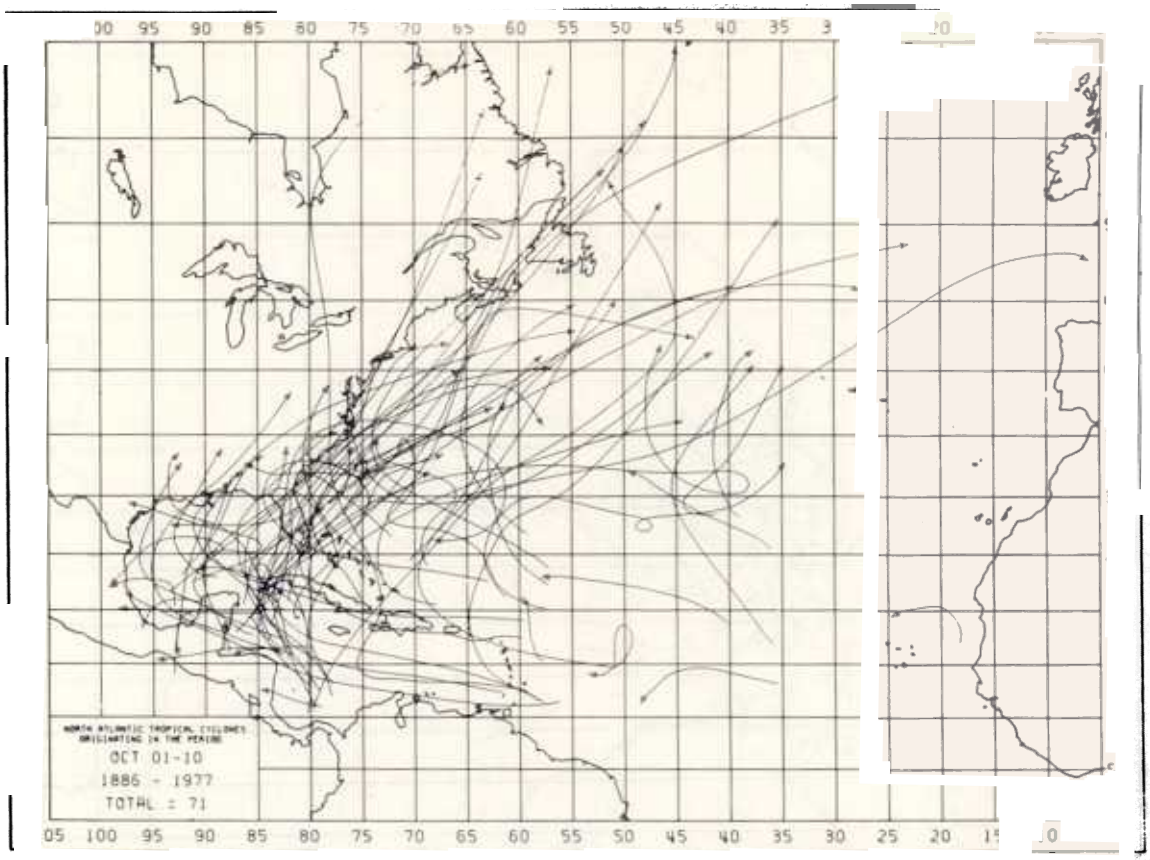

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG 11-20
1886 - 1977
TOTAL = 58

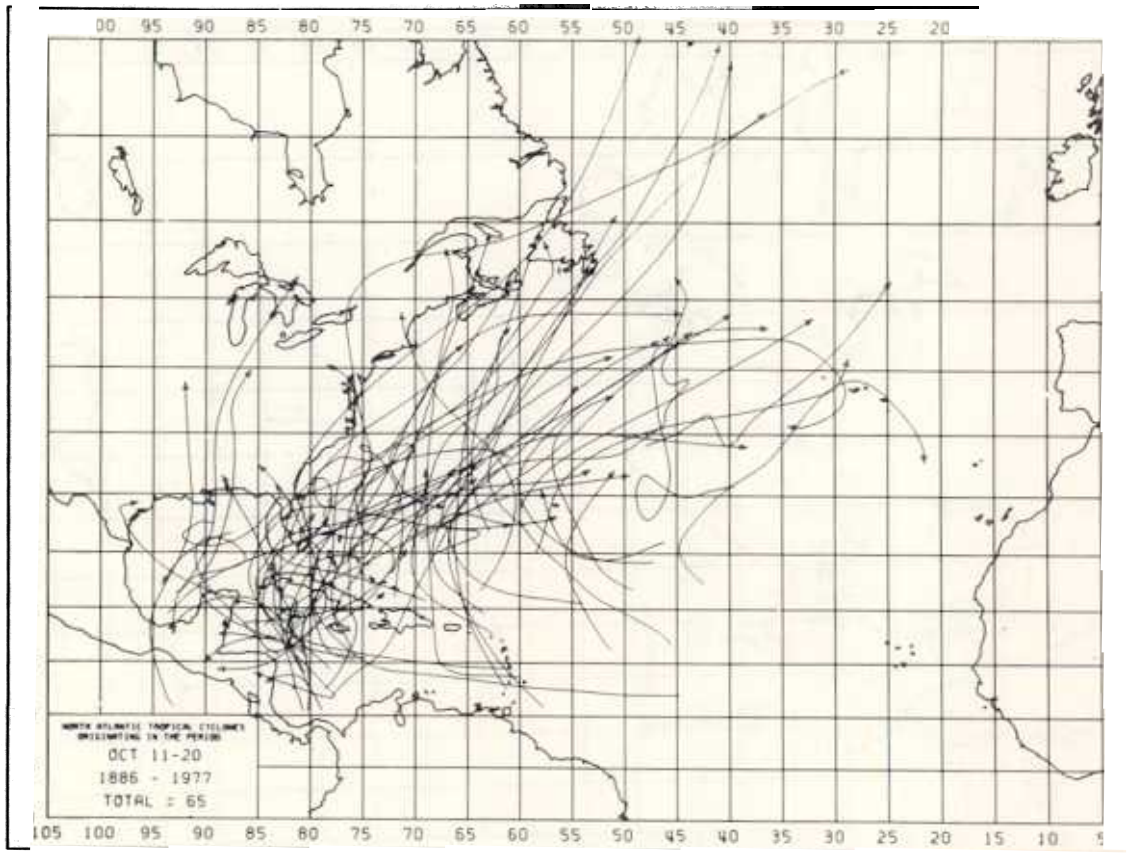

AUG 21-31
1886 - 1977
TOTAL : 82

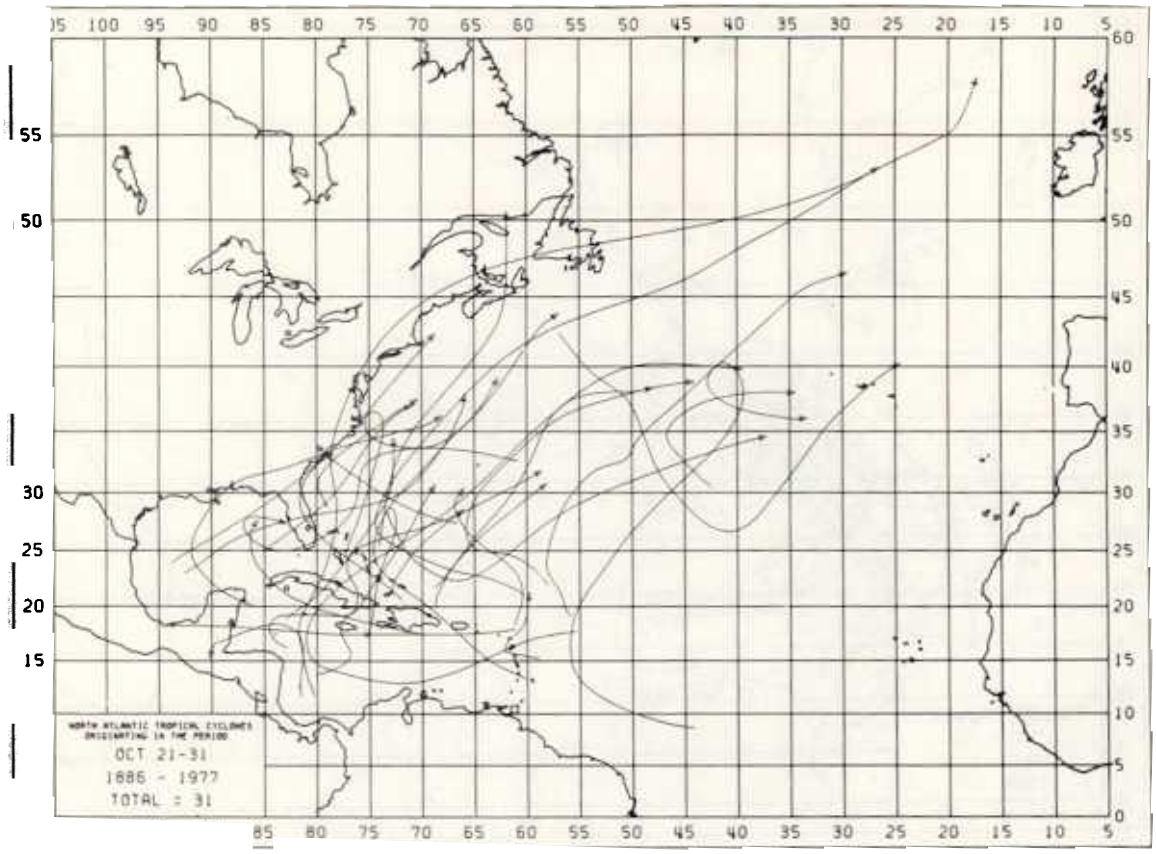

SEP 01-10
1886 - 1977
TOTAL : 101

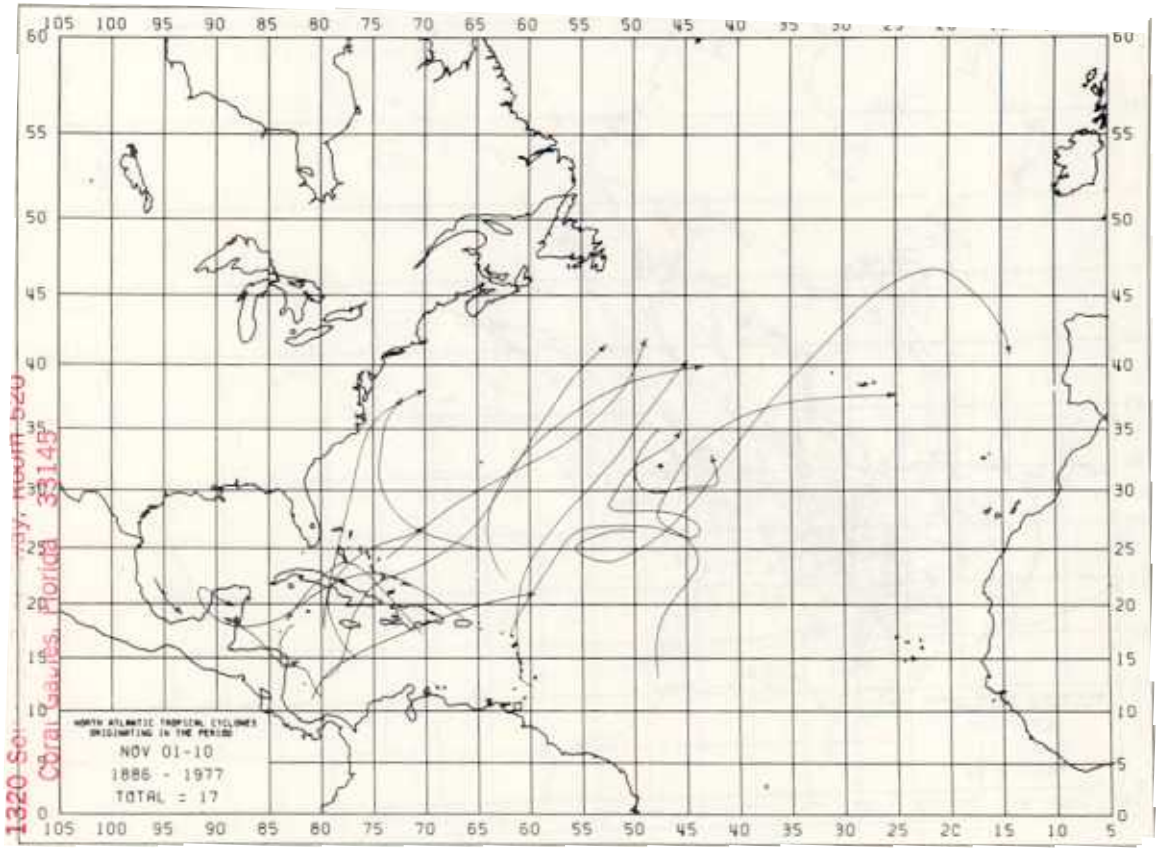

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
SEP 11-20
1886 - 1977
TOTAL = 85


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
SEP 21-30
1886 - 1977
TOTAL = 72

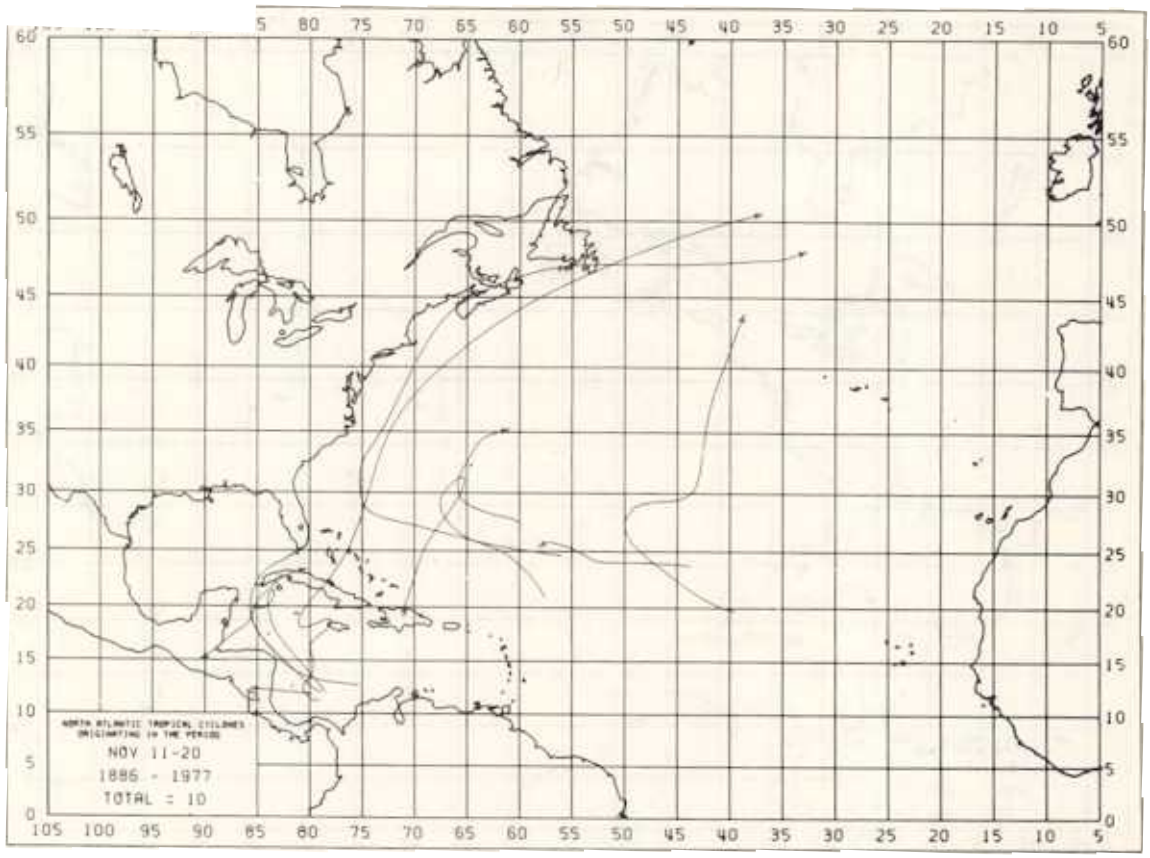

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
OCT 01-10
1886 - 1977
TOTAL : 71

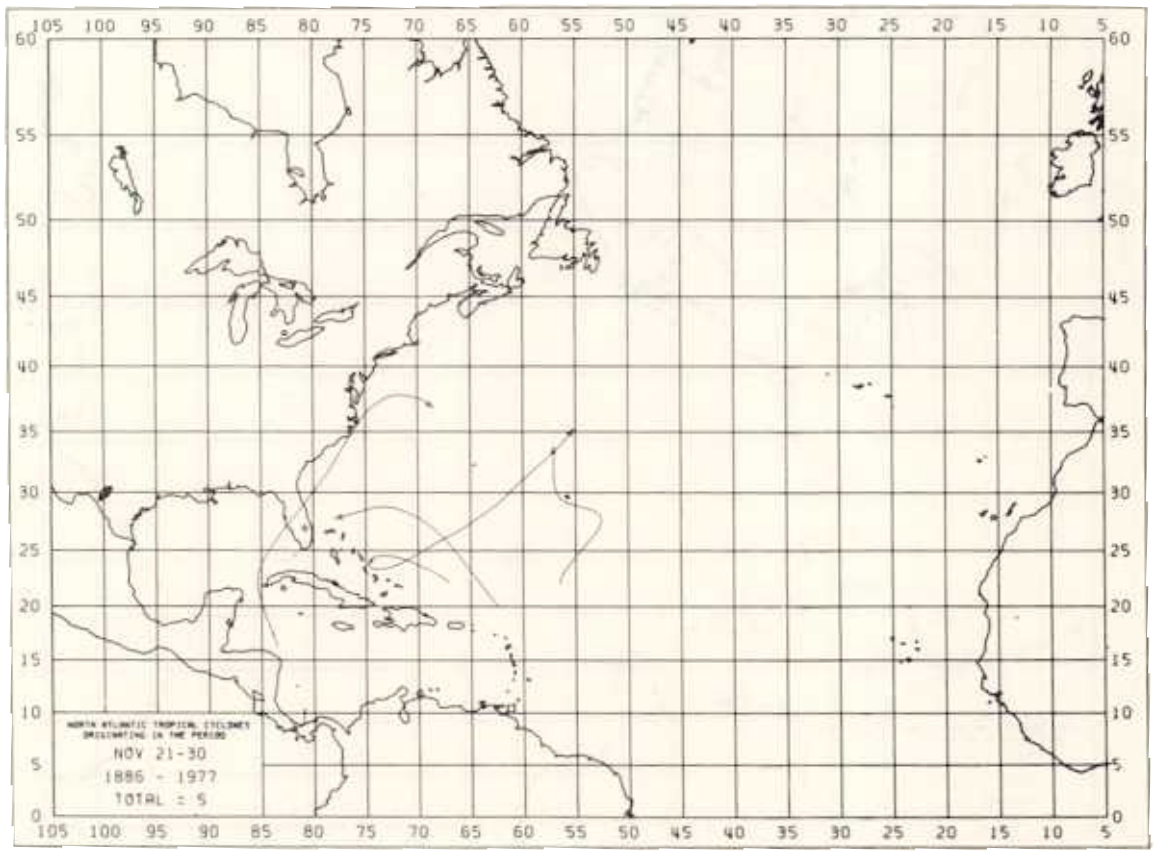

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
OCT 11-20
1886 - 1977
TOTAL : 65

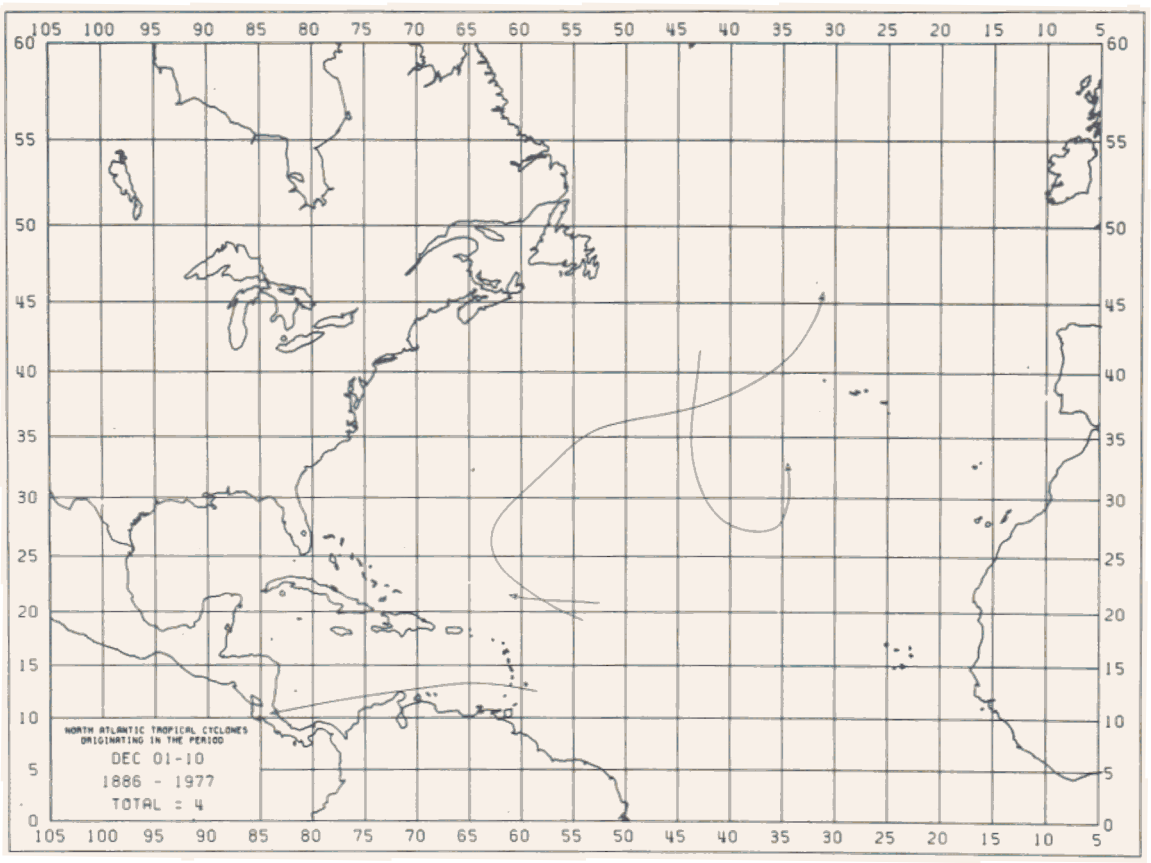




1320 Sc... Coral Gables, Florida 33145


NOV 11-20
1886 - 1977
TOTAL = 10


NOV 21-30
1886 - 1977
TOTAL = 5


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
DEC 01-10
1886 - 1977
TOTAL : 4

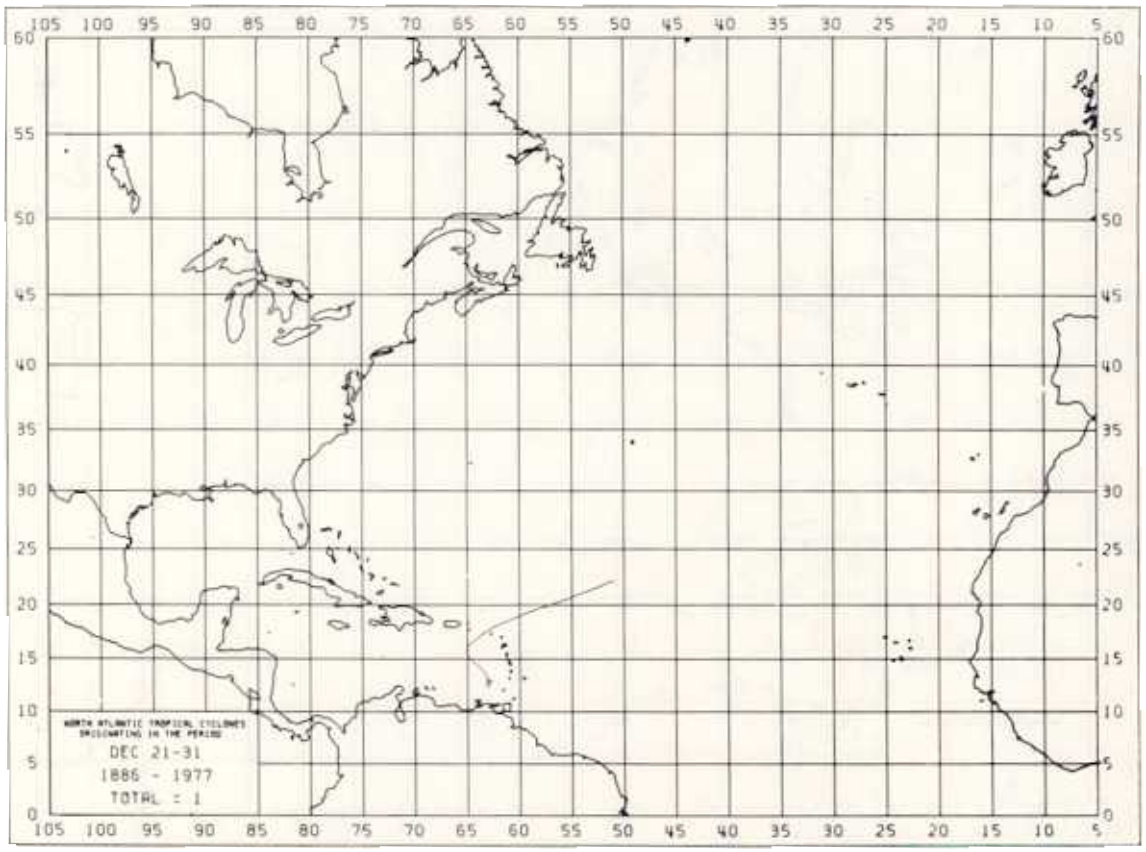
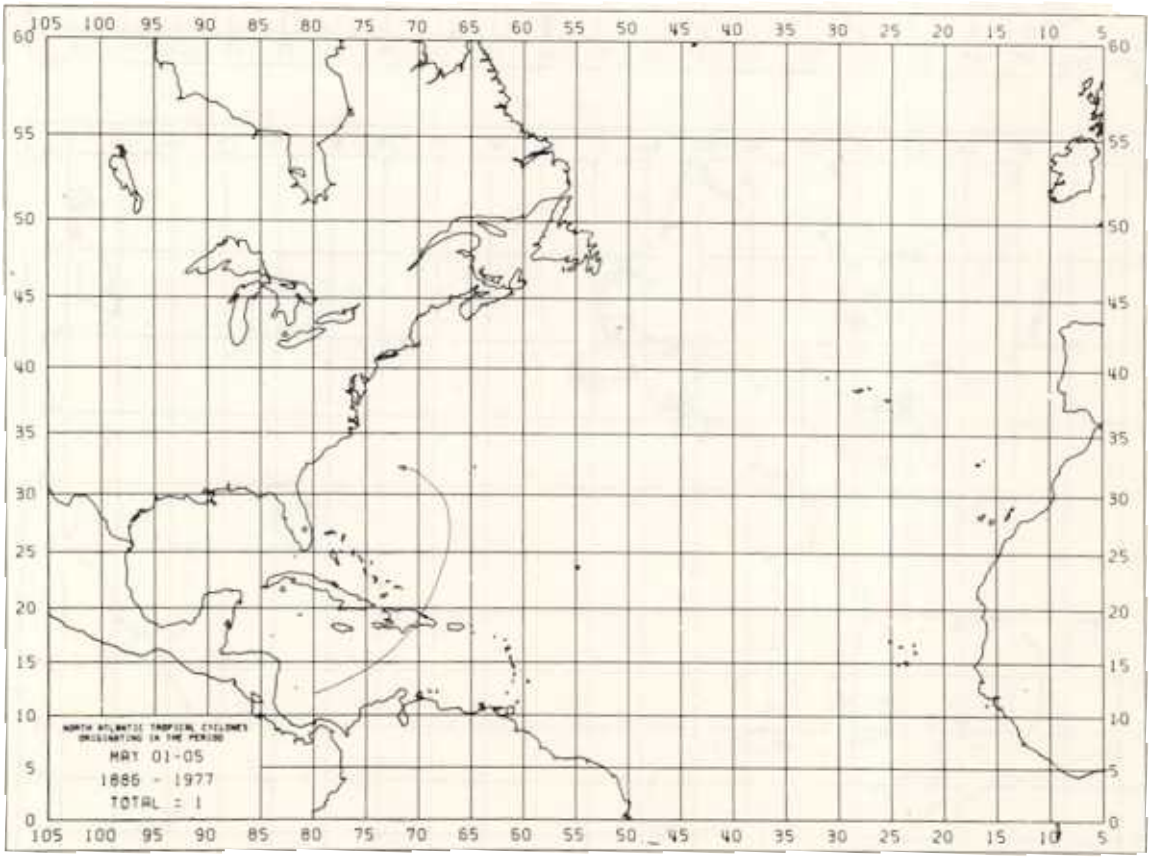
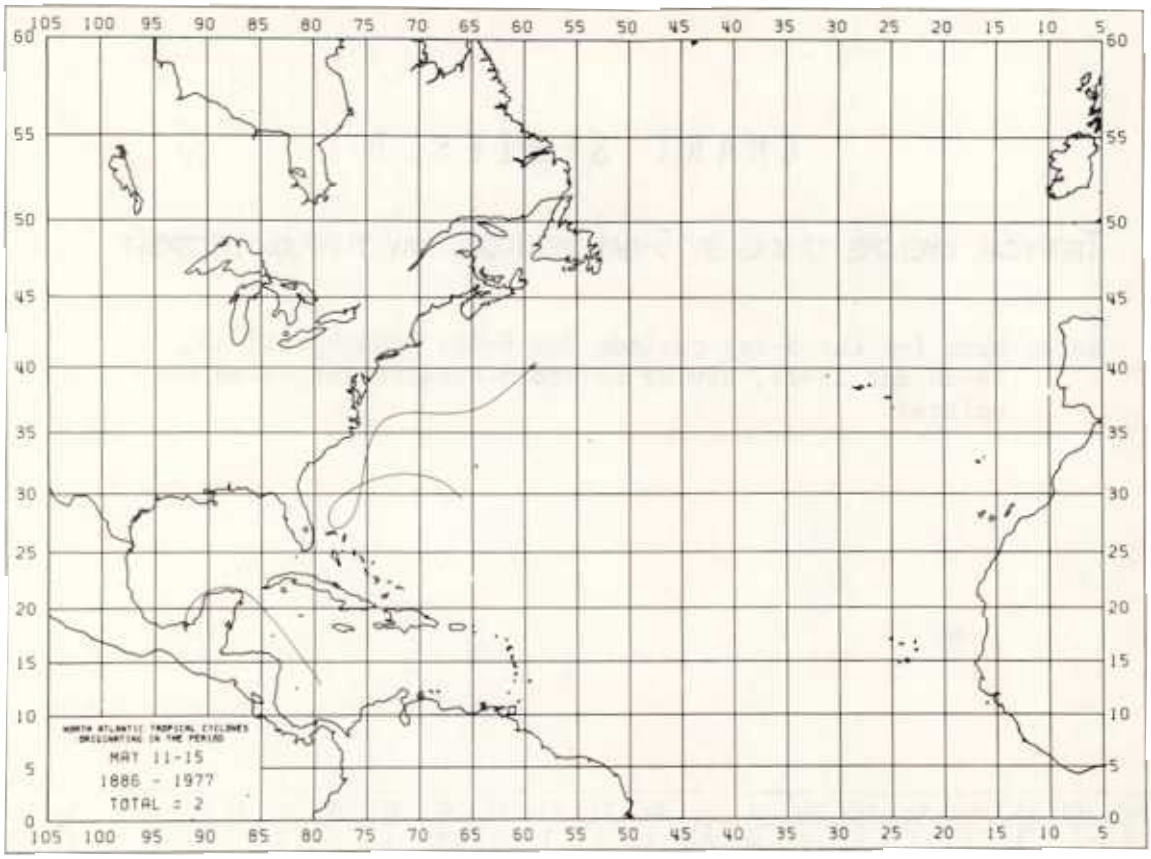

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
DEC 21-31
1886 - 1977
TOTAL : 1

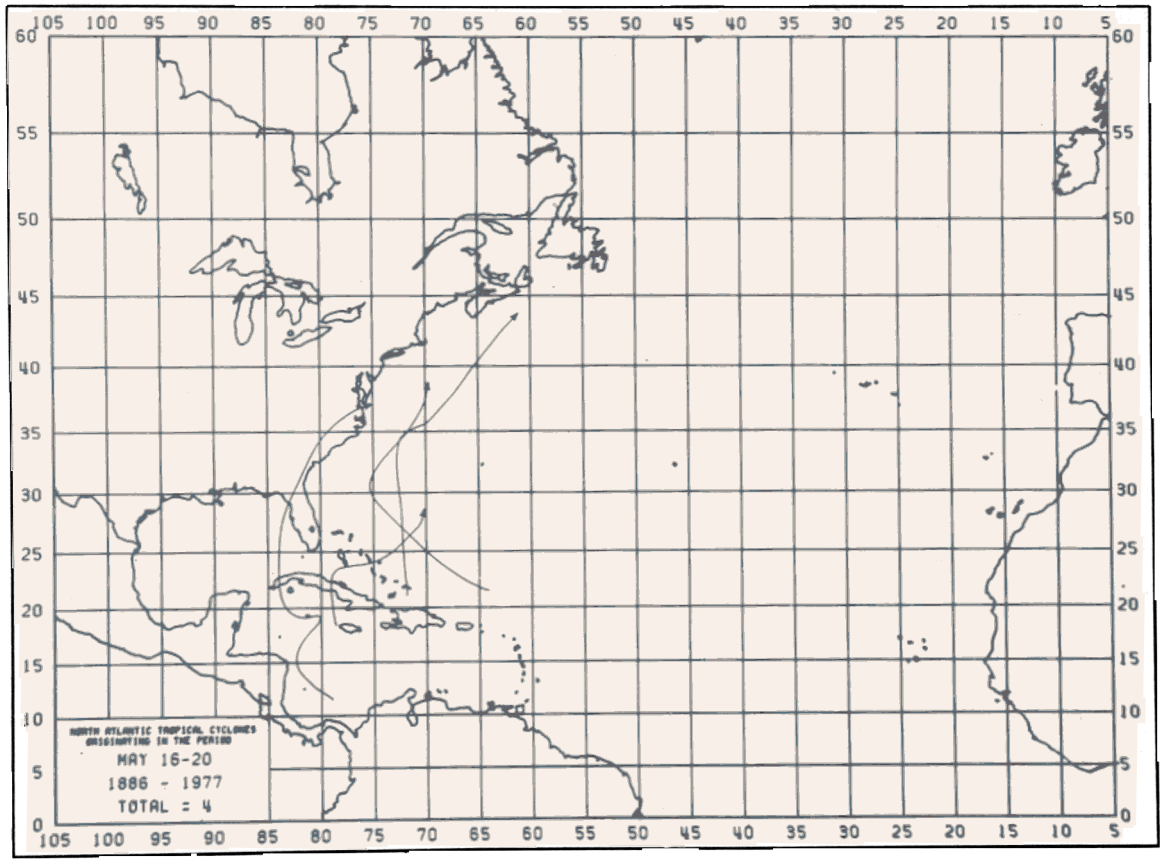
CHART SERIES D

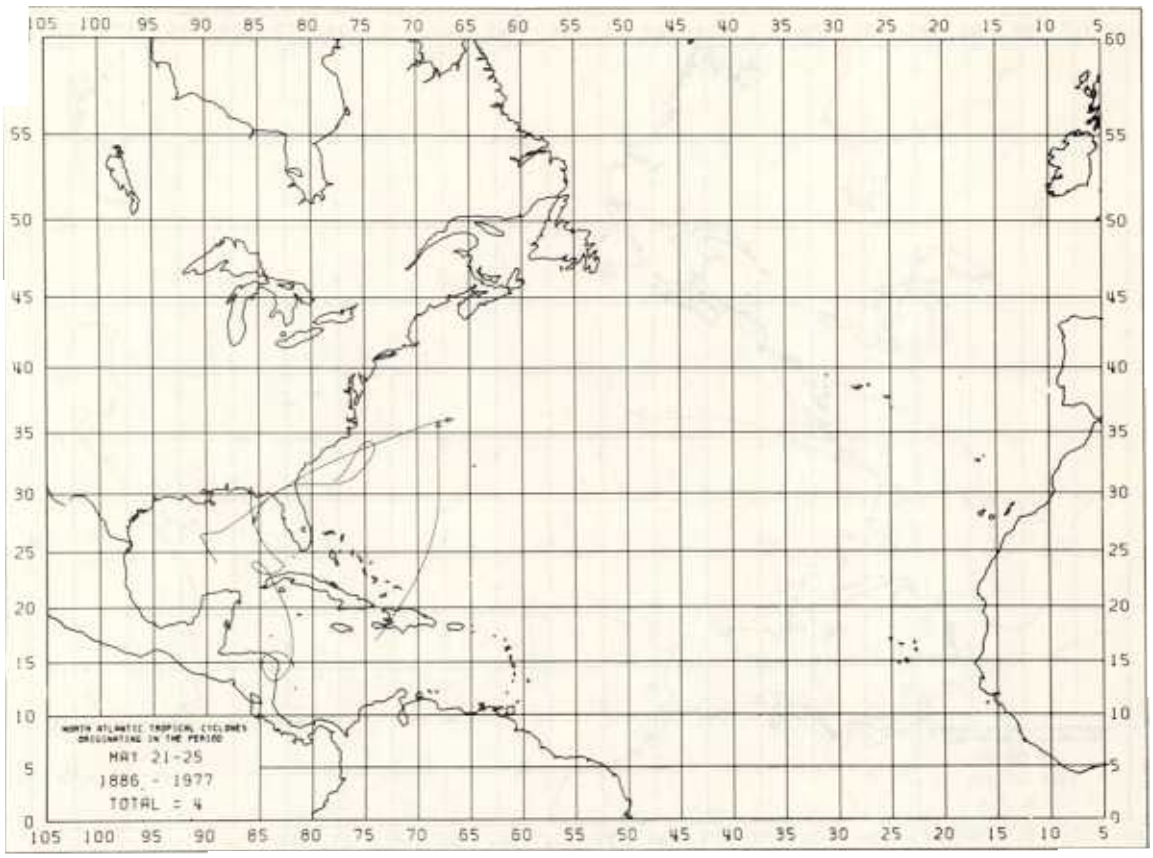
TROPICAL CYCLONE TRACKS BY 5-DAY PERIODS, MAY THROUGH DECEMBER

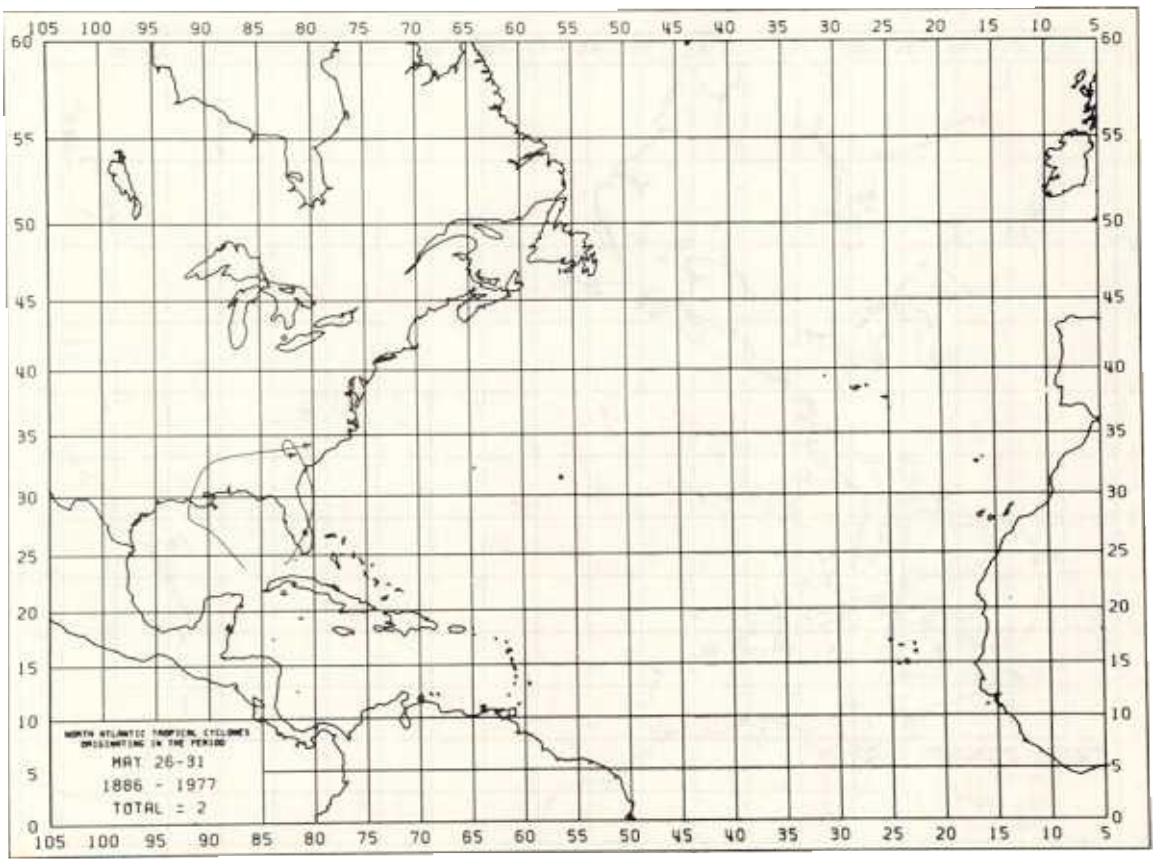
Note: Maps for the 5-day periods May 6-10, December 11-15, 16-20 and 21-25, having no storm occurrences, have been omitted.

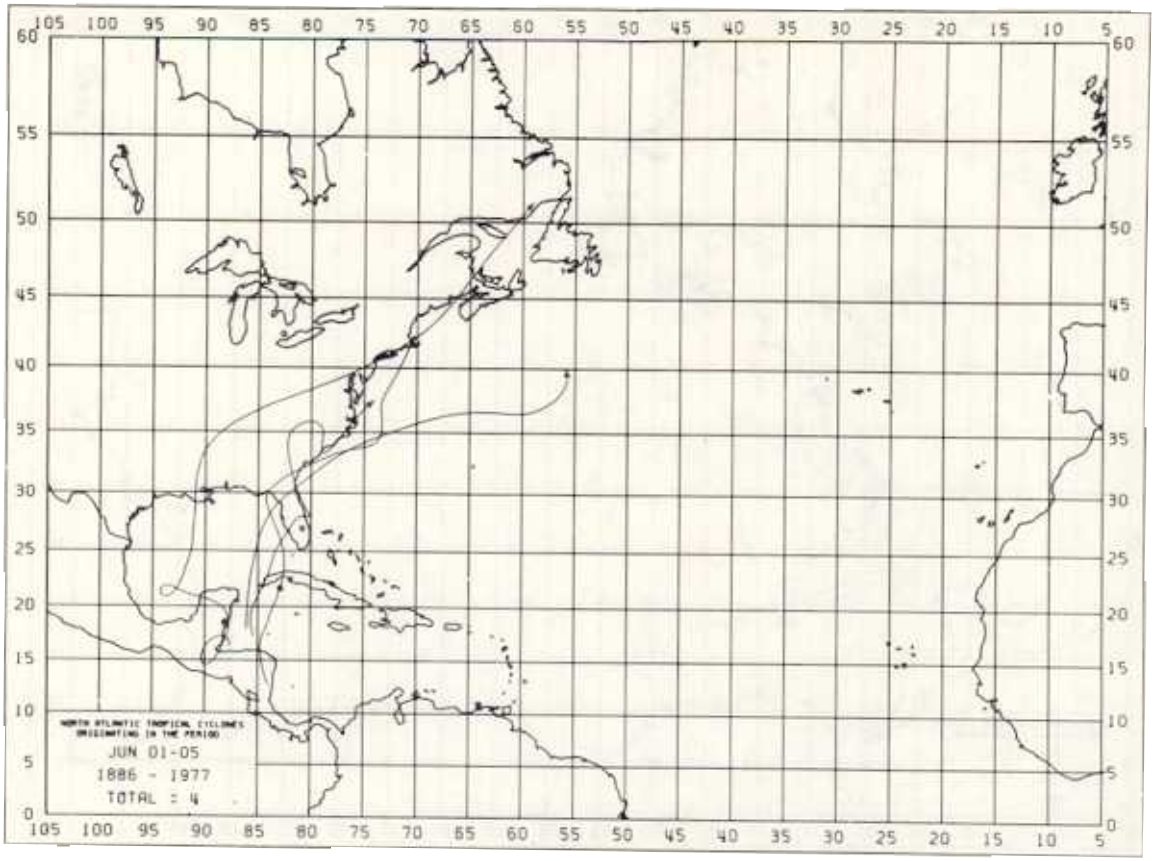


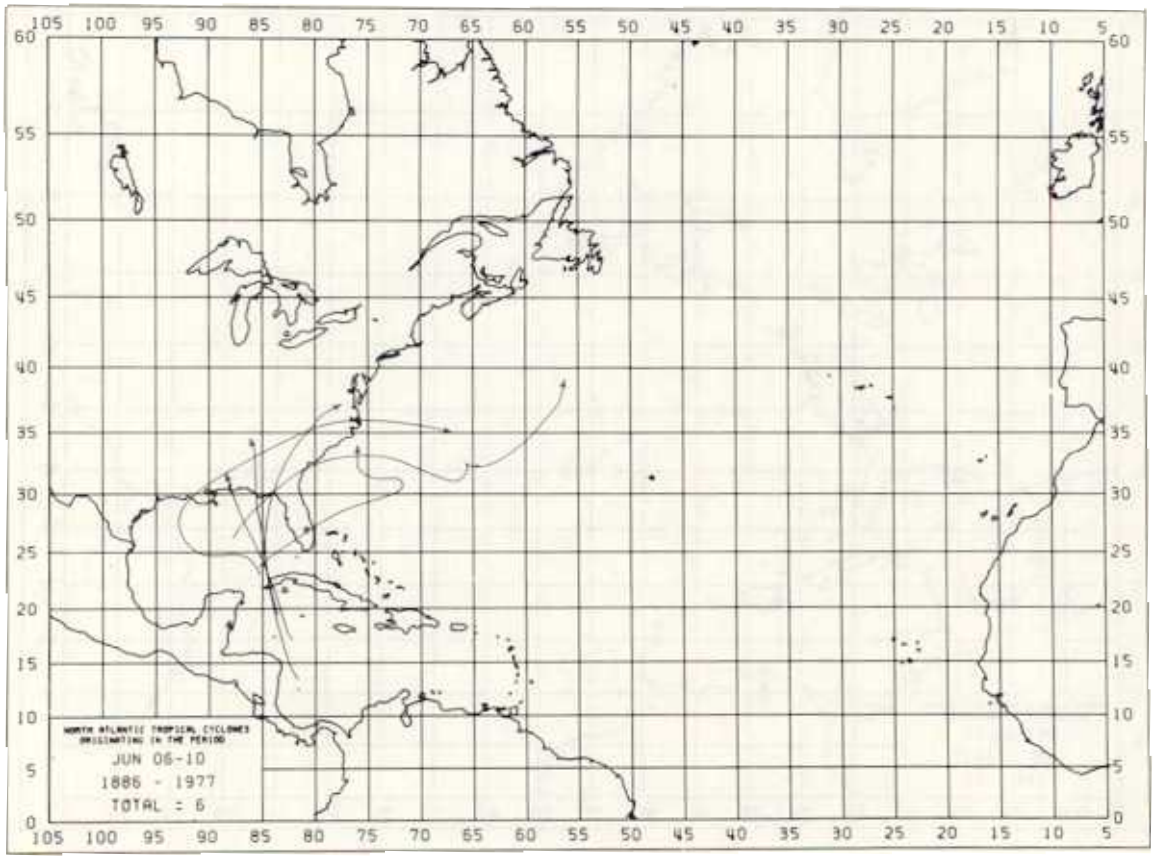

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
MAY 11-15
1886 - 1977
TOTAL = 2

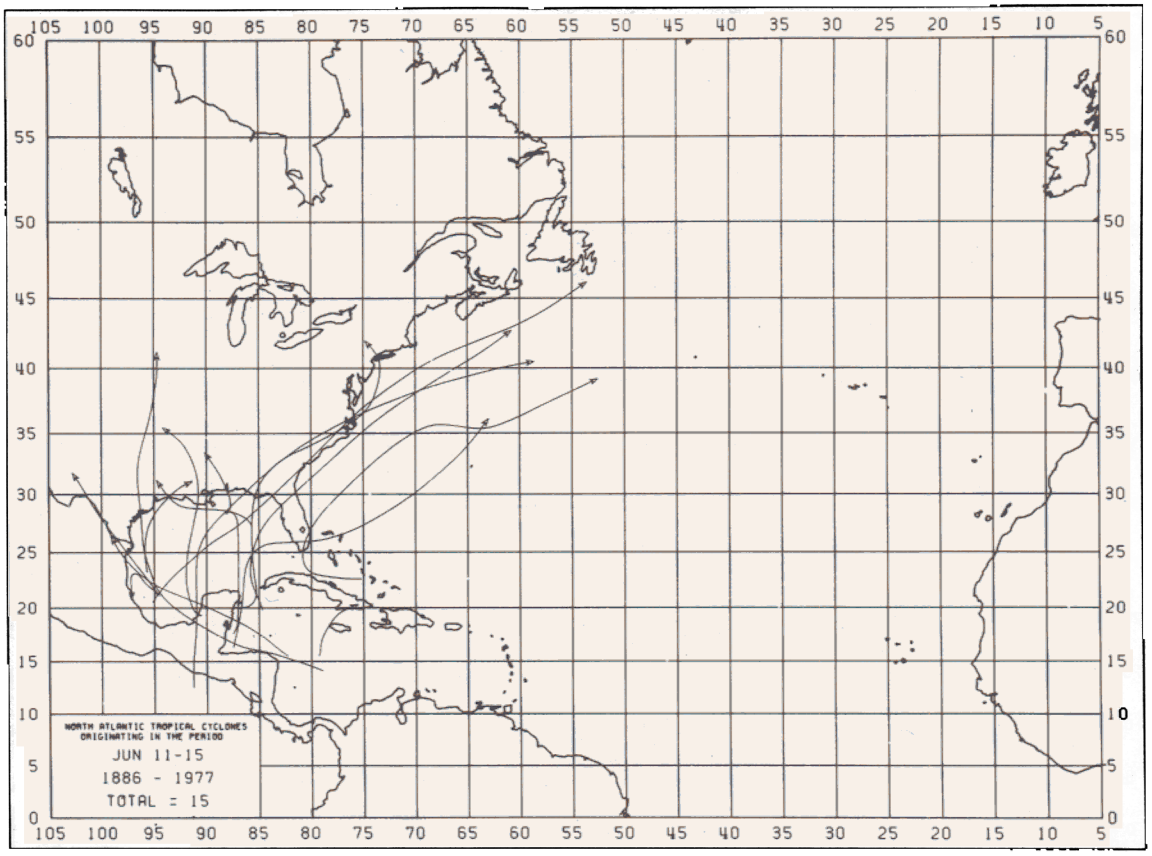

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
MAY 16-20
1886 - 1977
TOTAL = 4

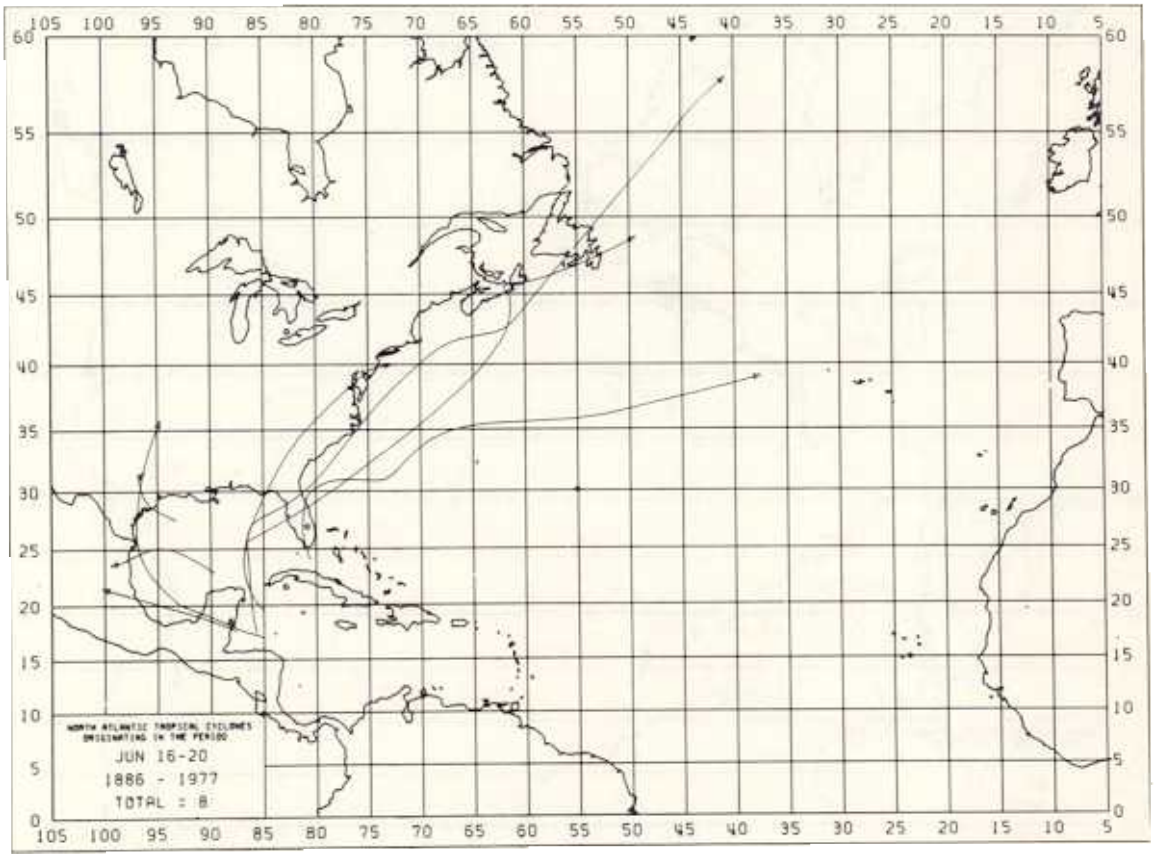

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
MAY 21-25
1886 - 1977
TOTAL = 4

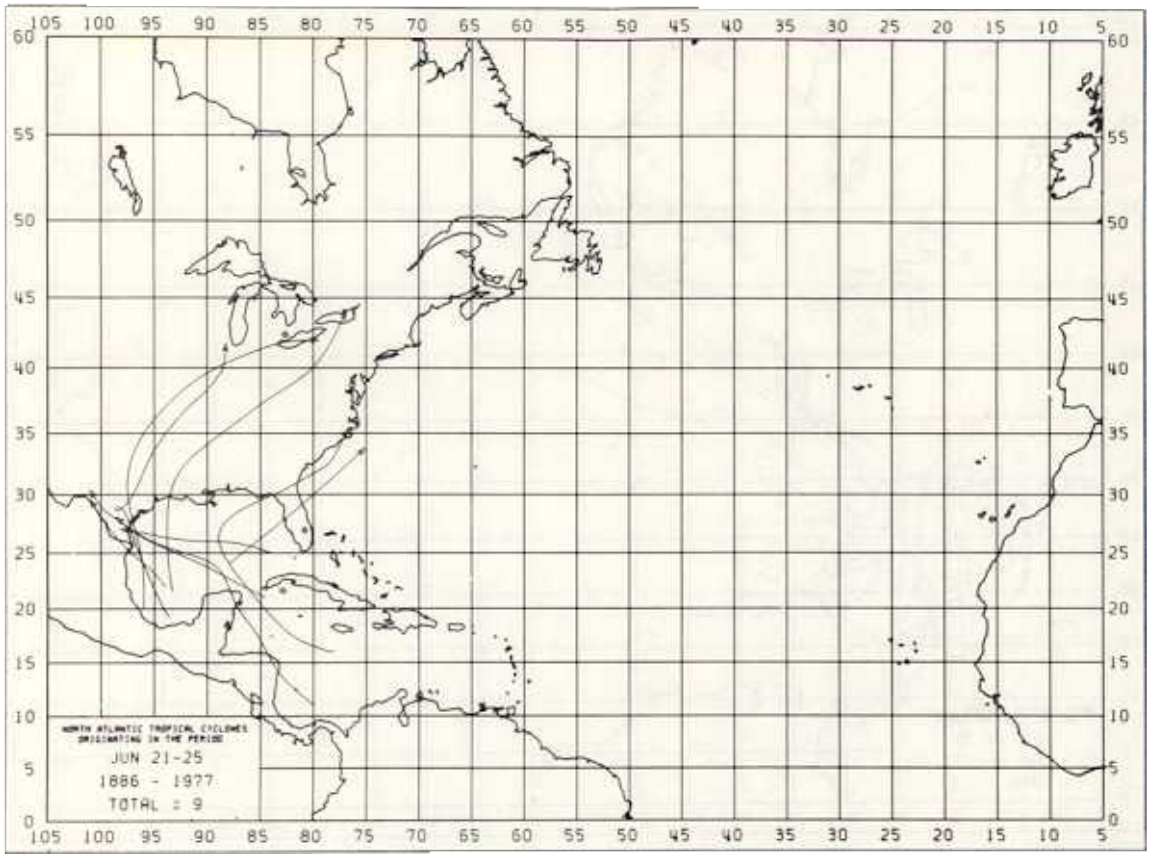

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
MAY 26-31
1886 - 1977
TOTAL = 2

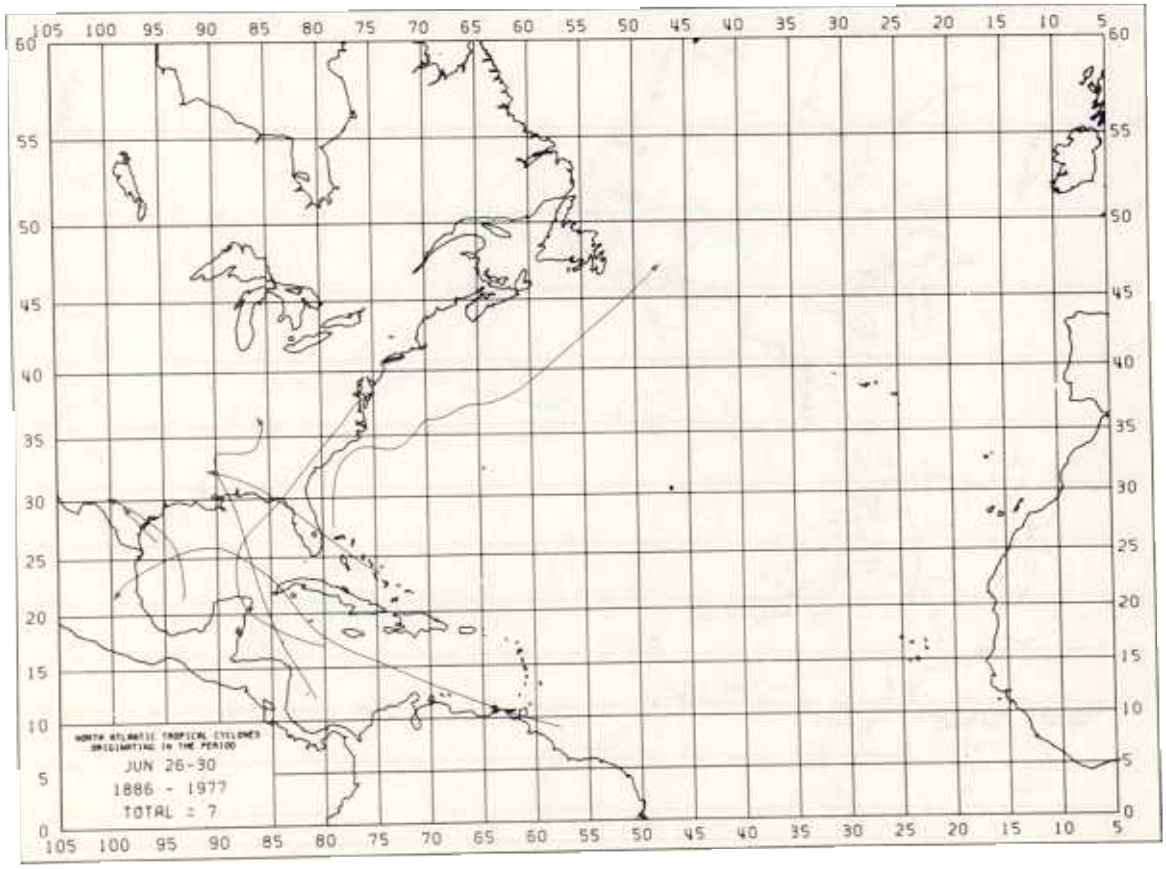

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 01-05
1886 - 1977
TOTAL : 4

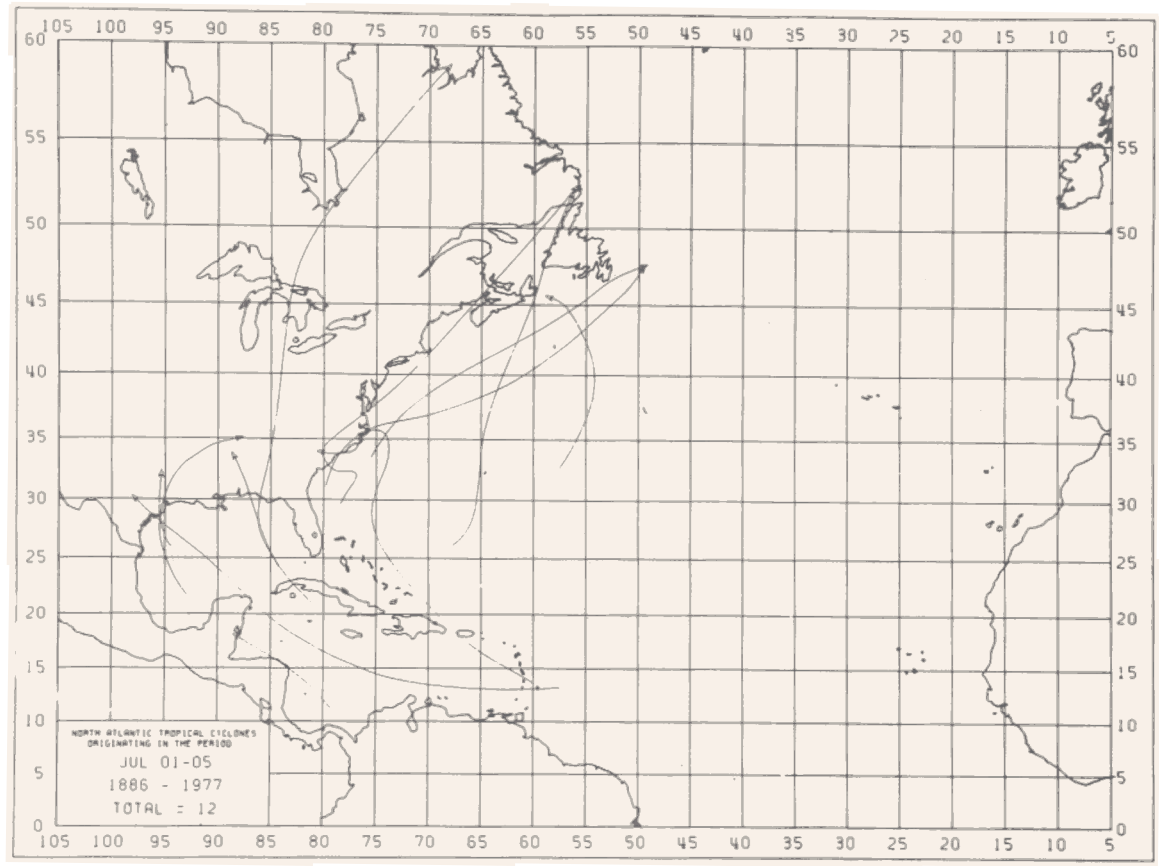

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 06-10
1886 - 1977
TOTAL : 6

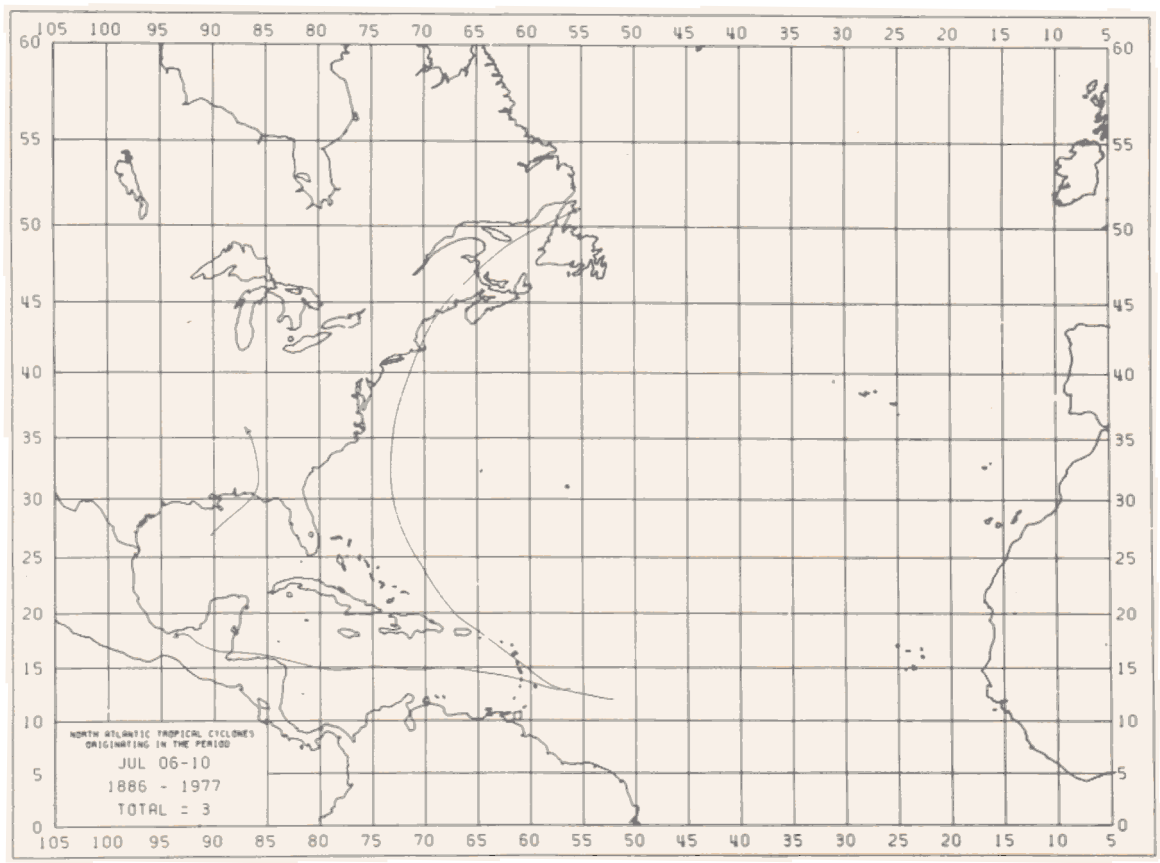

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 11-15
1886 - 1977
TOTAL = 15

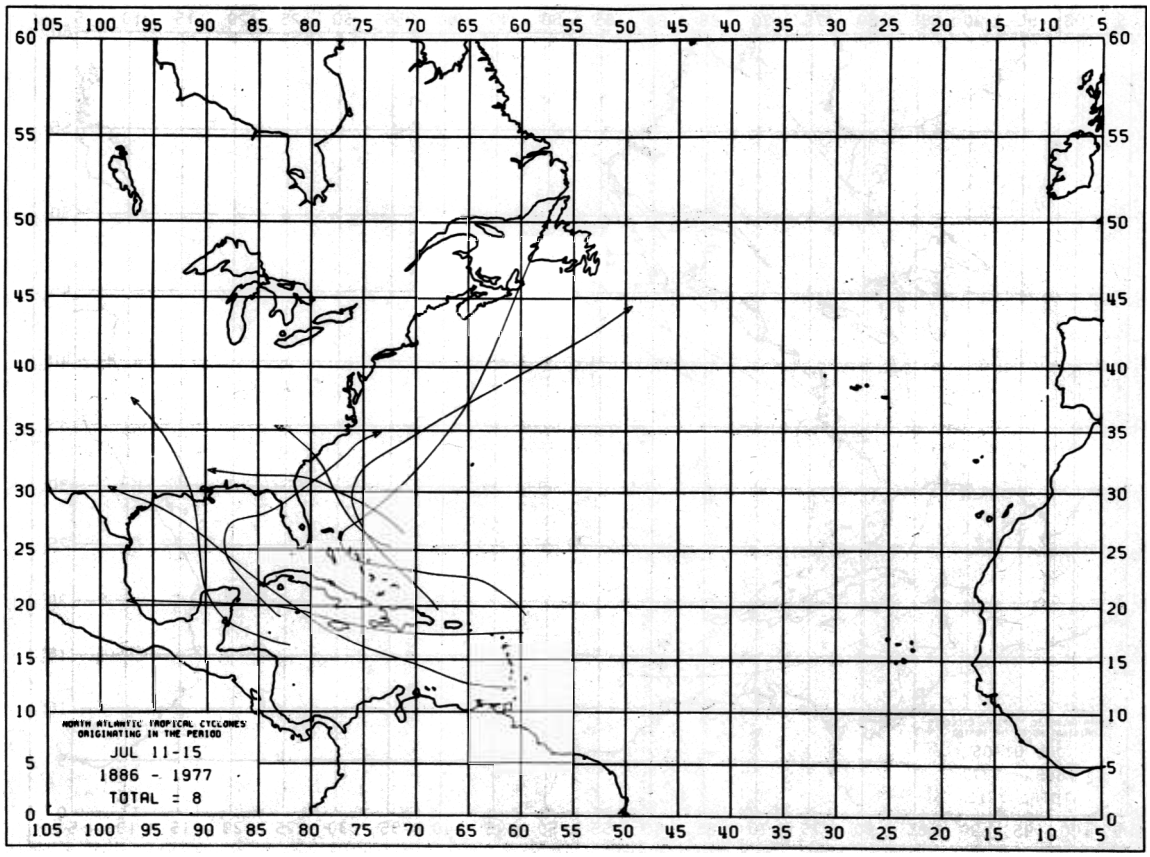

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 16-20
1886 - 1977
TOTAL = 8

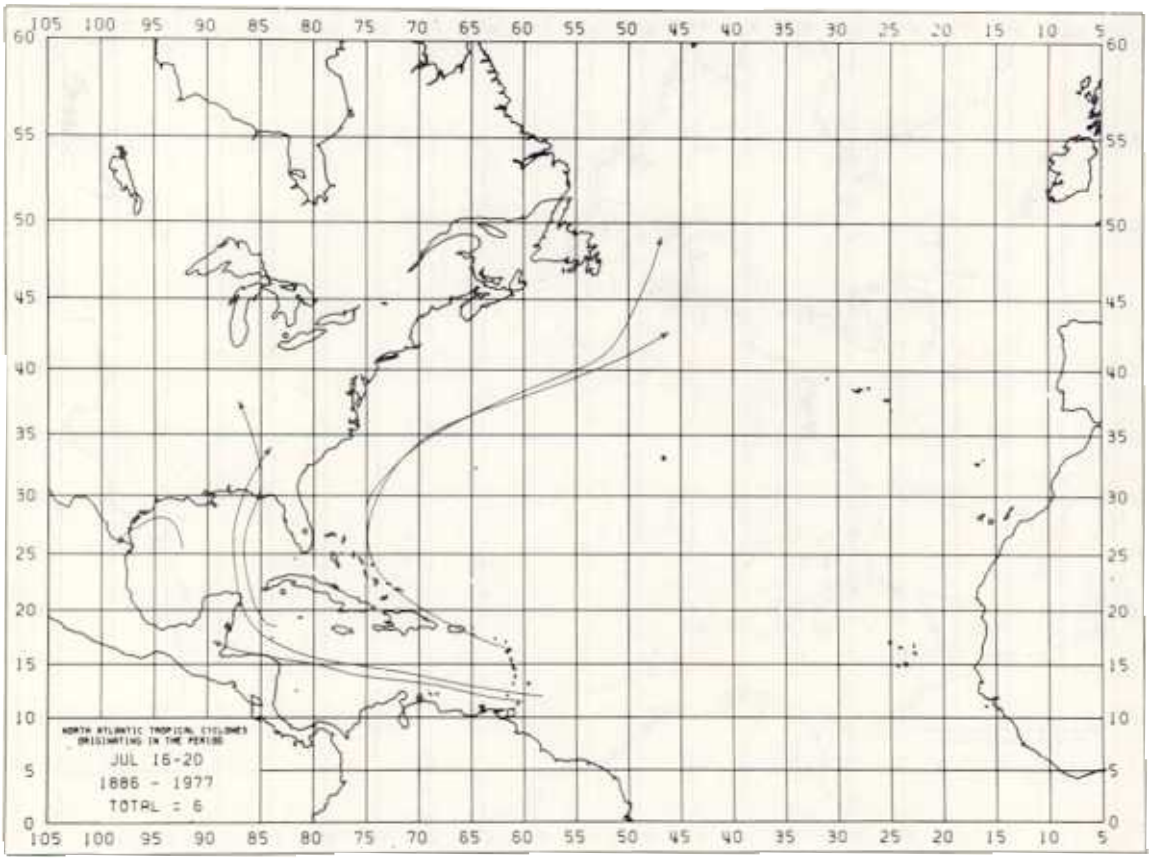

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 21-25
1886 - 1977
TOTAL : 9

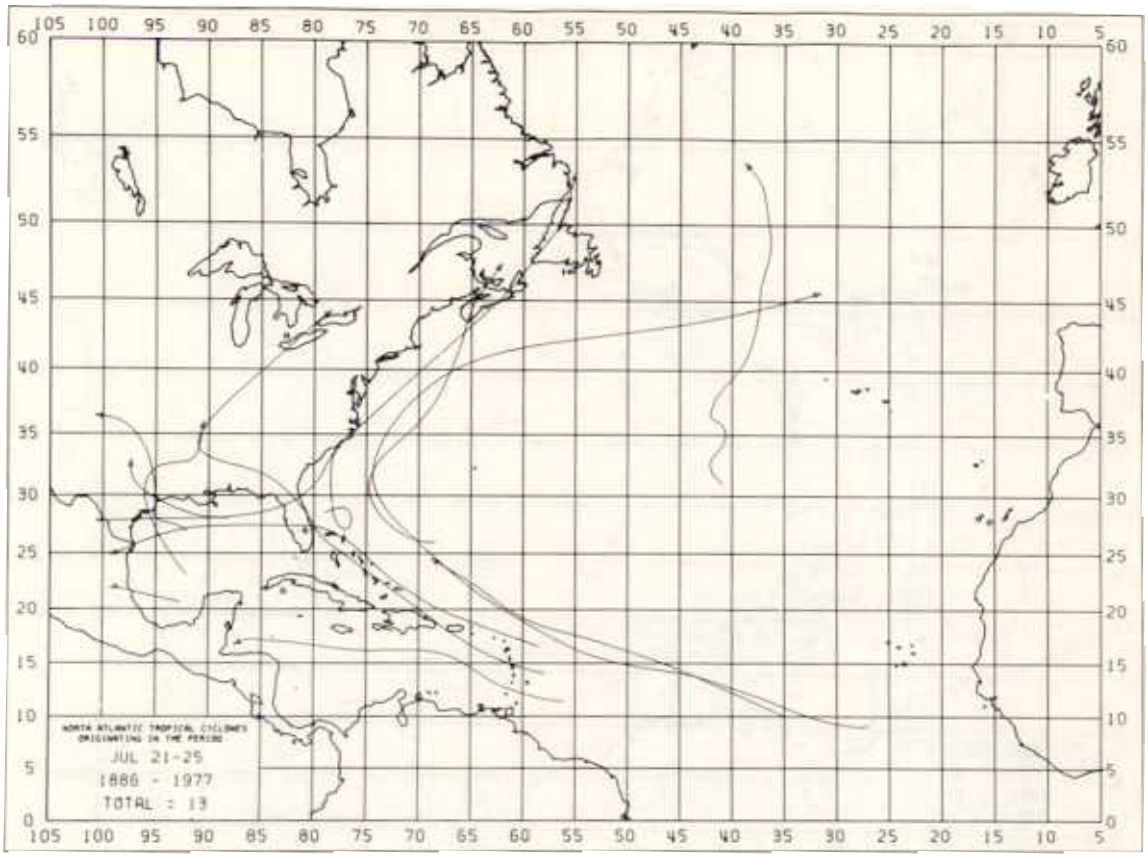

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUN 26-30
1886 - 1977
TOTAL : 7

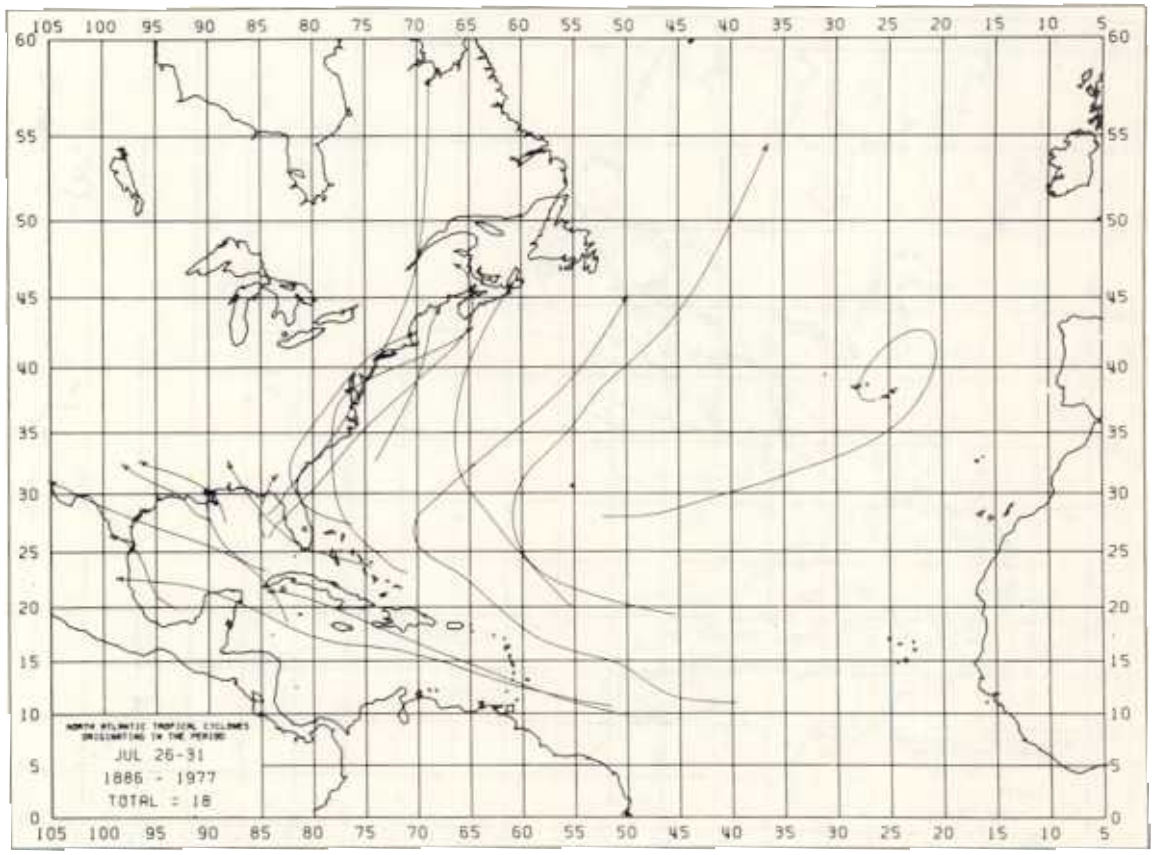

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 01-05
1886 - 1977
TOTAL = 12

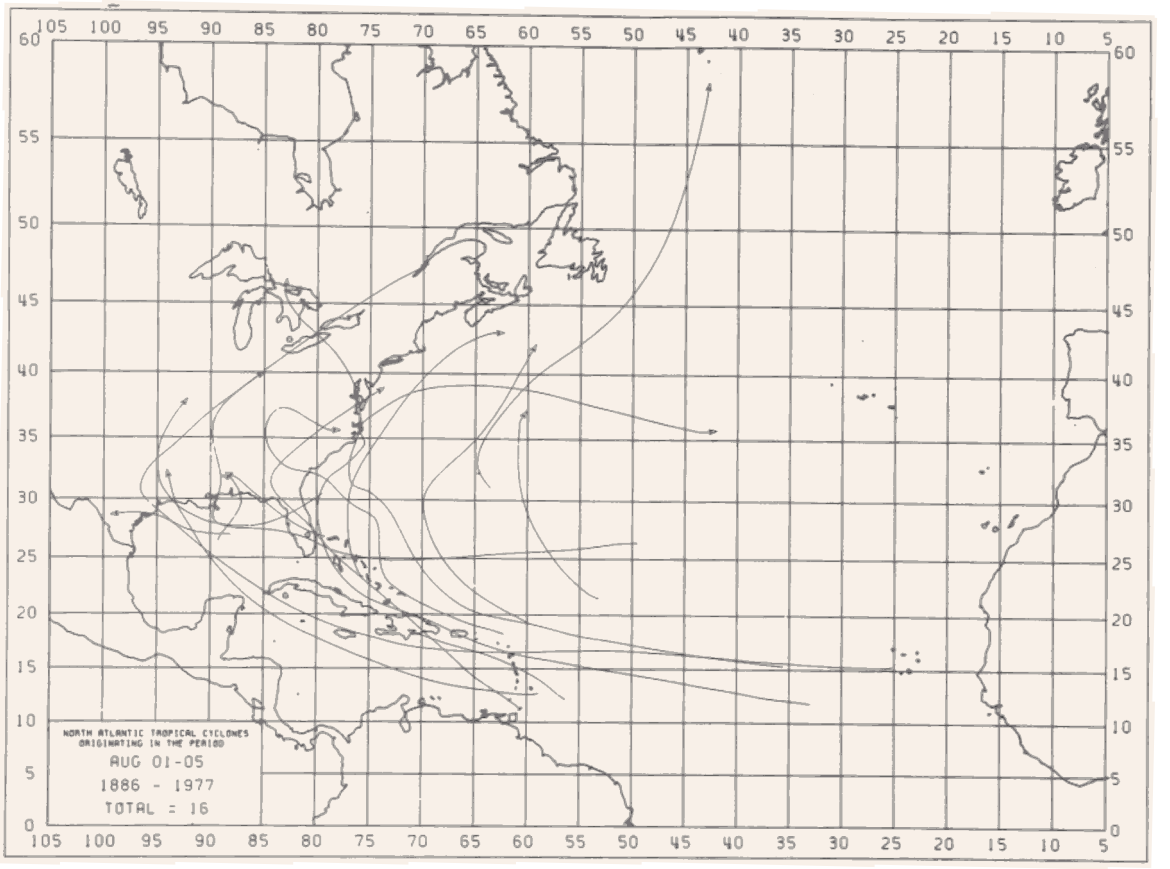

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 06-10
1886 - 1977
TOTAL = 3

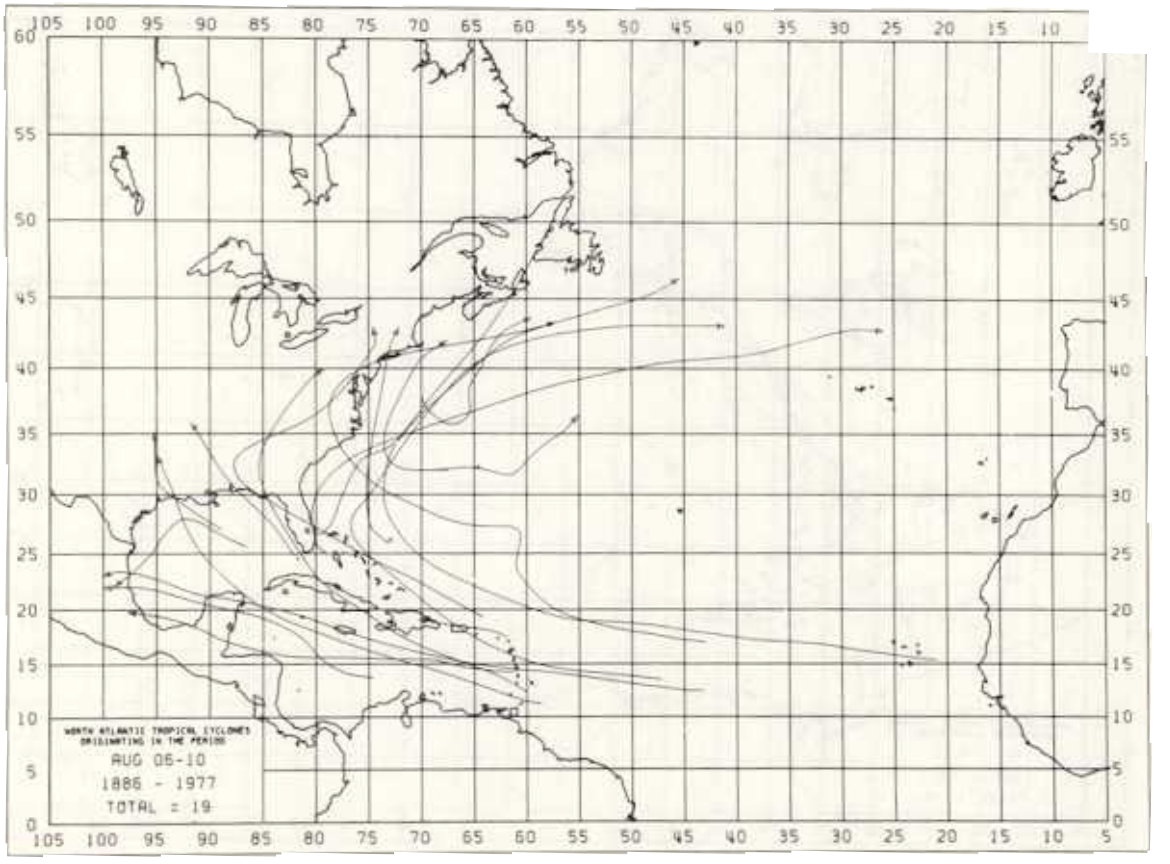

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 11-15
1886 - 1977
TOTAL = 8

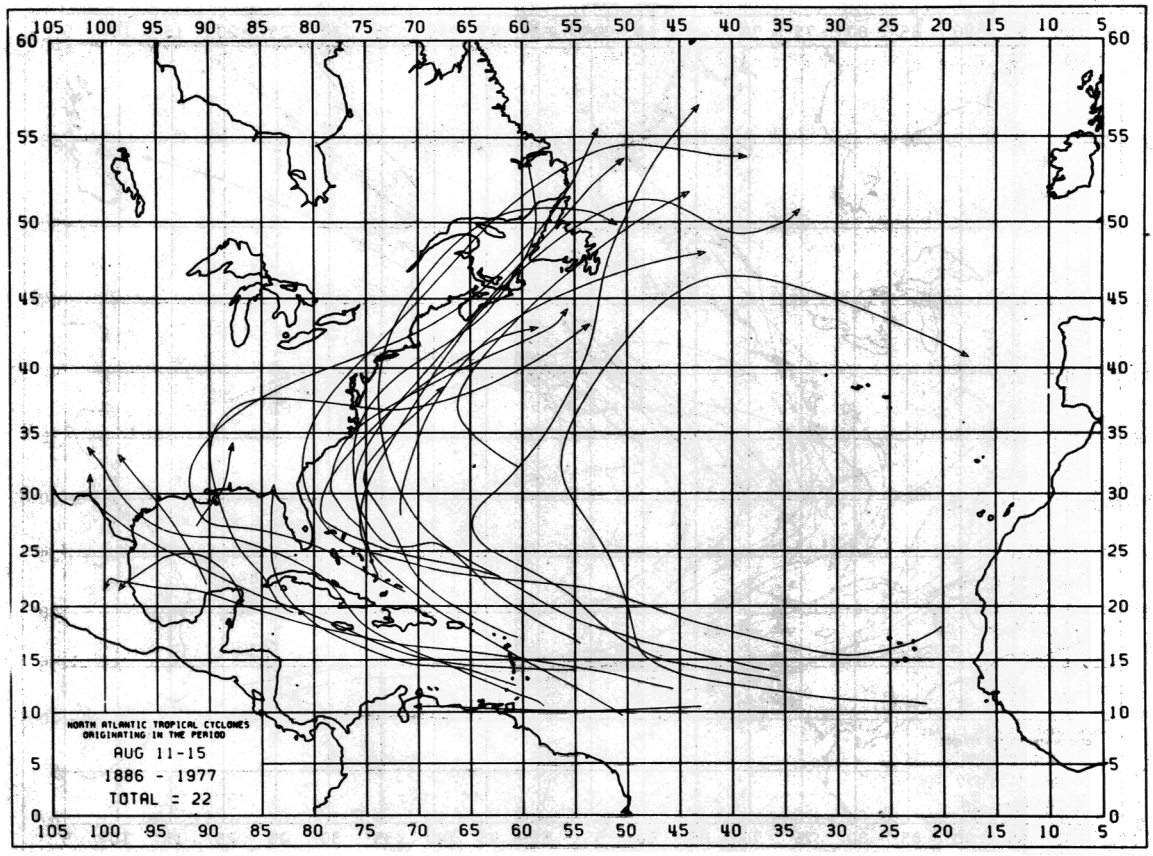

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 16-20
1886 - 1977
TOTAL = 6

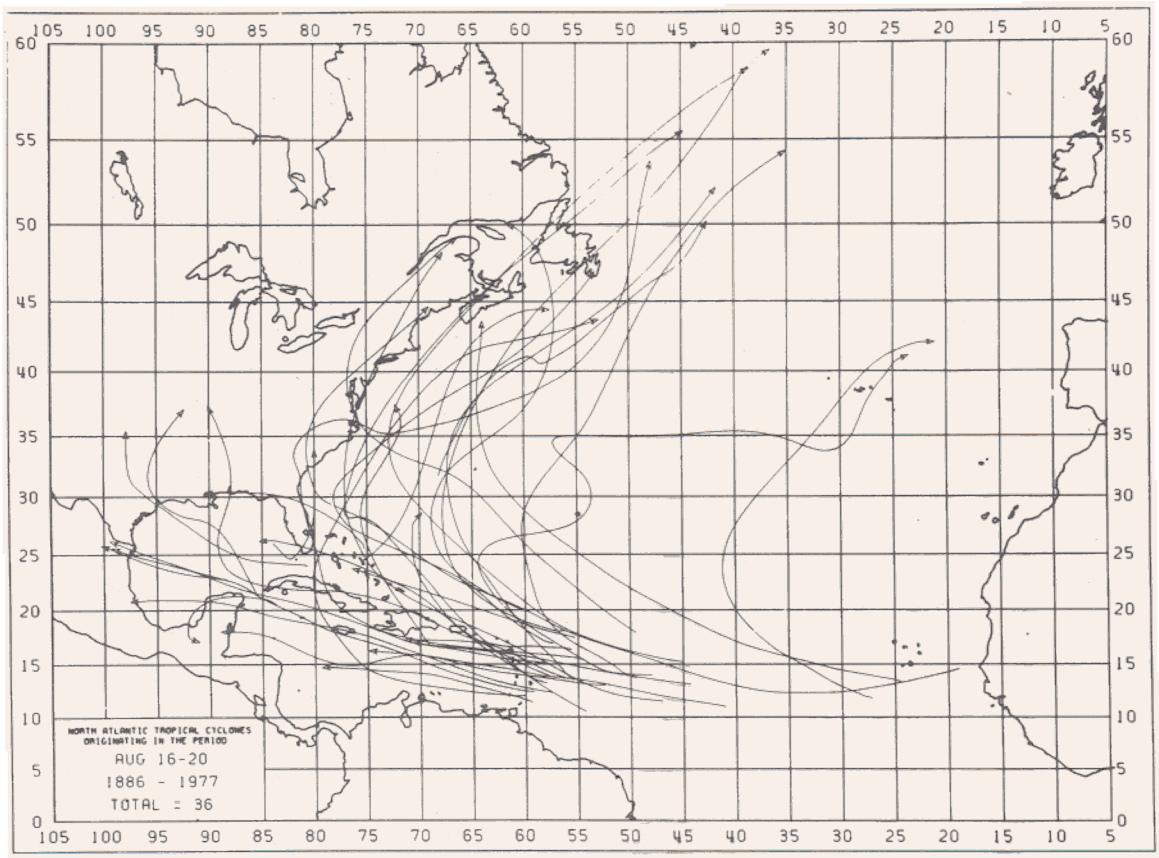

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 21-25
1886 - 1977
TOTAL : 13

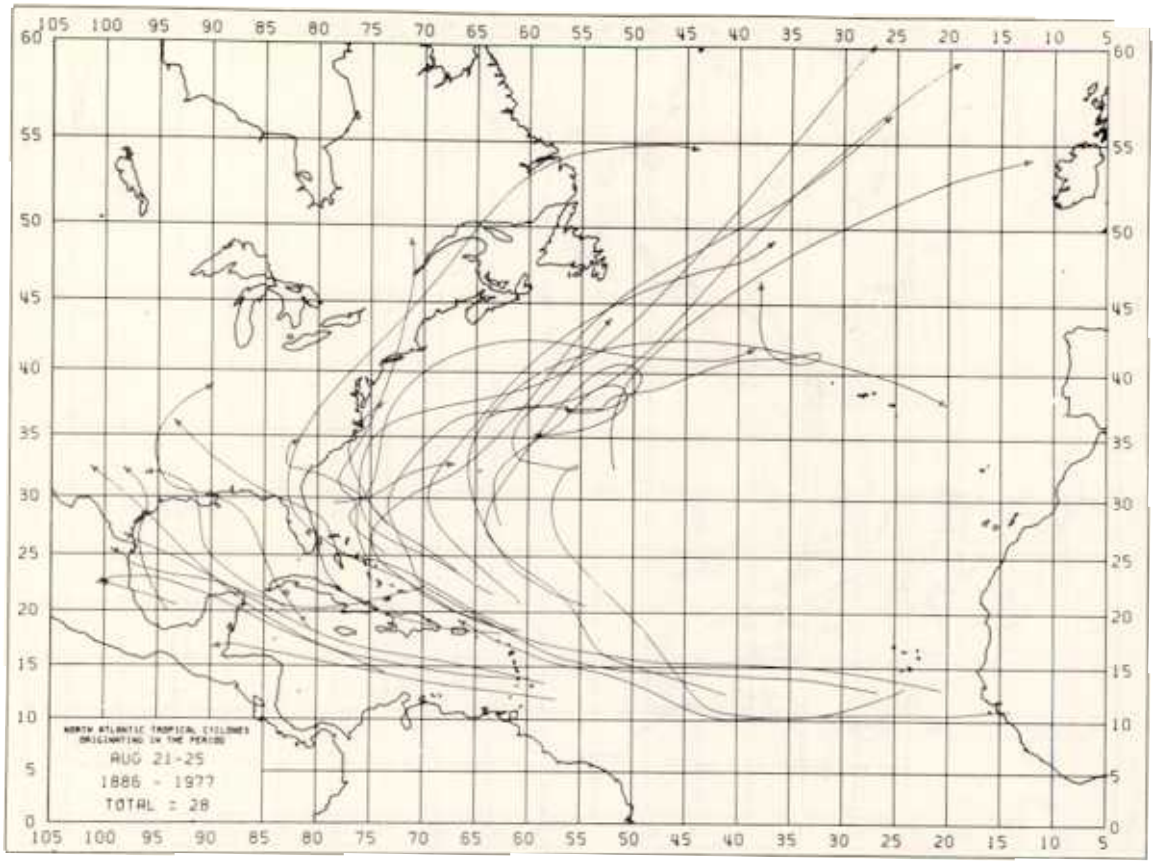

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
JUL 26-31
1886 - 1977
TOTAL : 18

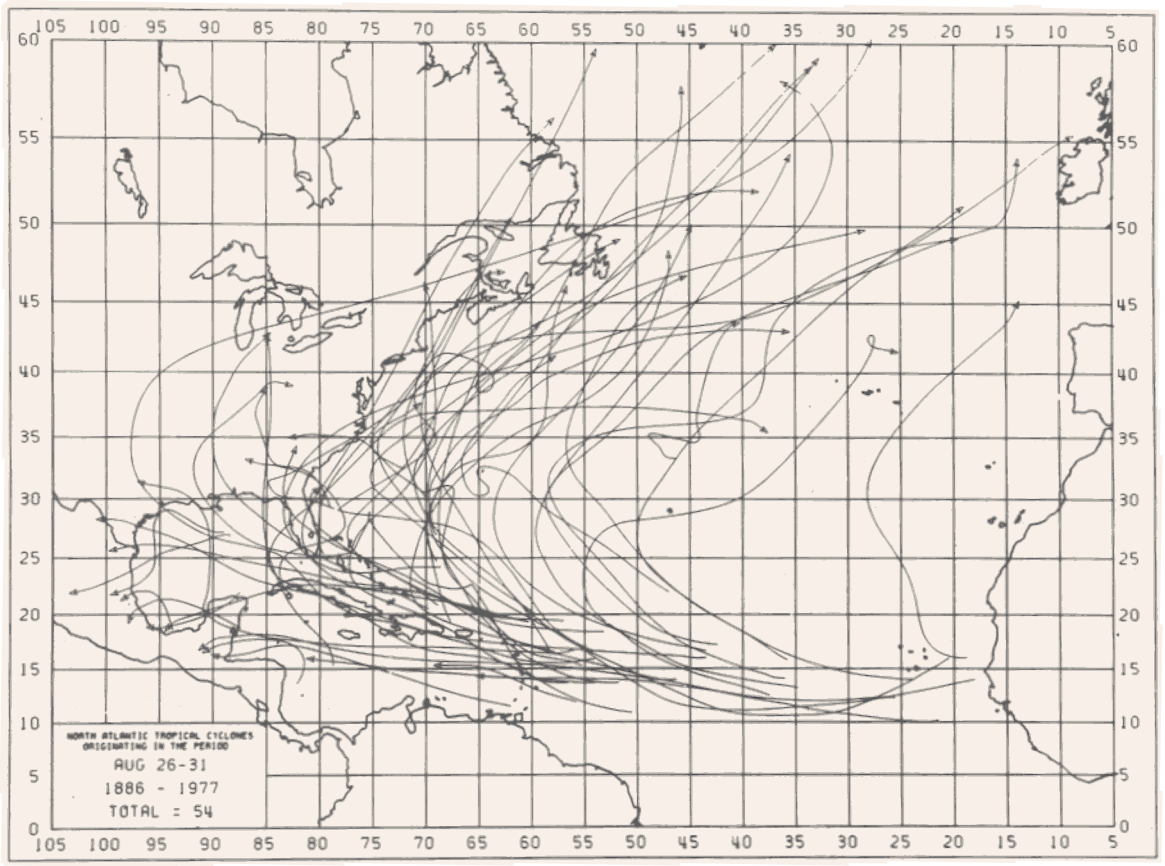

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG 01-05
1886 - 1977
TOTAL = 16

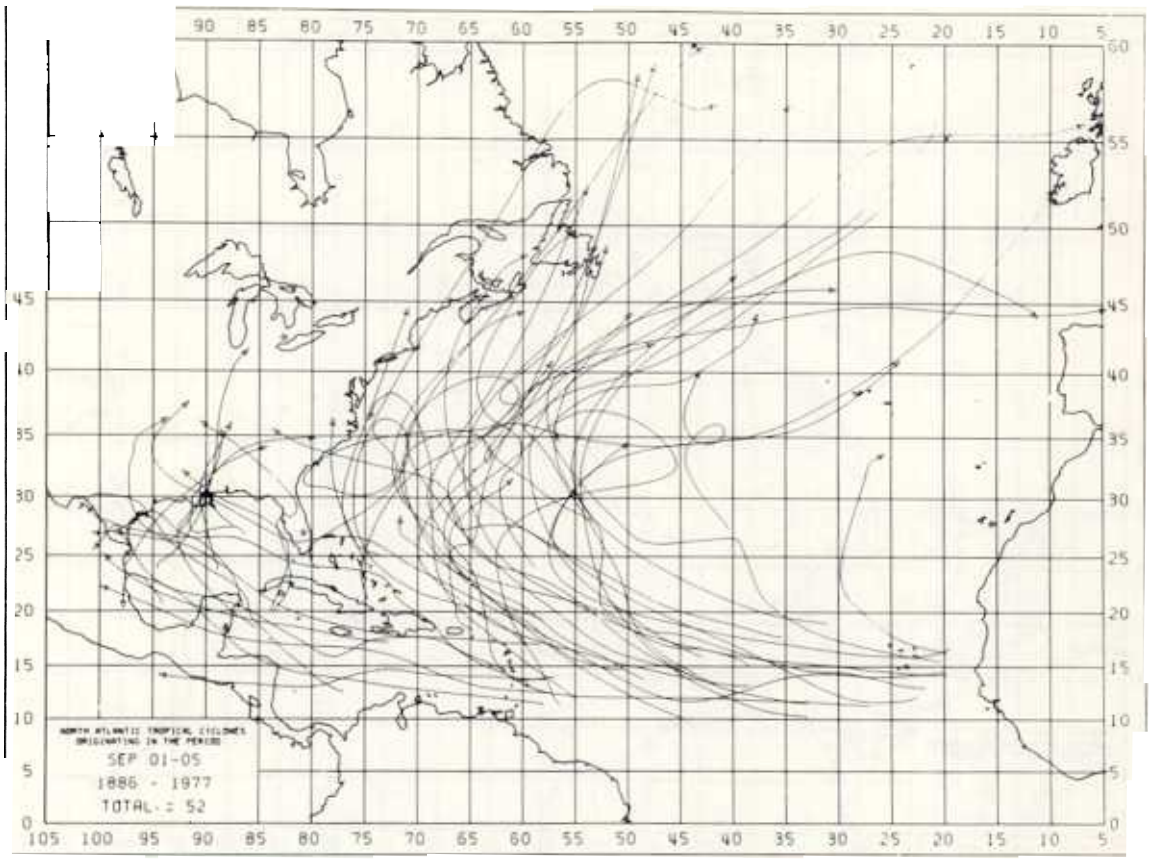

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG 06-10
1886 - 1977
TOTAL = 19

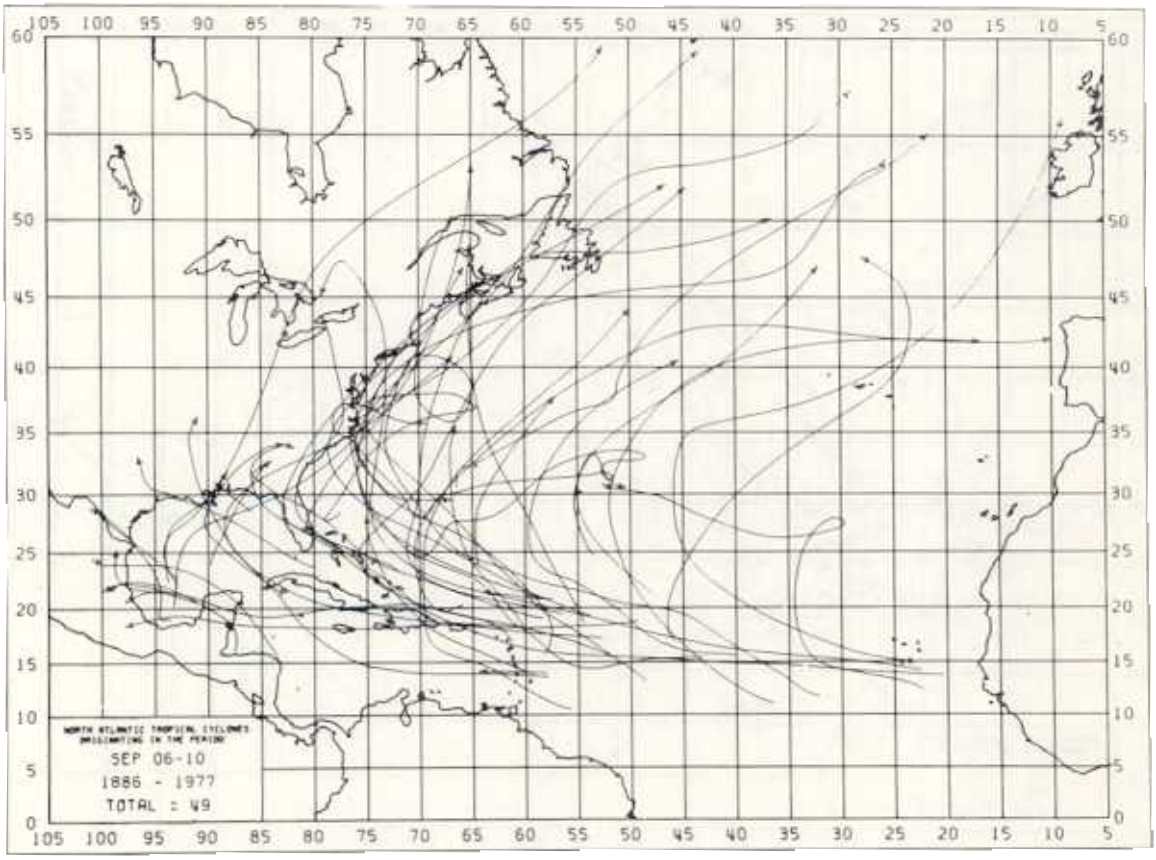

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG 11-15
1886 - 1977
TOTAL = 22

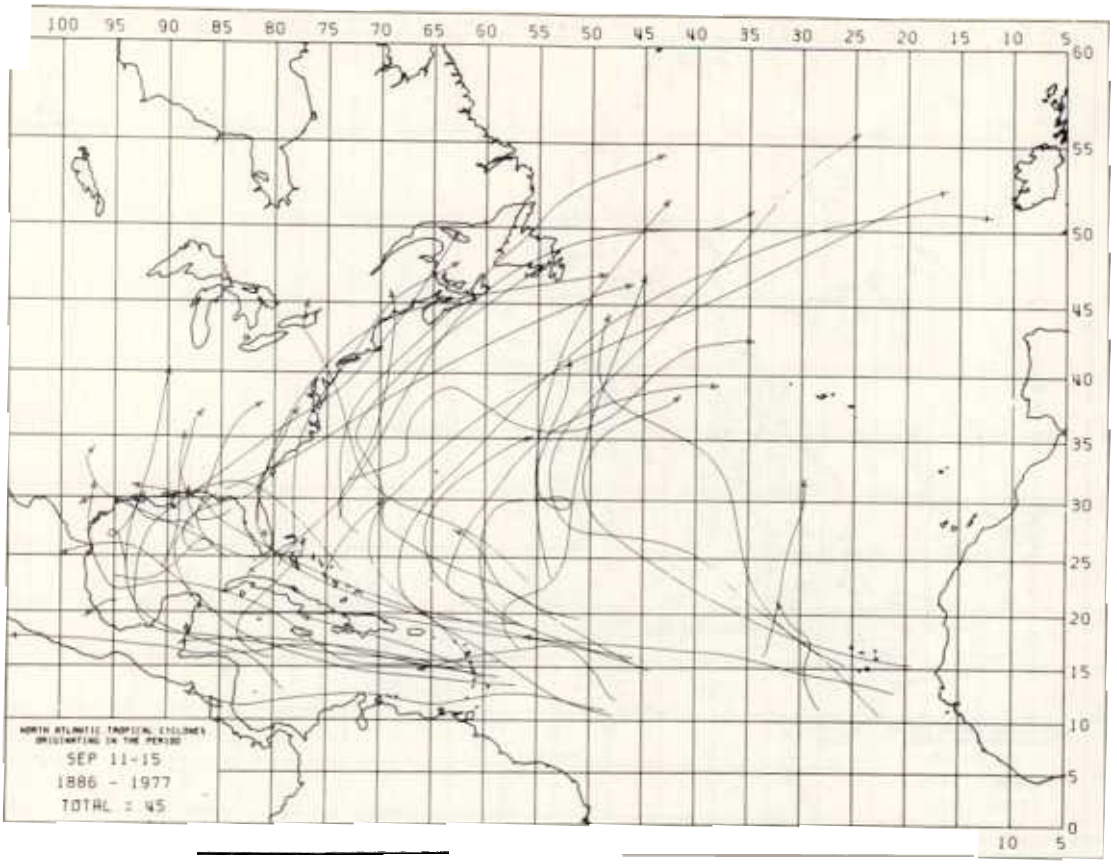

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG 16-20
1886 - 1977
TOTAL = 36

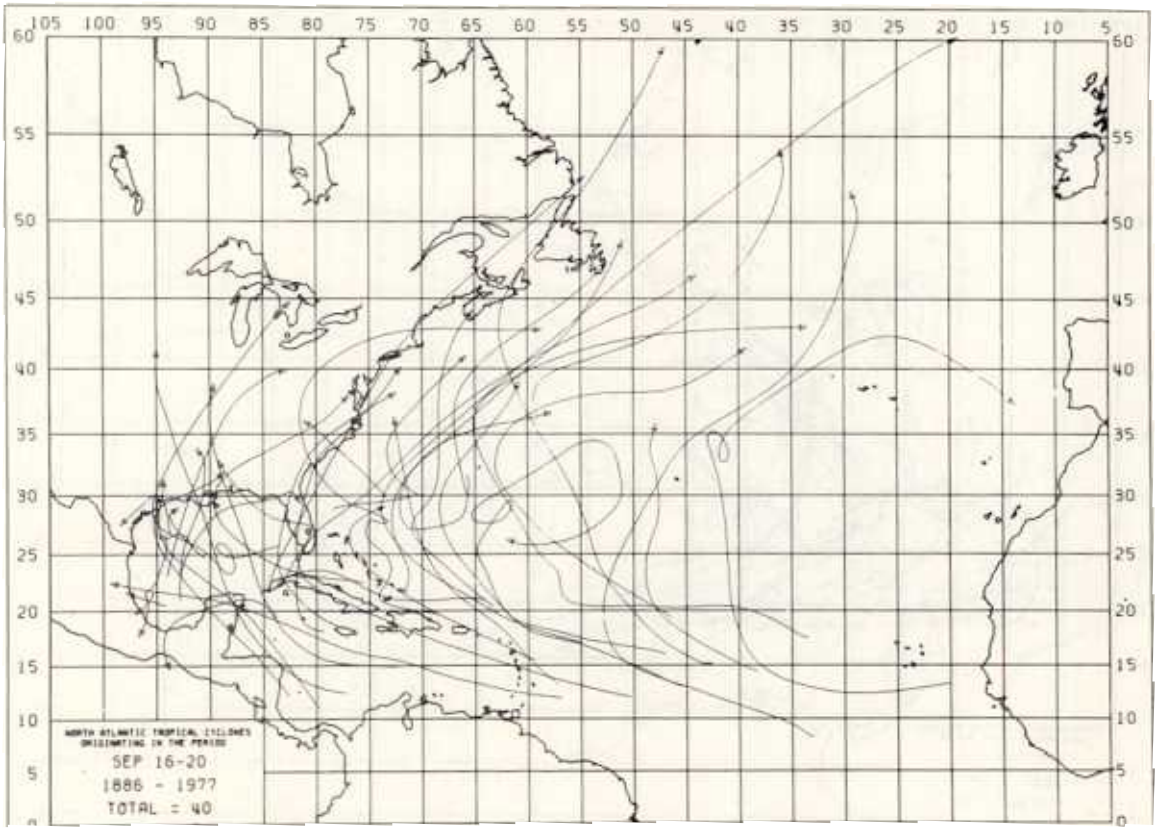

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG 21-25
1886 - 1977
TOTAL = 28

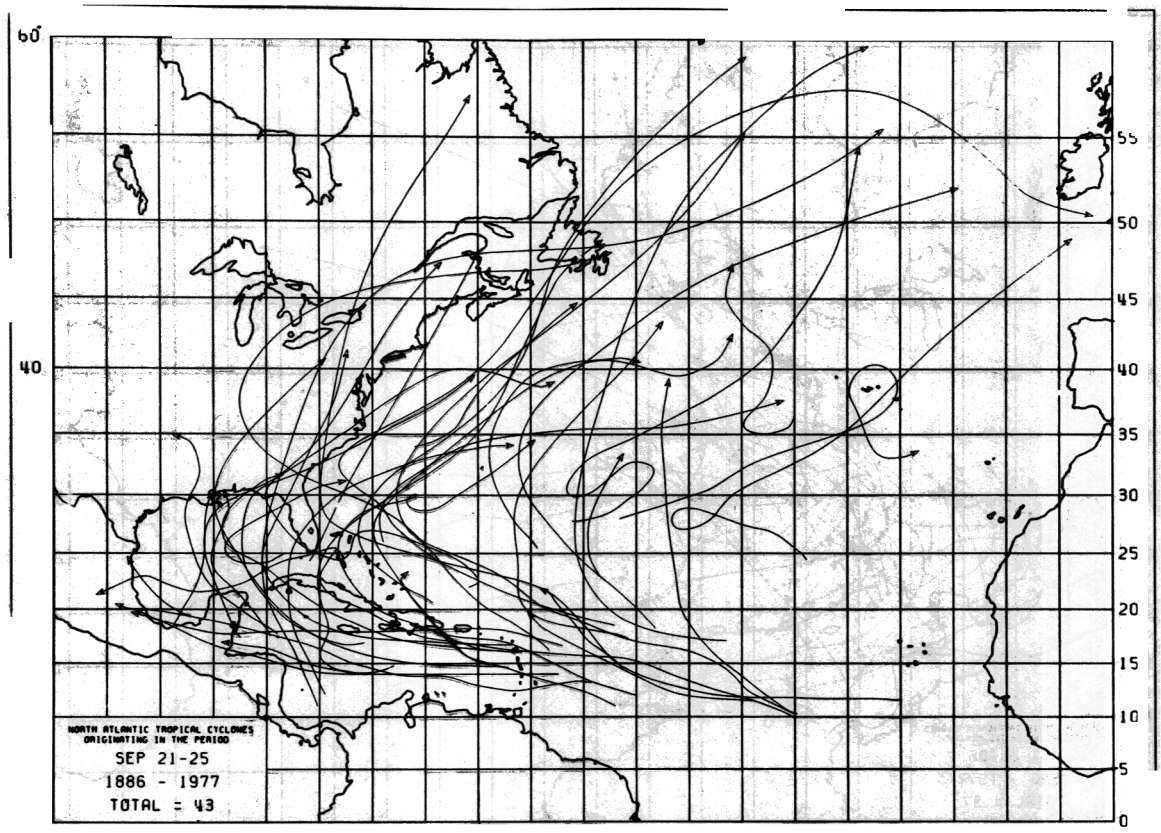

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
AUG 26-31
1886 - 1977
TOTAL = 54

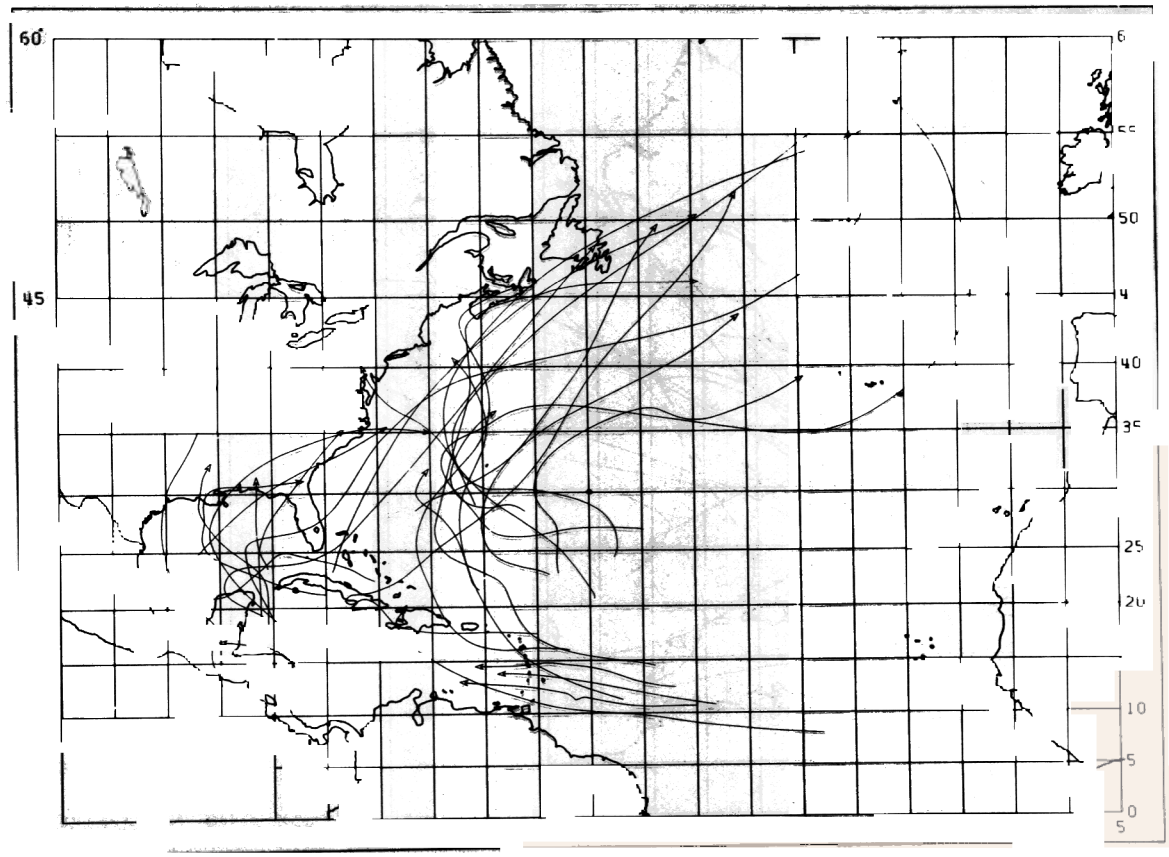

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
SEP 01-05
1886 - 1977
TOTAL : 52


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
SEP 06-10
1886 - 1977
TOTAL : 49


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
SEP 11-15
1886 - 1977
TOTAL = 45


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
SEP 16-20
1886 - 1977
TOTAL = 40


60
40
55
50
45
40
35
30
25
20
15
10
5
0
NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
SEP 21-25
1886 - 1977
TOTAL = 43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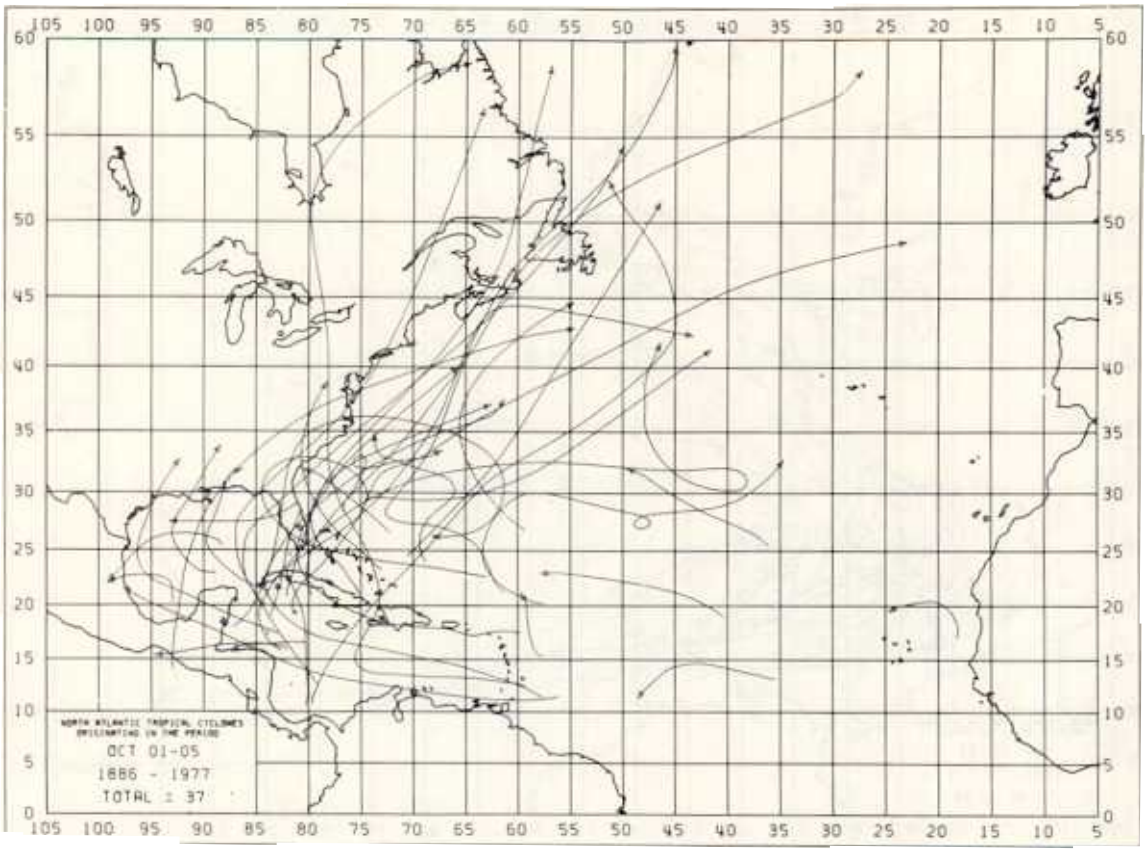
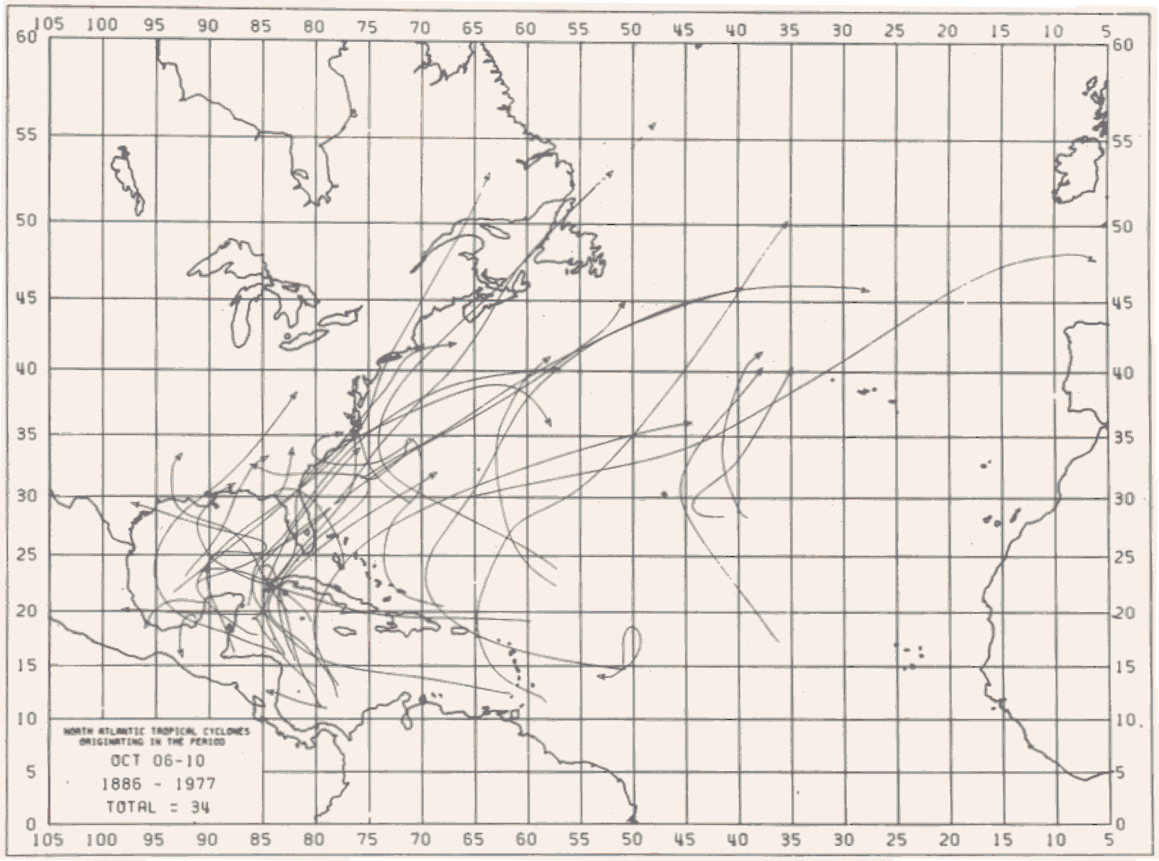
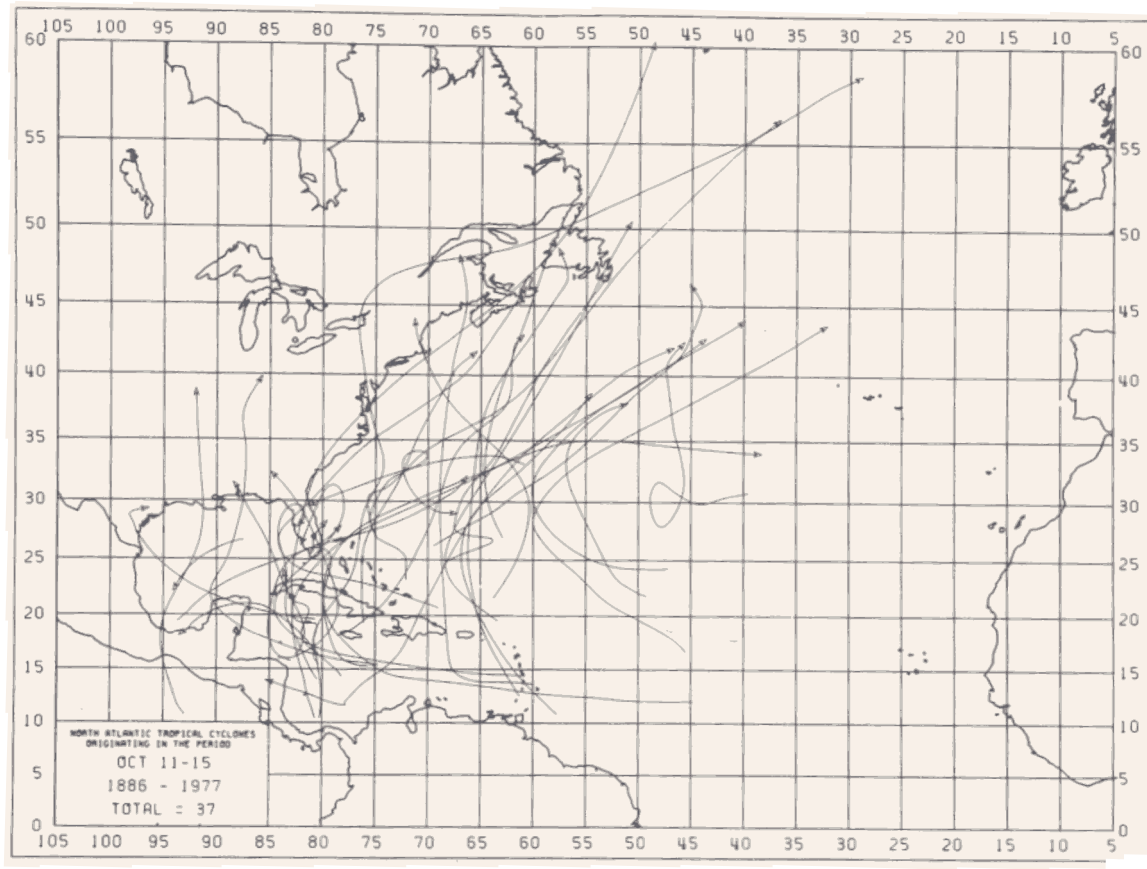
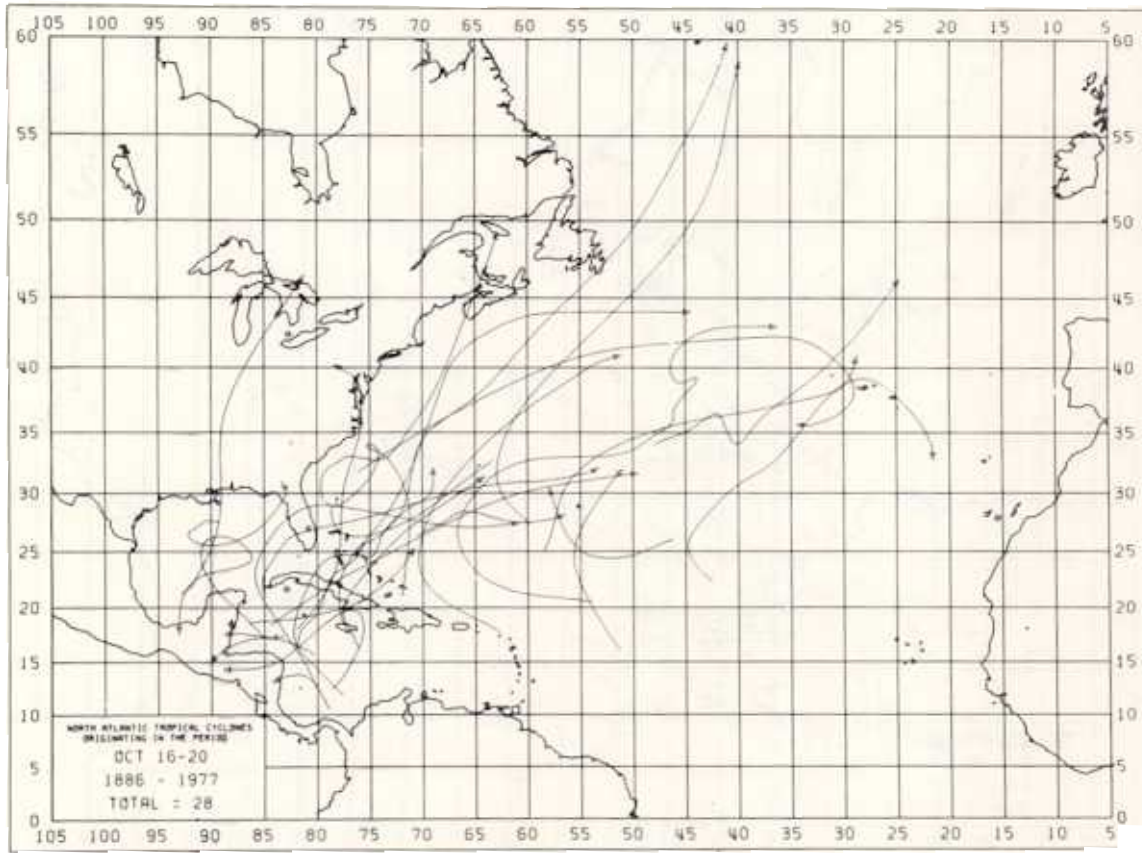
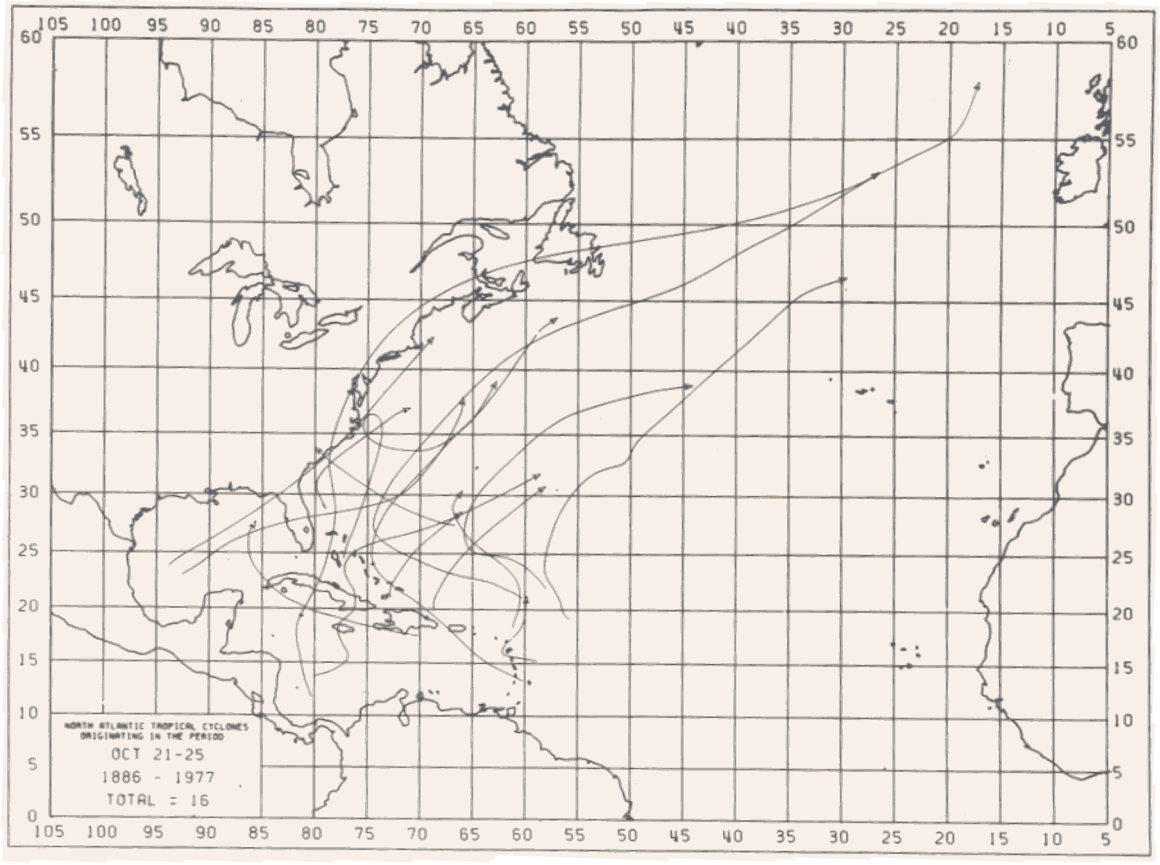
45
50
40
25
10
5
0

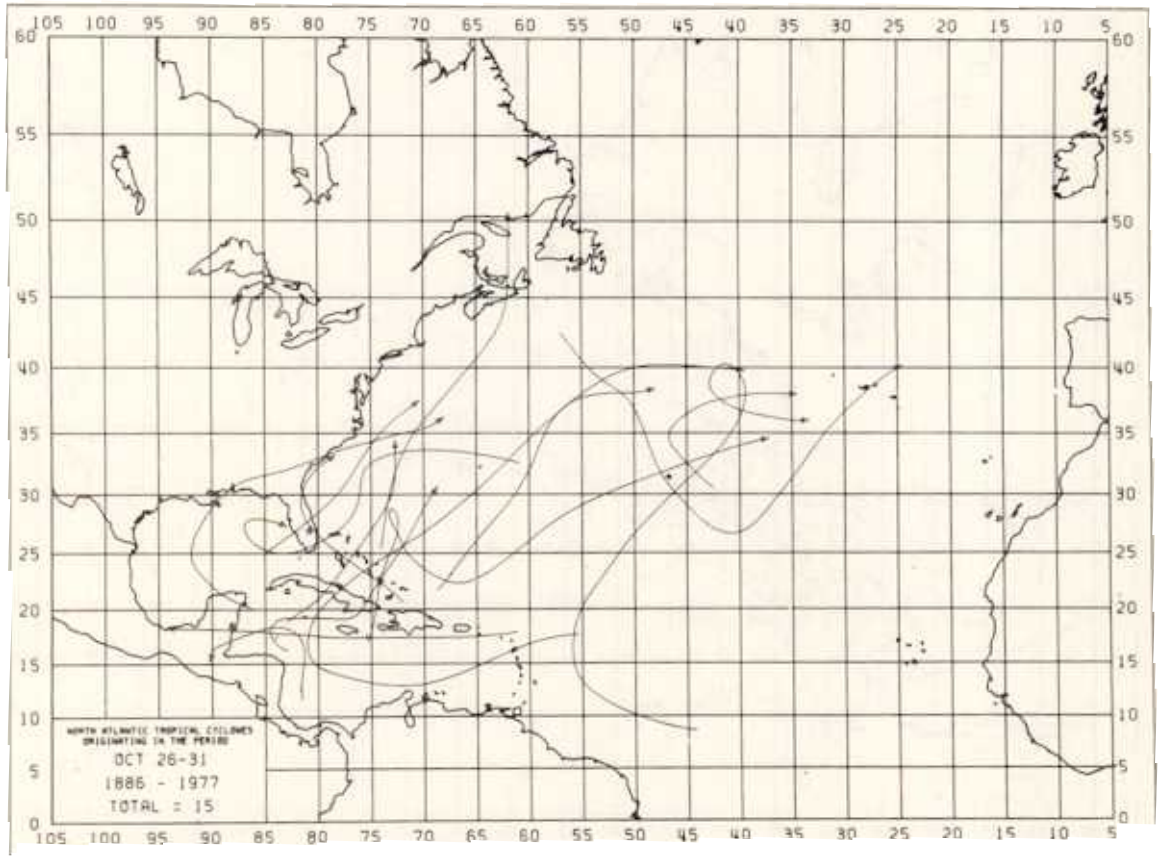

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
OCT 01-05
1886 - 1977
TOTAL = 37

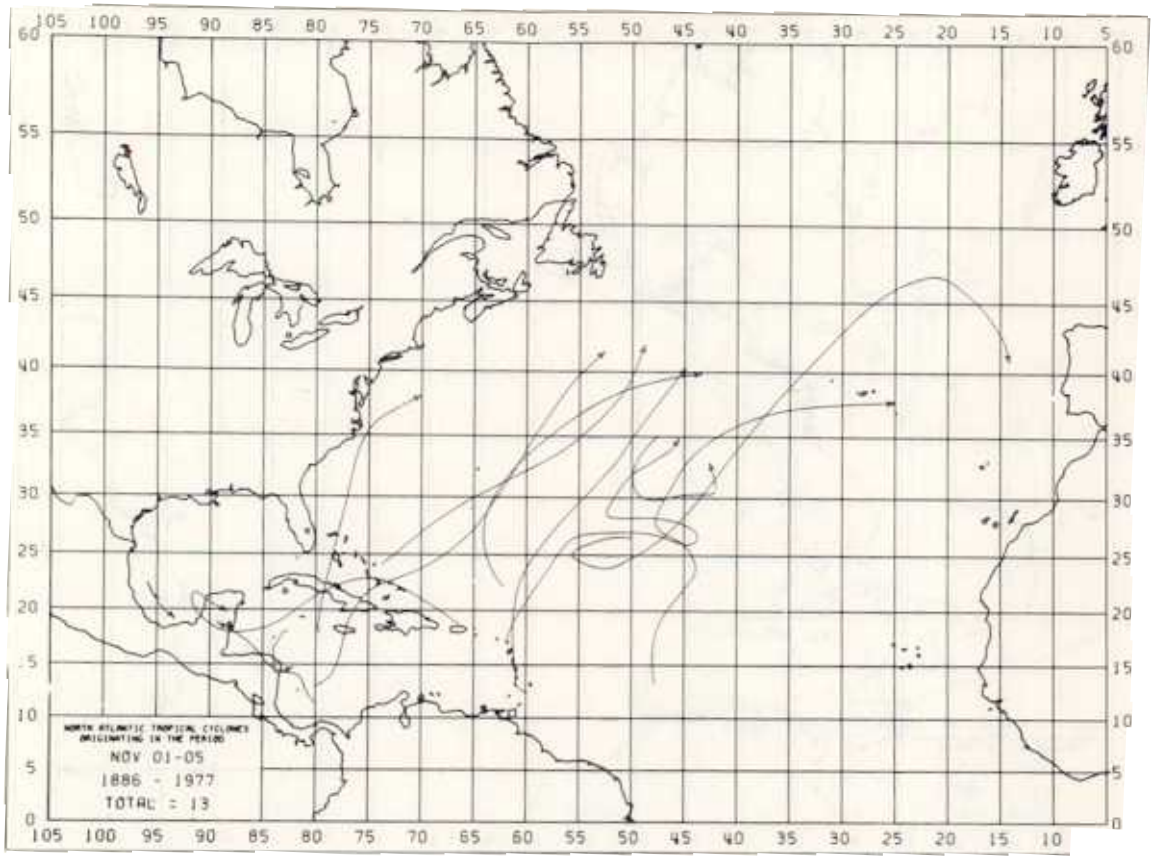

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
OCT 06-10
1886 - 1977
TOTAL = 34

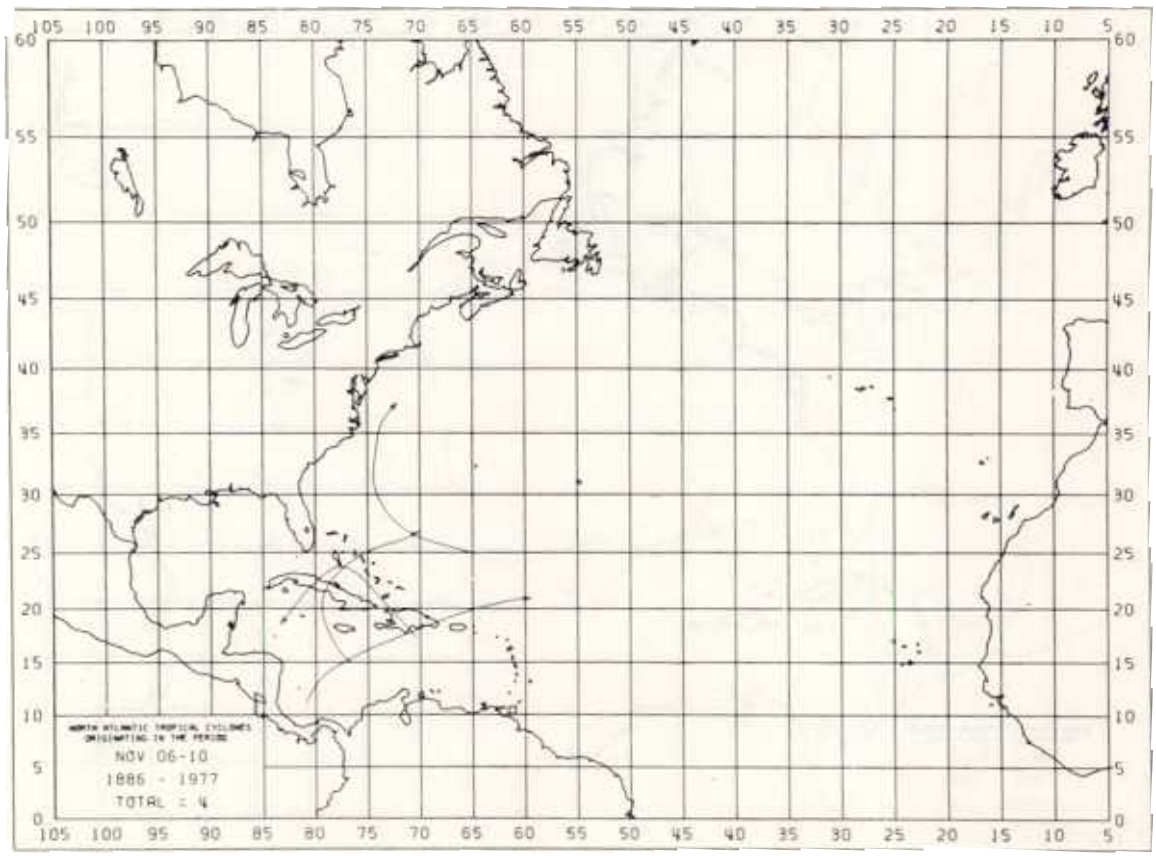

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
OCT 11-15
1886 - 1977
TOTAL = 37

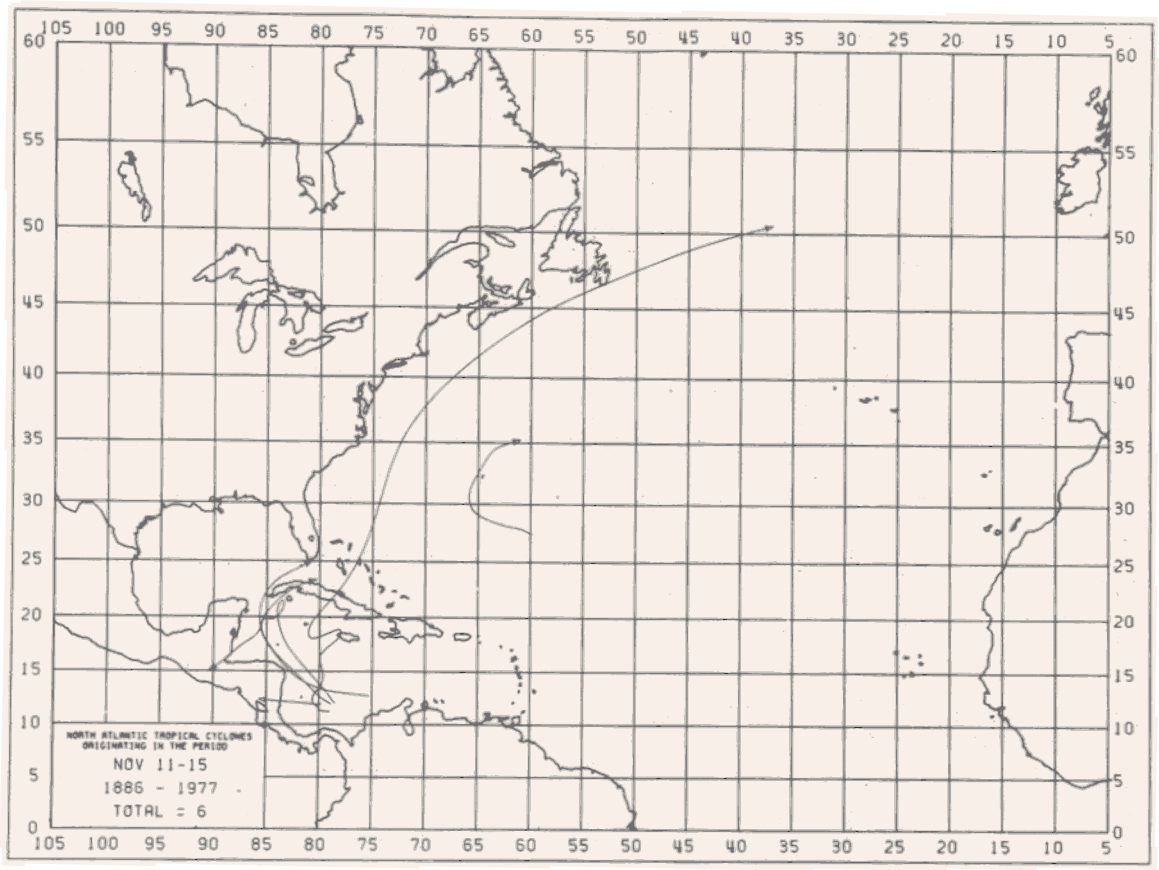

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
OCT 16-20
1886 - 1977
TOTAL = 28

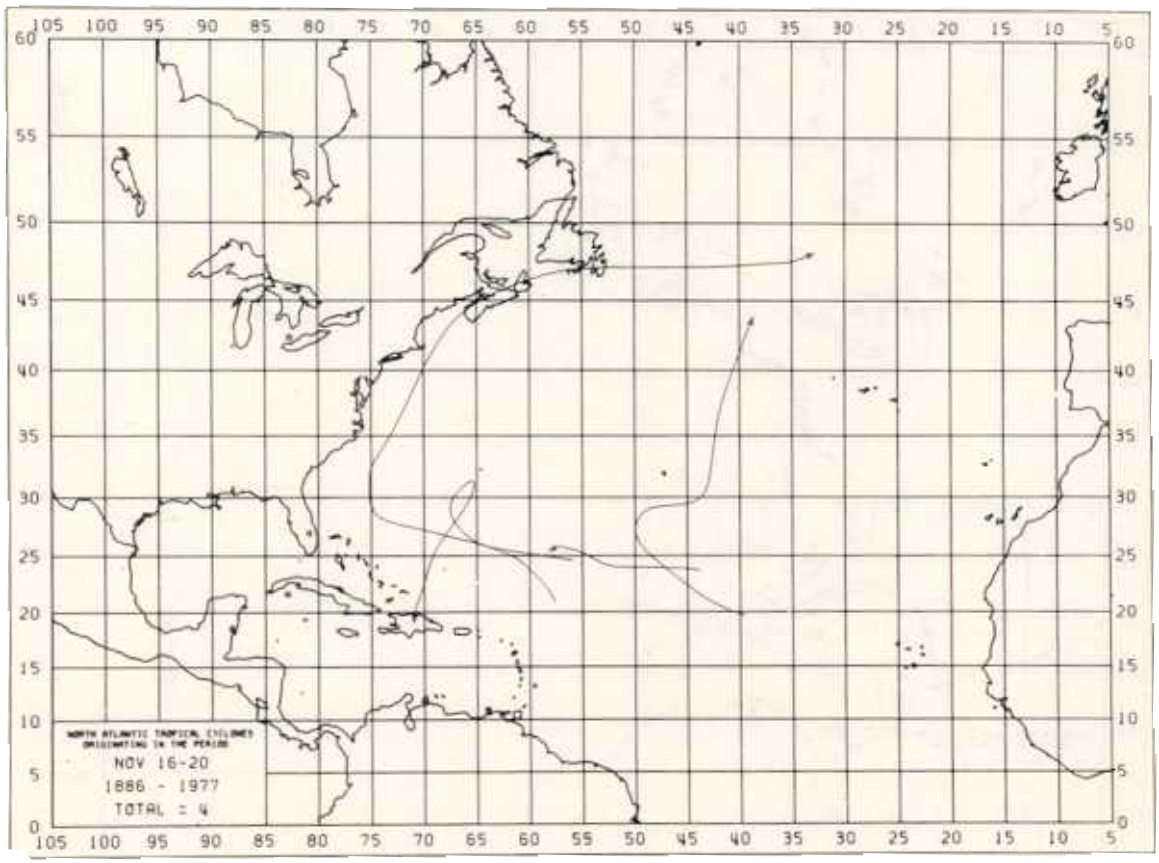

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
OCT 21-25
1886 - 1977
TOTAL = 16

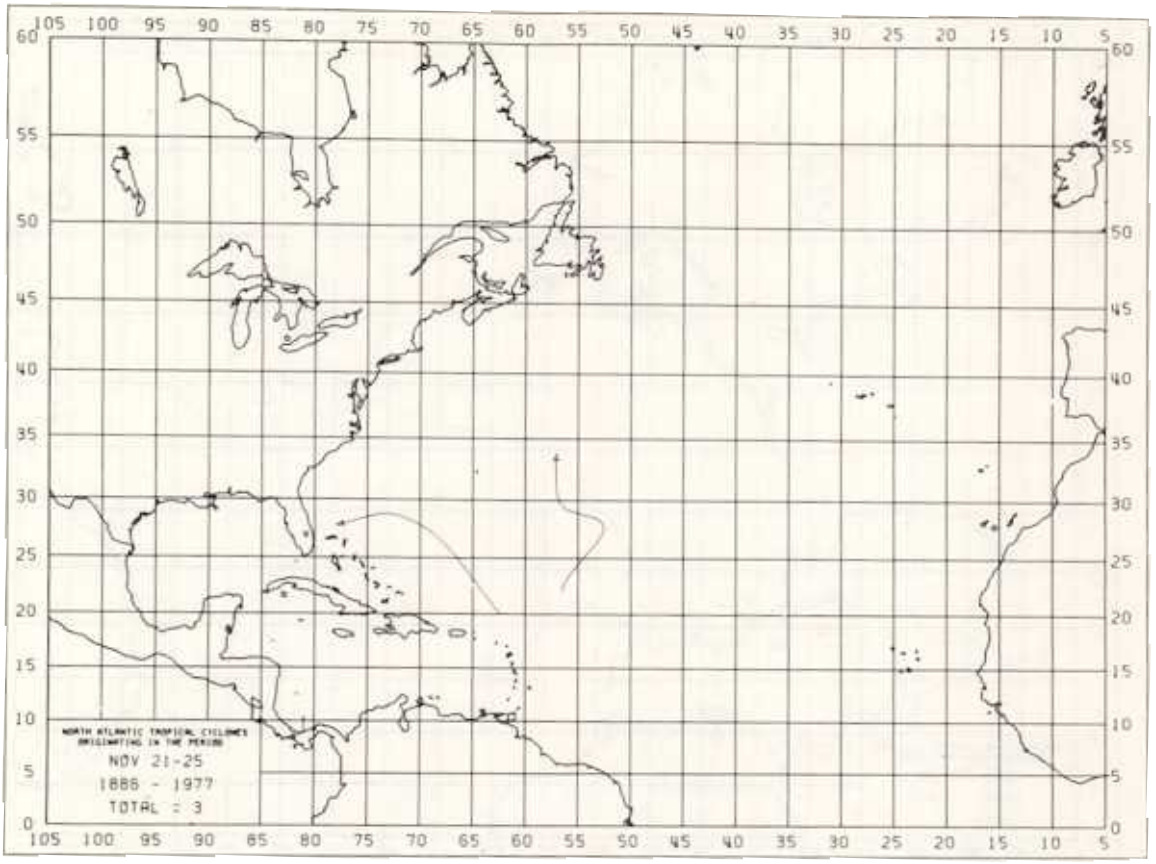

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
OCT 26-31
1886 - 1977
TOTAL = 15

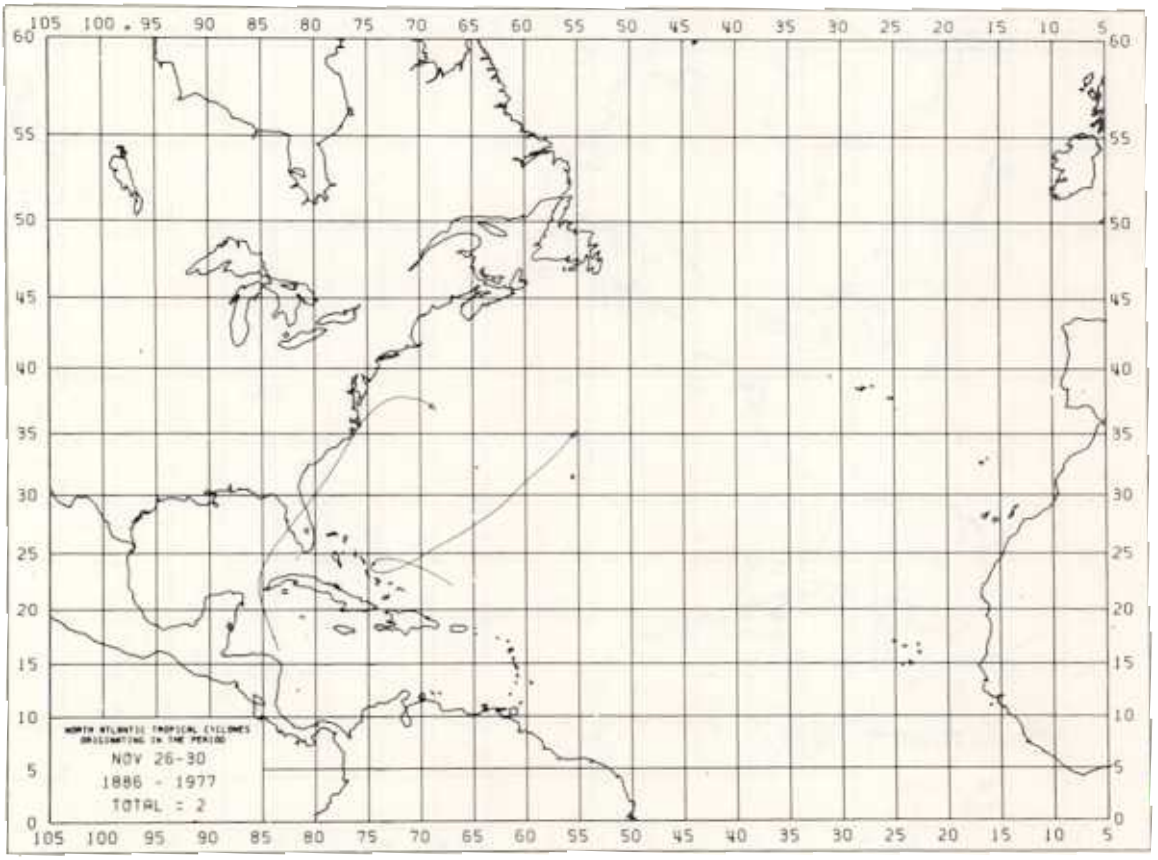

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
NOV 01-05
1886 - 1977
TOTAL : 13

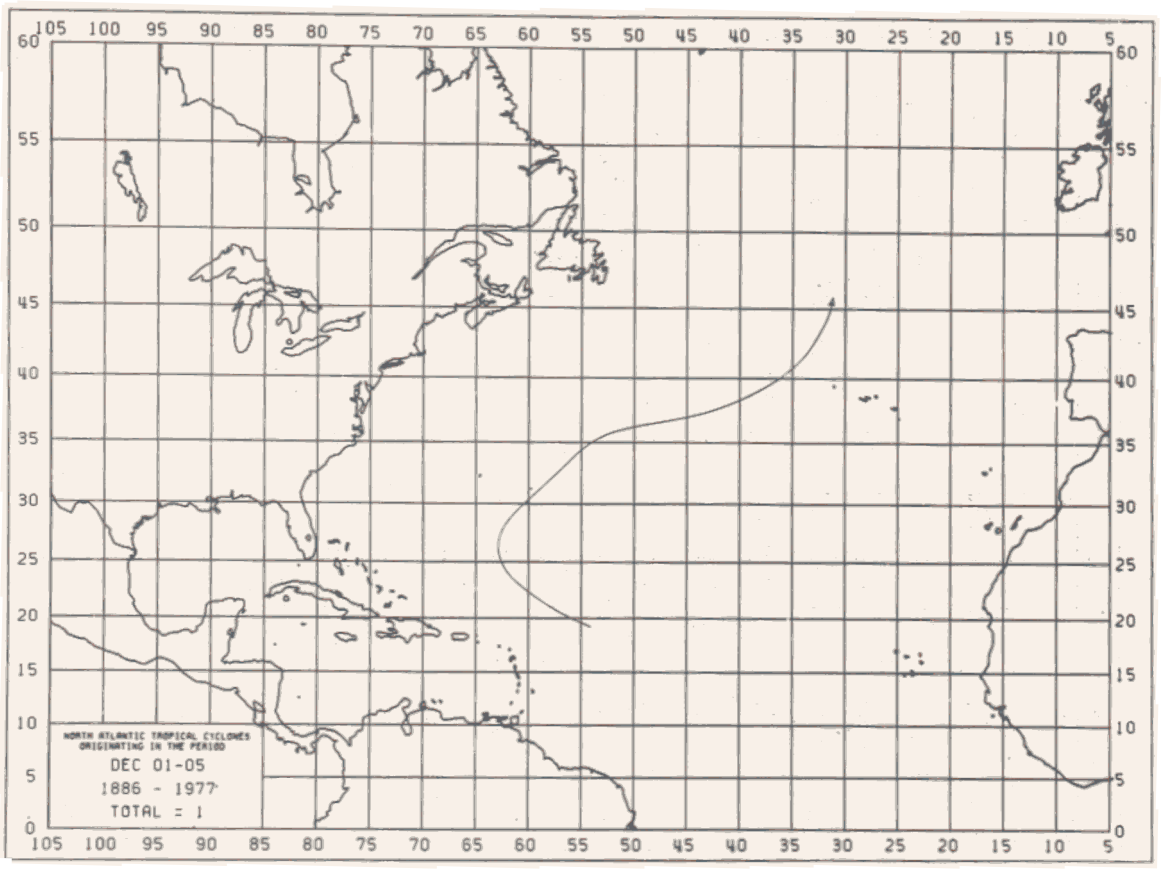

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
NOV 06-10
1886 - 1977
TOTAL : 4

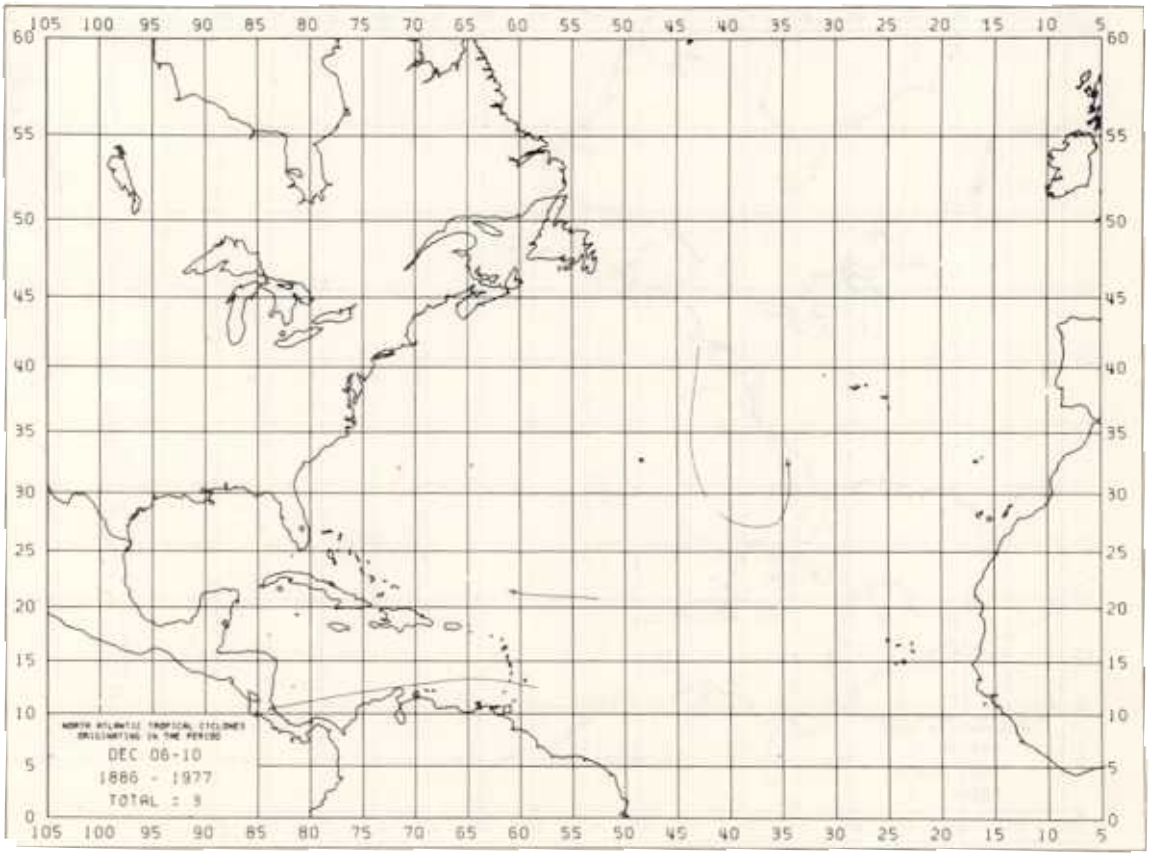

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
NOV 11-15
1886 - 1977
TOTAL = 6

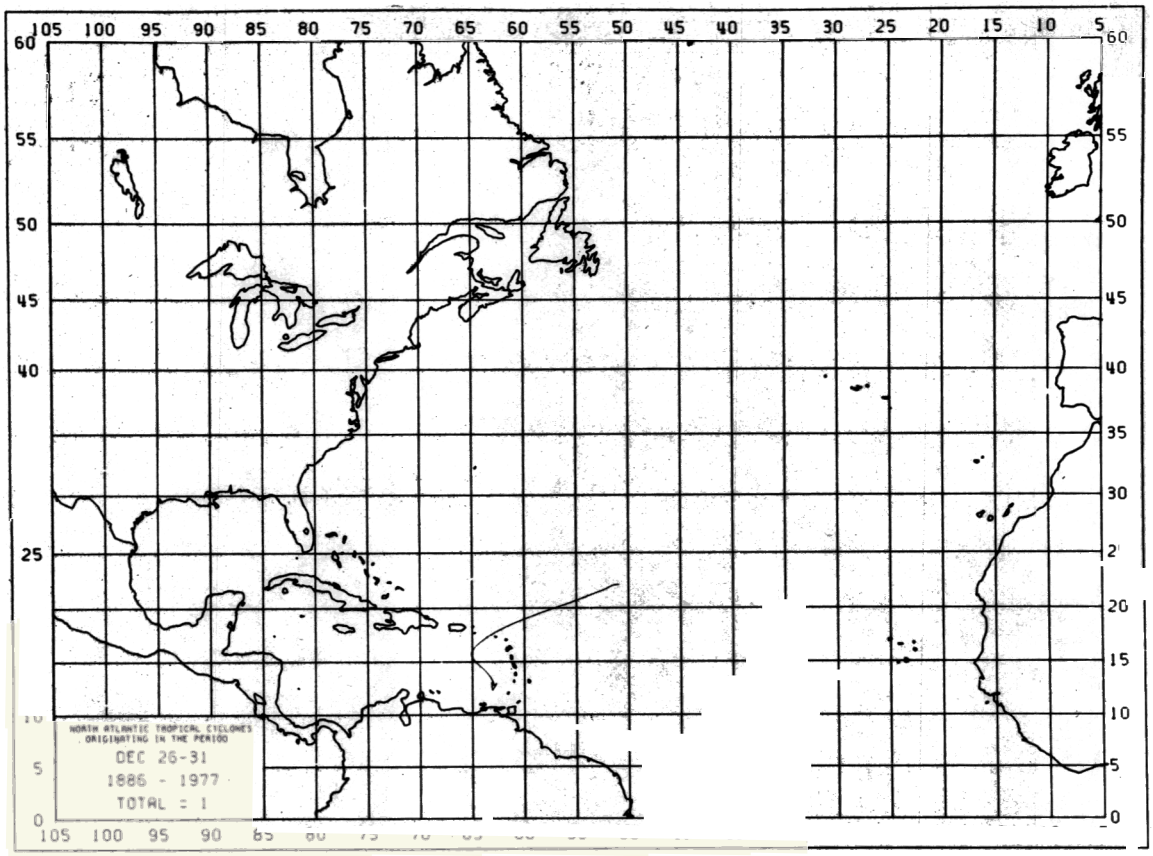

NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
NOV 16-20
1886 - 1977
TOTAL = 4


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
NOV 21-25
1886 - 1977
TOTAL = 3


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
NOV 26-30
1886 - 1977
TOTAL = 2


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
DEC 01-05
1886 - 1977
TOTAL = 1


DEC 06-10
1886 - 1977
TOTAL = 3


NORTH ATLANTIC TROPICAL CYCLONES
ORIGINATING IN THE PERIOD
DEC 26-31
1886 - 1977
TOTAL = 1