
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
U. S. Weather Bureau

Southern Region Technical Memorandum No. 25, September, 1966

ON THE USE OF DIGITIZED RADAR DATA FOR THE FLORIDA PENINSULA

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ABSTRACT

Radar echoes over the Florida peninsula have been recorded manually every three hours on a 7.5 by 7.5 mile grid during the past three summers. This note summarizes the echo distribution for the period May through August, 1963. The spatial and temporal variations of convective activity were found to be highly correlated with the sea breeze.

I. Introduction

The value of recording weather features observed on radar has been recognized by the Weather Bureau which has a radar-scope photography program. The researcher can often make good use of the film record. However, in many cases, the presence of echoes resulting from anomalous propagation, nearby ground clutter, or other non-meteorological targets makes it impossible to conclusively delineate precipitation patterns. Myers (1964) encountered this problem in his study of radar echoes of central Pennsylvania. On the other hand, the radar operator can analyze what is being seen and correctly interrupt the phenomena. This is done with respect to observation transmitted on teletype circuits. However, the concise description required for general use is not compatible with the quantitative detail needed for research.

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In consideration of these factors, the data collection routine with the Miami WSR-57 radar was expanded to provide for digital recording of echoes on a grid overlay during the summers of 1960 and 1961. Preliminary studies demonstrated the potential usefulness of the project and, beginning in 1962, it was extended to include observations from Tampa and Daytona Beach, providing coverage of the entire Florida peninsula and nearby waters. Data collected during the summer of 1963 have been processed. This note illustrates some of the results.

2. Objectives

The design of the project was based on the belief that the greatest practical application would be in revealing mesoscale patterns of shower activity. It was expected that temporal and spatial variations in convective activity could be correlated with such factors as the prevailing winds. Gentry and Moore (1954) found this to be true in a study for a small area near Miami using data from recording rain gauges. Radar provides a means of multiplying the number of observations and extending the field of view over both ocean and isolated interior areas.

It was felt that an examination of meso-scale features could be done most effectively in the absence of the masking influence of active weather producing systems of a synoptic scale. The project was therefore limited to the months May through August on the assumption neither frontal nor tropical systems would present serious interference during this period. This conclusion is partially justified in figure 1 which shows the diurnal cycle of the mean monthly divergence values calculated from surface winds at Tampa, Daytona Beach and Miami. The Bellamy triangle method (1949) was used to compute divergence. Obviously, local diurnal influences are dominant during this period. The maximum inflow is seen to occur at mid-day; divergence reaches its highest value during the night. This is slightly at variance with results of the Thunderstorm Project (1949) in which the low-level convergence maximum was found at 4 PM. However, their conclusion was based on 6-hourly wind reports in contrast to the 3-hourly observations of the present study.

3. Procedures in Recording the Data

The areal coverage at each radar site was dictated by the desire to avoid a) failure to detect smaller cells which would not reach the level of the radar beam at greater distances, and b) loss of resolution due to beam width at longer ranges. The optimum range setting was chosen as 100 nautical miles. Figure 2 shows the grid used and the coverage obtained by the three radar stations. The grid interval is 7.5 nautical miles. At three-hourly intervals, the observers indicated by a check mark those grid squares showing precipitation echoes. Surface and 5,000 ft. winds were also recorded for possible use as predictors. The data were subsequently transferred to punch cards.

It has been assumed that precipitation was falling from all echoes observed. Considering the geographical location and season of the year, this is probably valid. Braham (1964) reported that 80 percent of the convective echoes observed in Southern Missouri produced measurable rain.

4. Analysis of the Data

Since an important control of convective activity over Florida is the sea breeze, it is logical to relate the radar data with this influence. The distance which the sea breeze penetrates inland and the associated vertical motion patterns are functions of the prevailing broad scale winds. Estoque (1962) illustrated this in a numerical model of the sea breeze. A preliminary study by Moore (1963), on a very limited sample, indicated fair agreement between radar-observed shower patterns and those implied by Estoque's calculations of the vertical motion. To test the hypothesis more completely, an approach similar to the one used by these two authors was employed.

Each day was placed into one of five regimes based on the 1200Z 5,000 ft. winds. The 5,000 ft. wind is assumed to represent the large scale flow pattern. The five categories are defined in figure 3. The sector divisions are arbitrary and differ slightly for each station. The desire to obtain the best distribution of days within each regime dictated the critical wind speed of 6 kts. Table 1 shows the number of days in each regime for the three stations.

In the first analysis the stations were treated separately. The diurnal cycle of shower activity was examined for the various regimes by computing echo frequency maps for the 8 observation times (1,4,7, etc.). This gives 120 charts; i.e., three stations with 8 observations per day for 5 regimes. The complete file for each station is attached in the Appendix. A few of the more interesting features will be illustrated with selected maps for Miami.

The onset of the sea breeze develops a perturbation on the basic current which moves with the prevailing winds. This can be seen by comparing figures 4, 5 and 6 which show the 1000, 1300 and 1600 maps for the three regimes; onshore flow, offshore flow and the light and variable case. By 1000 the line of echoes which is apparently associated with the sea breeze has reached 15 miles inland. The line is most prominent on the windward coast. As the day procedes, the windward echo line (also referred to as the primary line in this paper) moves with the basic current and a secondary line forms on the opposite coast. This is best illustrated on the westerly regime chart for 1300, figure 5(b). By late afternoon, figures 4(c) and 5(c), the primary and secondary lines merge on the leeward coast. When the winds are light, the showers are equally prevalent on both coasts and show little movement during the day, figure 6.

The limited data sample and other factors complicate the sea breeze pattern on the individual charts; therefore, a smoothing technique was used to highlight this feature. If the sea breeze is the dominate effect as assumed, echo bands should parallel the coast; therefore, smoothing can extend over a longer distance along rather than perpendicular to the coast. Thus, the north/south medians of echo frequency were obtained for the five number rows shown in figures 4 through 6. These were subjected to a three grid east/west running mean computation. Figures 7 through 9 illustrate the diurnal cycle of the resulting smooth curves. To ease comparision, the 1600 frequency curves were extracted from figures 7 through 9 and combined in figure 10. The points mentioned above are much better verified on these diagrams. For example, at 1600, figure 10, note the maximum frequencies on the leeward coasts with a double maximum indicated for the light wind regime. The progression of the windward shower axis along the basic current at a speed of 11 kts. can be seen in figures 7 and 8. The secondary maximum which develops on the leeward coast near mid-day should be noted.

The data from Daytona Beach and Tampa showed similar, but less marked patterns. The reason for this is unknown but is undoubtly related to terrain influences. The southern peninsula is flat with extensive ridges. Highest ground is below 50 ft. From Lake Okeechobee northward low rolling hills of 100 to 300 ft. dominate and orographic effects are probably more pronounced.

Early morning coastal showers are also well related to the prevailing winds. Figure 11 shows the 7 AM smoothed frequency curves for the onshore and offshore regimes. The same smoothing technique was employed as described above. The east coast frequencies as well as location of the maximum axis with easterly flow are more pronounced and closer to the coast than with west winds. A similar pattern is also seen on the west coast; however the frequencies are lower. It must be remembered we are viewing frequencies and not echo intensity. Morning showers tend to be weak and limited in vertical extent. The chances of being observed by radar are much better at closer ranges. The higher frequencies on the east coast are probably due to this effect.

5. Climatology

The simplest and most obvious use of the data collected is for determining seasonal averages or establishing a "climatology" of radar patterns. The project has not been underway long enough to ascertain the stability of the patterns but the 1963 seasonal distribution of echoes is of considerable interest.

Figure 12 shows the diurnal cycle of radar echoes over the Florida peninsula from 7 AM to 10 PM for the summer season of 1963 (May-August). The nighttime maps for 1 AM and 4 AM are so similar to the 7 AM chart that they are not shown. Isolines of echo frequency have been drawn for 5 percent intervals starting with the 10 percent line. The limit of the radar coverage for each station is included on the diagrams.

The dominate role played by solar heating is readily apparent as the radar echoes undergo a rhythmic diurnal cycle. Over land, frequencies are highest in the late afternoon and lowest at night. As a matter of fact, frequencies over the peninsula from 2200-0700 are generally less than 10 percent with large areas where there were no echoes recorded at all. This lends support to the assumption made earlier that synoptic systems were at a minimum during this period.

Over the coastal waters, the reverse is true. Showers are more frequent at night. The 7 AM chart shows the primary activity off the northwest and southeast coasts. This is undoubtly related to the prevailing wind. Table 1 shows that the easterly regime prevailed nearly half of the time in Miami. At Daytona and Tampa, westerly or light winds were more common. In the previous section it was shown that early morning coastal showers are more prevalent with onshore rather than offshore flow.

The spread or development of showers during the day generally follow the patterns shown for Miami. Over the southern half of the peninsula, the influence of prevailing easterlies is evident with late afternoon activity favoring the leeward (west) coast. North of Lake Okeechobee, the distribution is similar to some combination of the westerly and light wind catagories with the later regime being dominate. This is indicated by a tendency for a double maximum during the afternoon, one just west of Daytona Beach and the other inland from the west coast.

It is interesting to note the minimum of echoes over Lake Okeechobee particularily during the daytime. This feature has been observed by pilots for years and more recently the absence of clouds has also been seen on satellite pictures. Undoubtly this is caused by a weak lake breeze.

6. Conclusions

The primary purpose of this paper is not to present tested results; but rather, to encourage interest in a routine radar data collection program. Ultimately, automatic digital recorders will serve this purpose. Atlas (1963) and Kessler and Russo (1963) discuss two approaches to this problem. Best estimates indicate it may be several years before such a program can be fully implemented. In the meantime, useful information can be recorded by hand. For many purposes, such as climatology, a number of years of data are required to give meaningful results. Each year that passes without observations prolongs the time when these objectives will be fulfilled. The time to begin collecting data is now!

The computer is producing excellent forecasts of the large scale flow patterns and the future looks even brighter. However, there remains a large gap between this product and the local weather distribution. Statical studies based on radar data such as illustrated in this paper offer a partial solution to this problem. One can visualize a time when the general flow parameters obtained in numerical forecasts will be used in conjuction with local radar studies to obtain both the areal and temporal distribution of precipitation.

The present study was handicapped by a limited data sample. This restricted the number of stratification categories. Data collected in 1964 is being processed and will soon be combined with the 1963 data. During the summer of 1965, the observing net was expanded to include Apalachicola, Florida and Charleston, South Carolina. It is planned to continue the data collection during the summer of 1966.

Acknowledgement: The authors are indebted to Dr. R. C. Gentry, Director of the National Hurricane Research Laboratory for providing the computer time necessary to make these calculations. We are also deeply appreciative of all the radar observers at Tampa, Daytona and Miami who faithfully recorded the observations that made this study possible.

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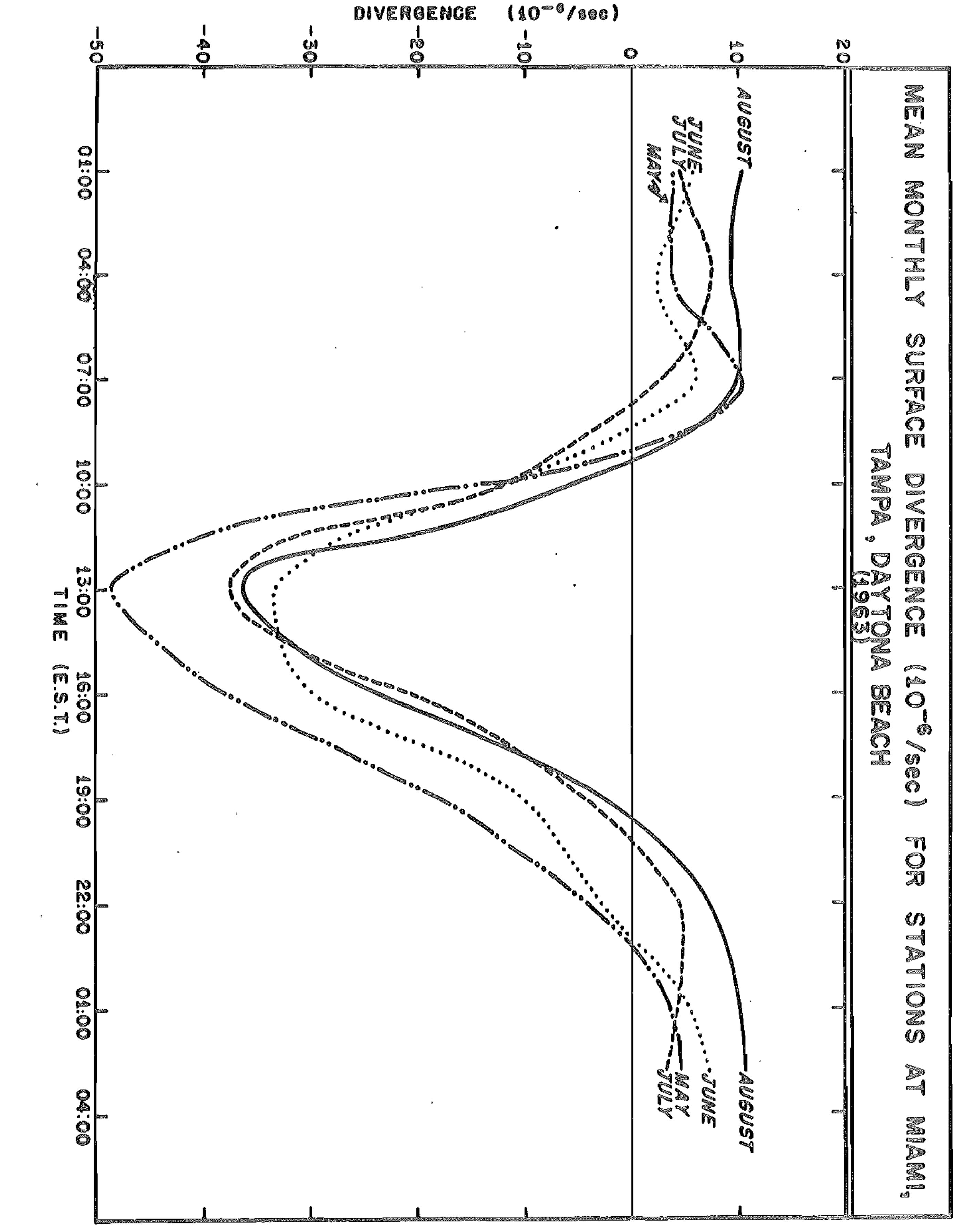
Table 1. Number of days in each Regime during the period May-August 1963.

	Miami	Tampa	Daytona
Regime 1. (NLY winds 6 kts.)	8	3	6
Regime 2. (ELY winds 6 kts.)	52	25	21
Regime 3. (SLY winds 6 kts.)	8	21	18
Regime 4. (WLY winds 6 kts.)	16	39	39
Regime 5. (LGT winds)	31	32	31

Only days with Radar data were considered.



MEAN MONTHLY SURFACE DIVERGENCE (10^{-6}/sec) FOR STATIONS AT MIAMI, TAMPA, DAYTONA BEACH
(1963)
DIVERGENCE (10^{-6}/sec)
20
10
0
-10
-20
-30
-40
-50
AUGUST
JUNE
JULY
MAY
01:00
04:00
07:00
10:00
13:00
16:00
19:00
22:00
01:00
04:00
TIME (E.S.T.)

Figure 1.

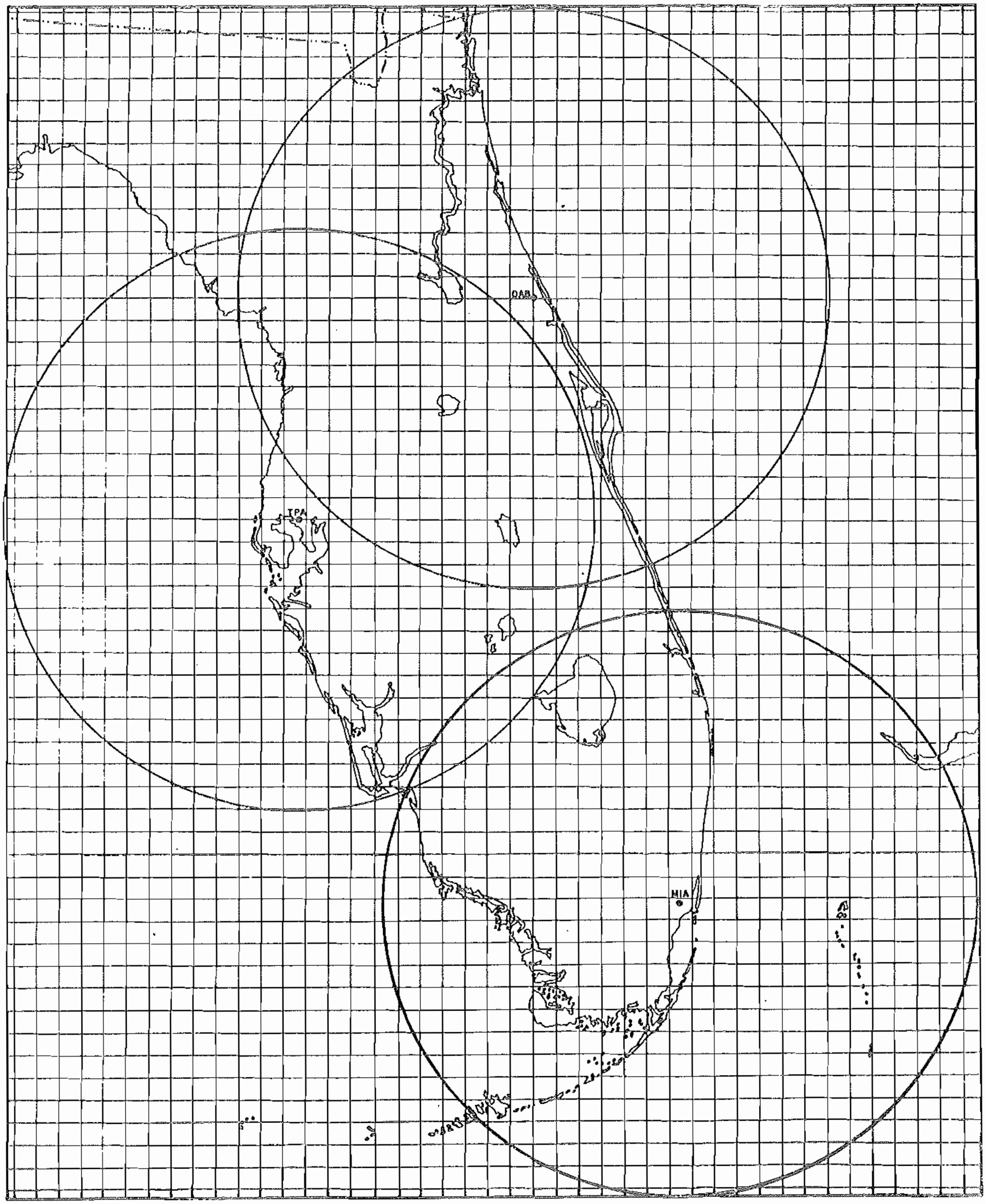


Figure 2. The area covered by the three radar stations which participated in this study when the radar set was placed on a 100 mile range. The 7.5 by 7.5 mile grid has been superimposed on this figure.

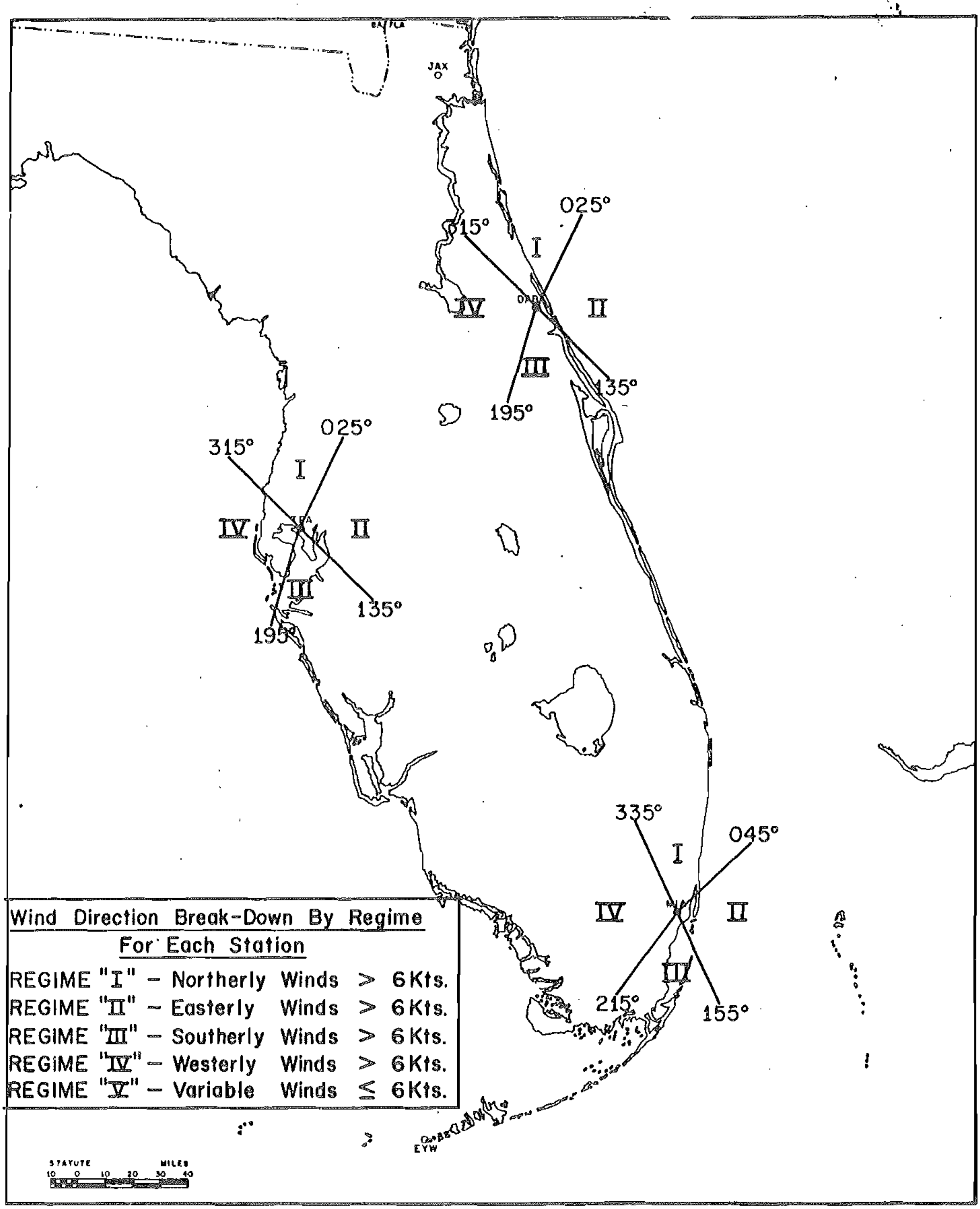

JAX
025°
315°
I
II
III
IV
195°
135°
025°
315°
I
II
III
IV
195°
135°
335°
045°
I
II
III
IV
215°
155°
EYW
Wind Direction Break-Down By Regime
For Each Station
REGIME "I" – Northerly Winds > 6 Kts.
REGIME "II" – Easterly Winds > 6 Kts.
REGIME "III" – Southerly Winds > 6 Kts.
REGIME "IV" – Westerly Winds > 6 Kts.
REGIME "V" – Variable Winds ≤ 6 Kts.
STATUTE MILES
10 0 10 20 30 40

Figure 3.

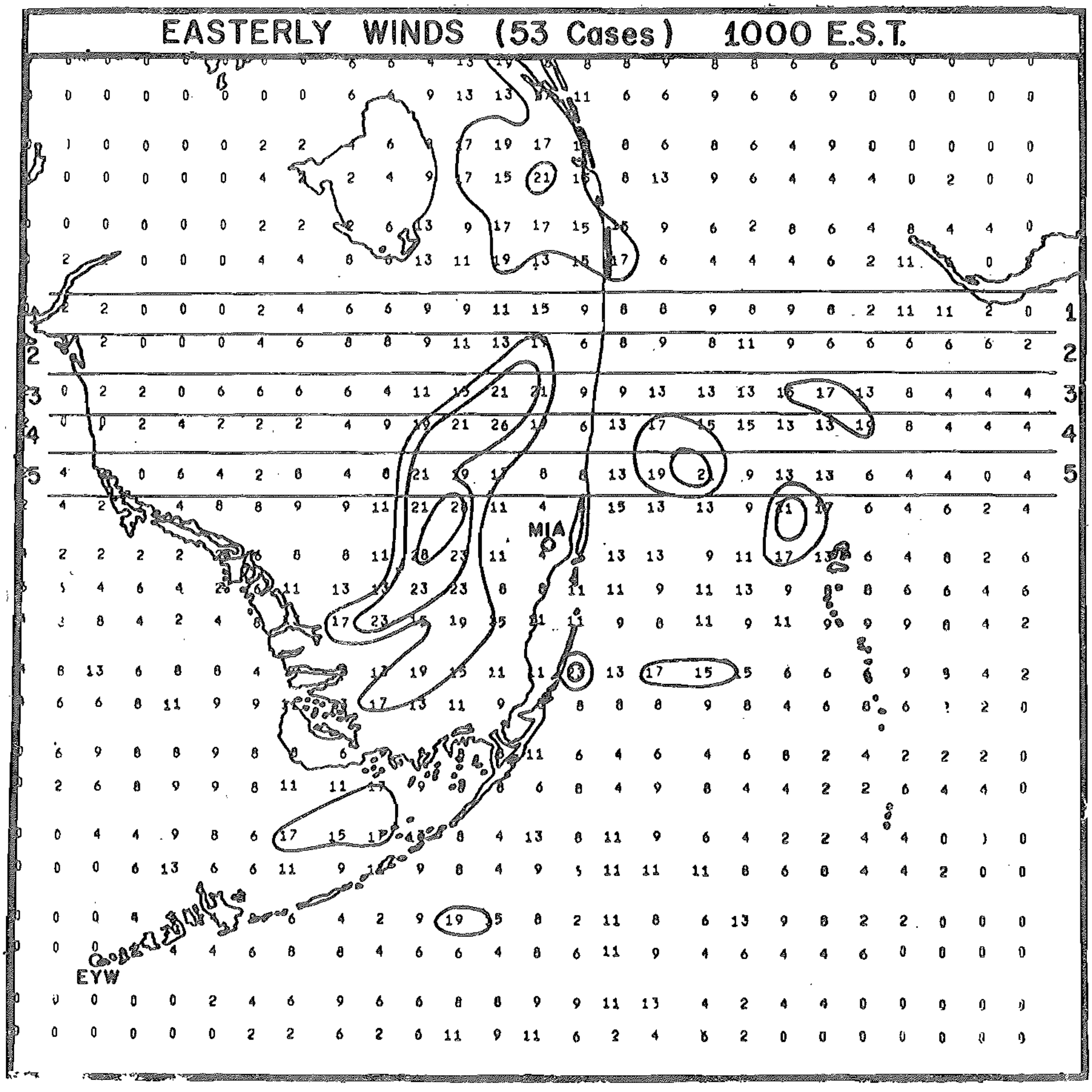


Figure 4(a). The radar echo frequency (expressed in %) maps for the easterly regime at Miami for 1000 E. S. T. Isolines of frequency are drawn in 5 percent intervals beginning with the 15 percent line.

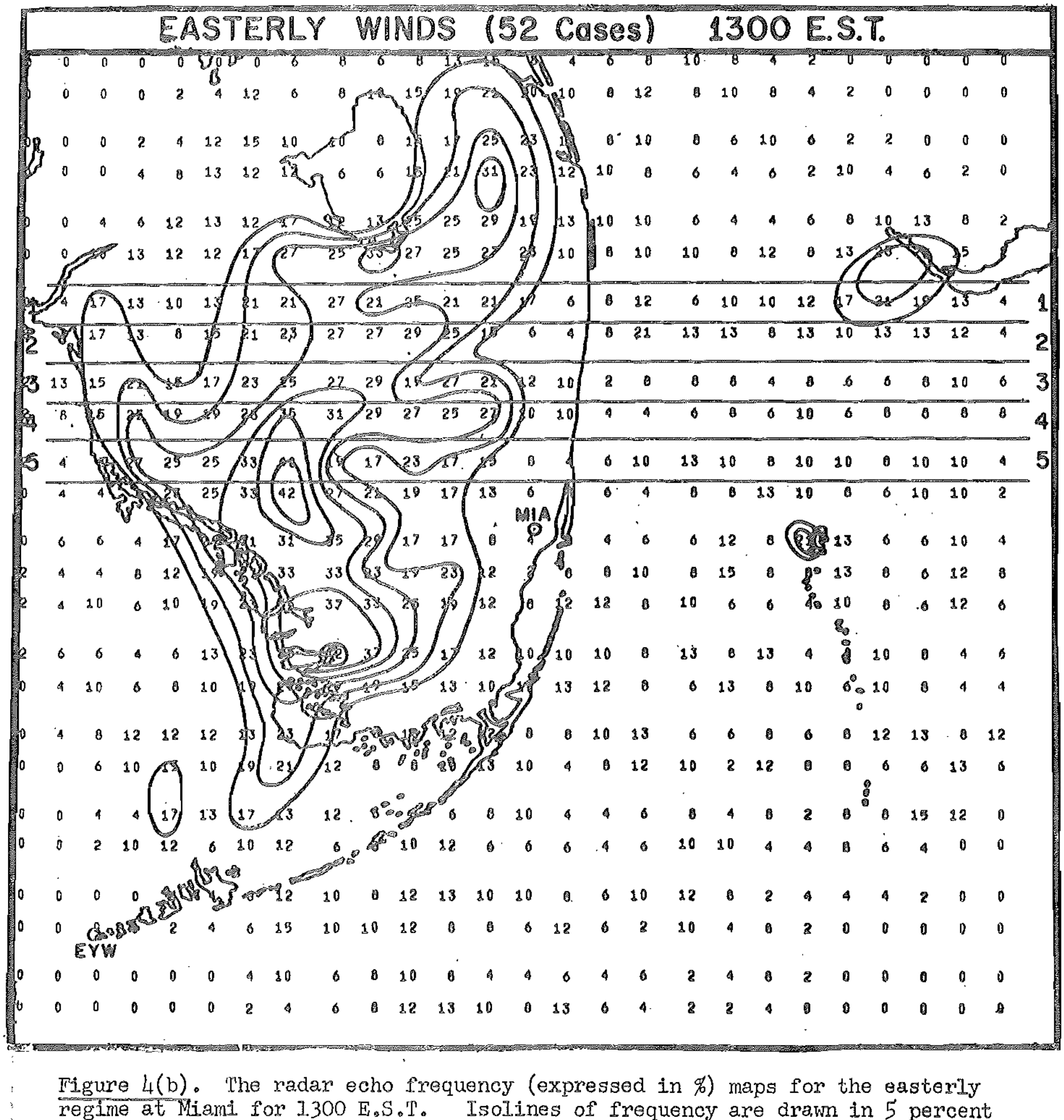


Figure 4(b). The radar echo frequency (expressed in %) maps for the easterly regime at Miami for 1300 E.S.T. Isolines of frequency are drawn in 5 percent intervals beginning with the 15 percent line.

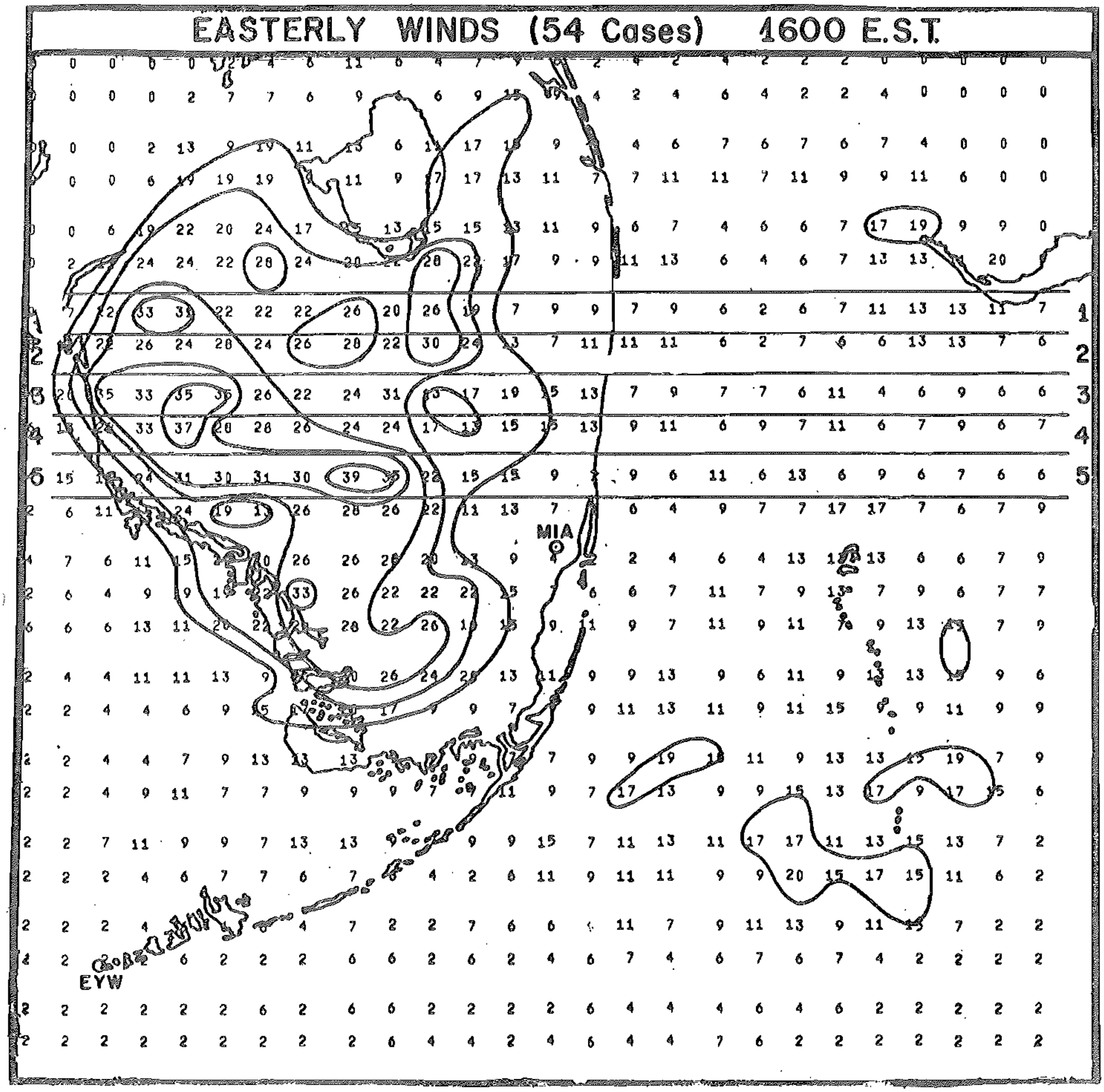


Figure 4(c). The radar echo frequency (expressed in %) maps for the easterly regime at Miami for 1600 E.S.T. Isolines of frequency are drawn in 5 percent intervals beginning with the 15 percent line.

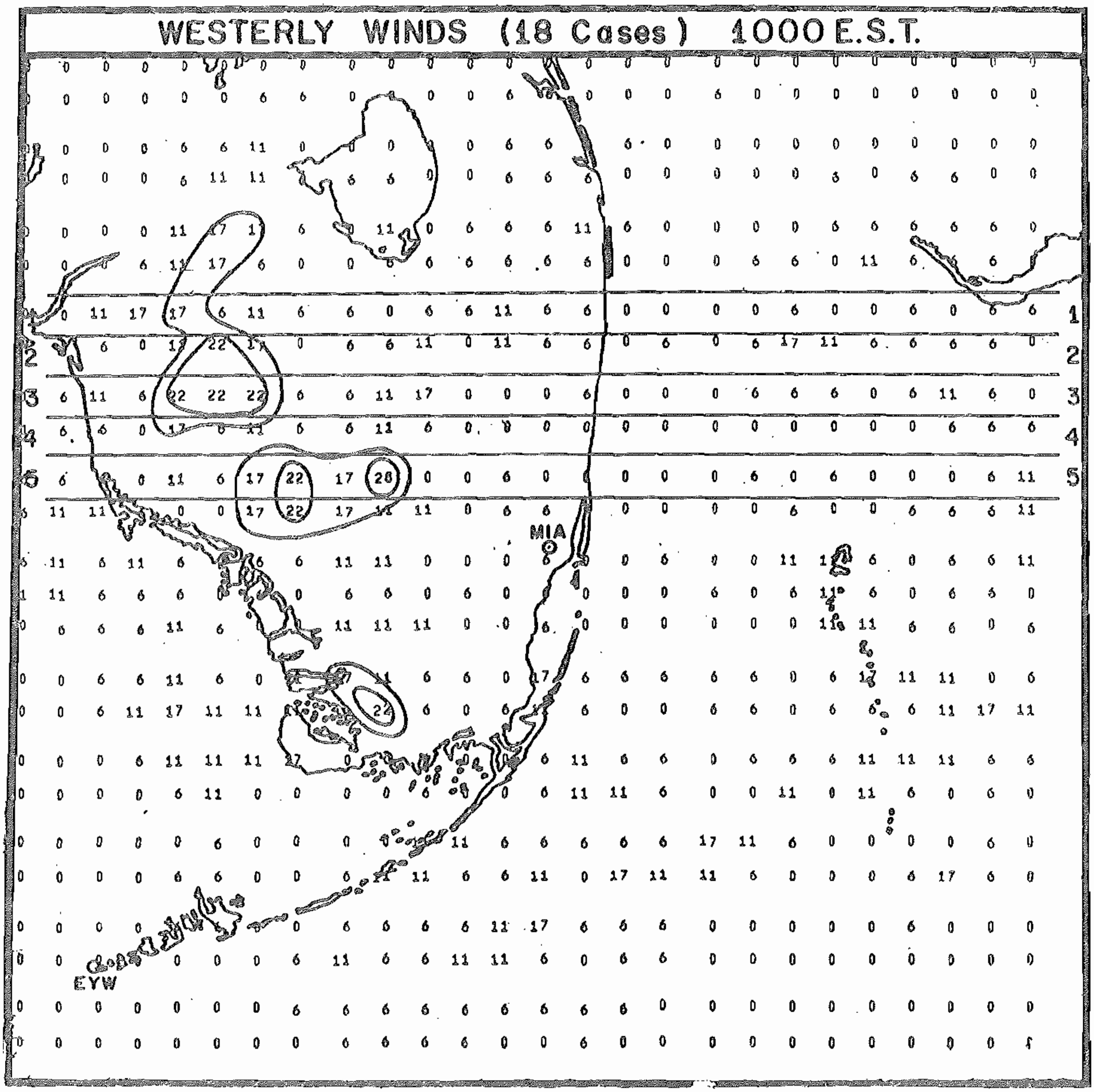


Figure 5(a). The radar echo frequency (expressed in %) maps for the westerly regime at Miami for 1000 E.S.T. Isolines of frequency are drawn in 5 percent intervals beginning with the 15 percent line.

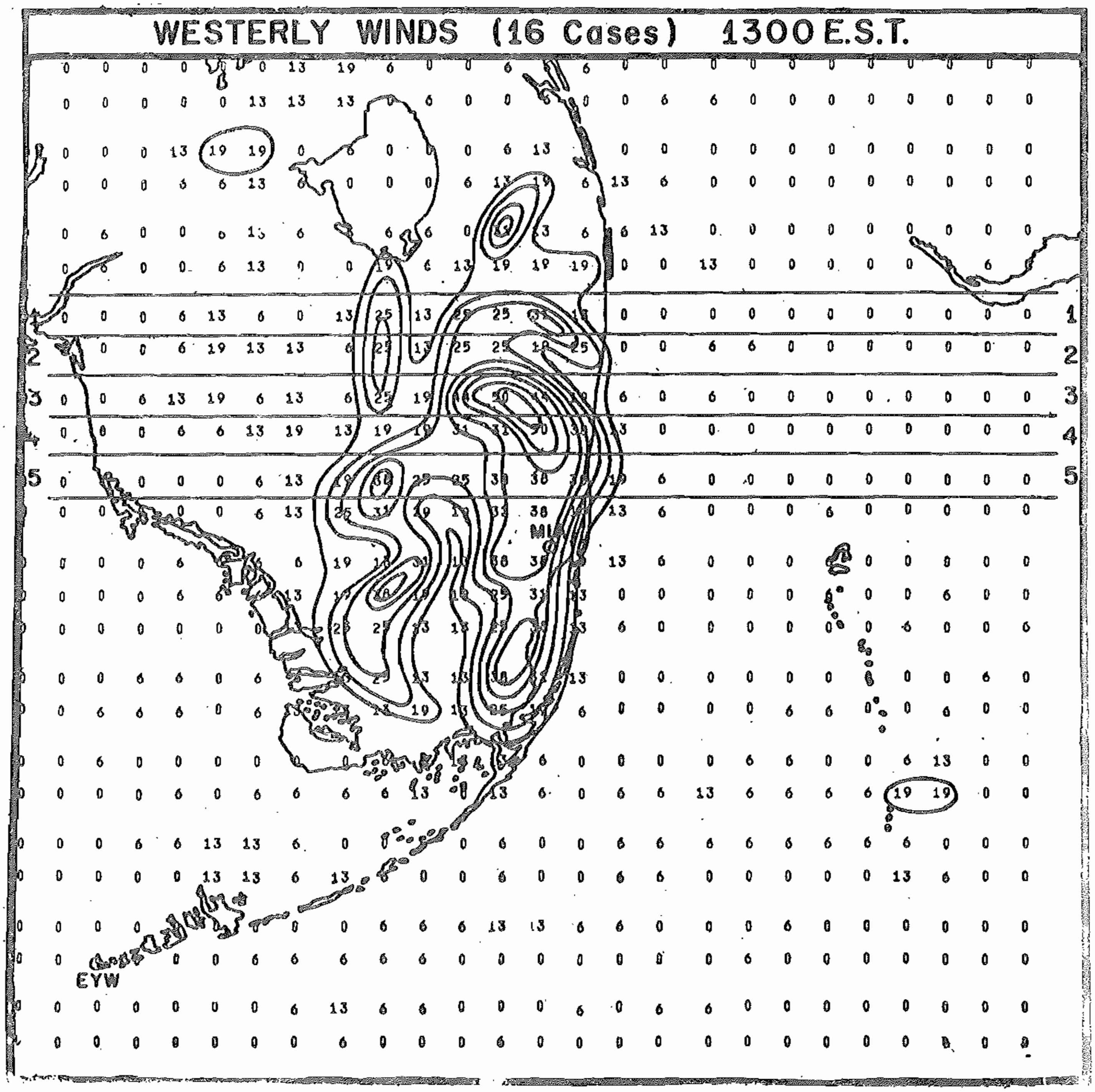


Figure 5(b). The radar echo frequency (expressed in %) maps for the westerly regime at Miami for 1300 E.S.T. Isolines of frequency are drawn in 5 percent intervals beginning with the 15 percent line.

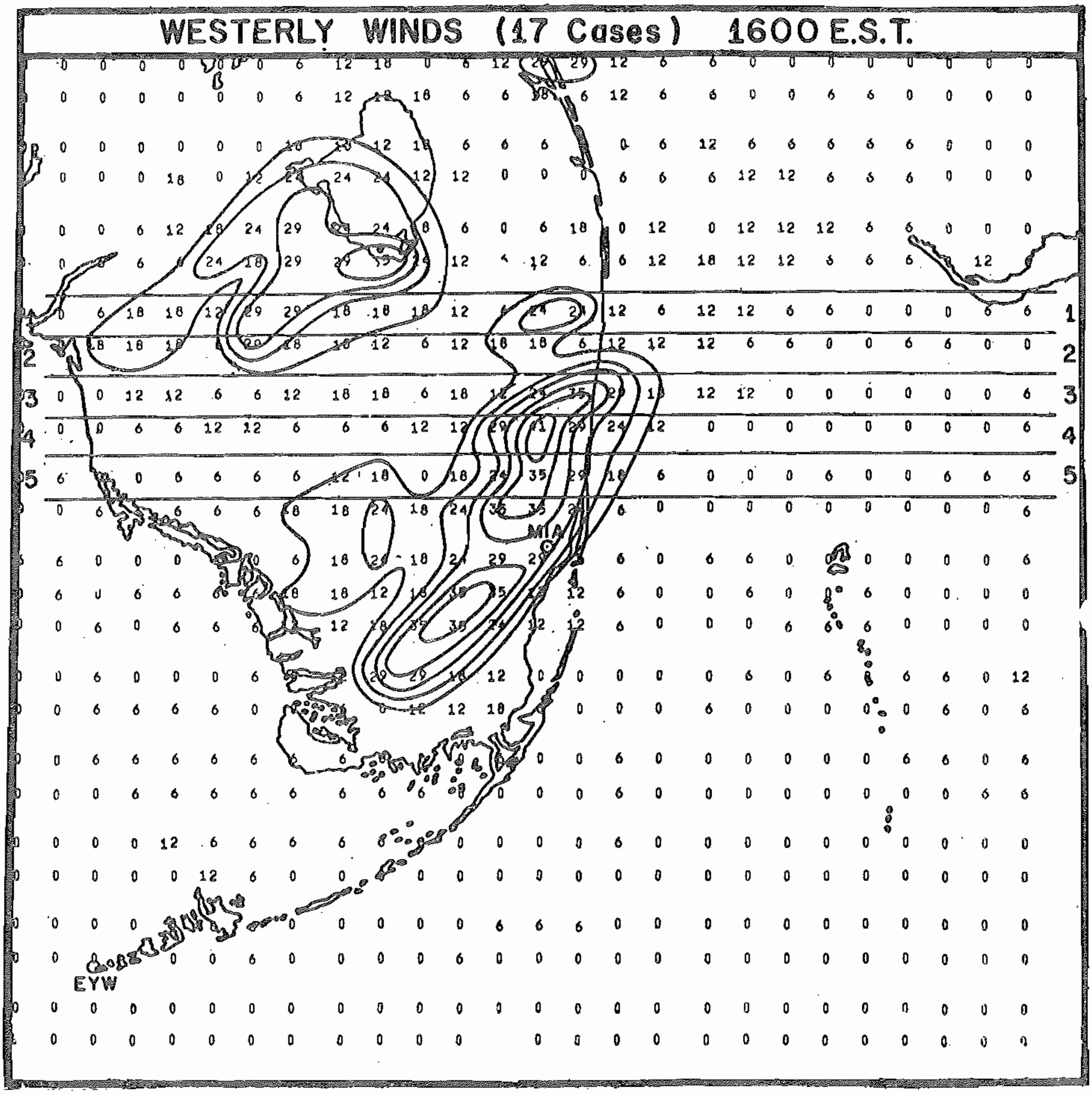


Figure 5(c). The radar echo frequency (expressed in %) maps for the westerly regime at Miami for 1600 E.S.T. Isolines of frequency are drawn in 5 percent intervals beginning with the 15 percent line.

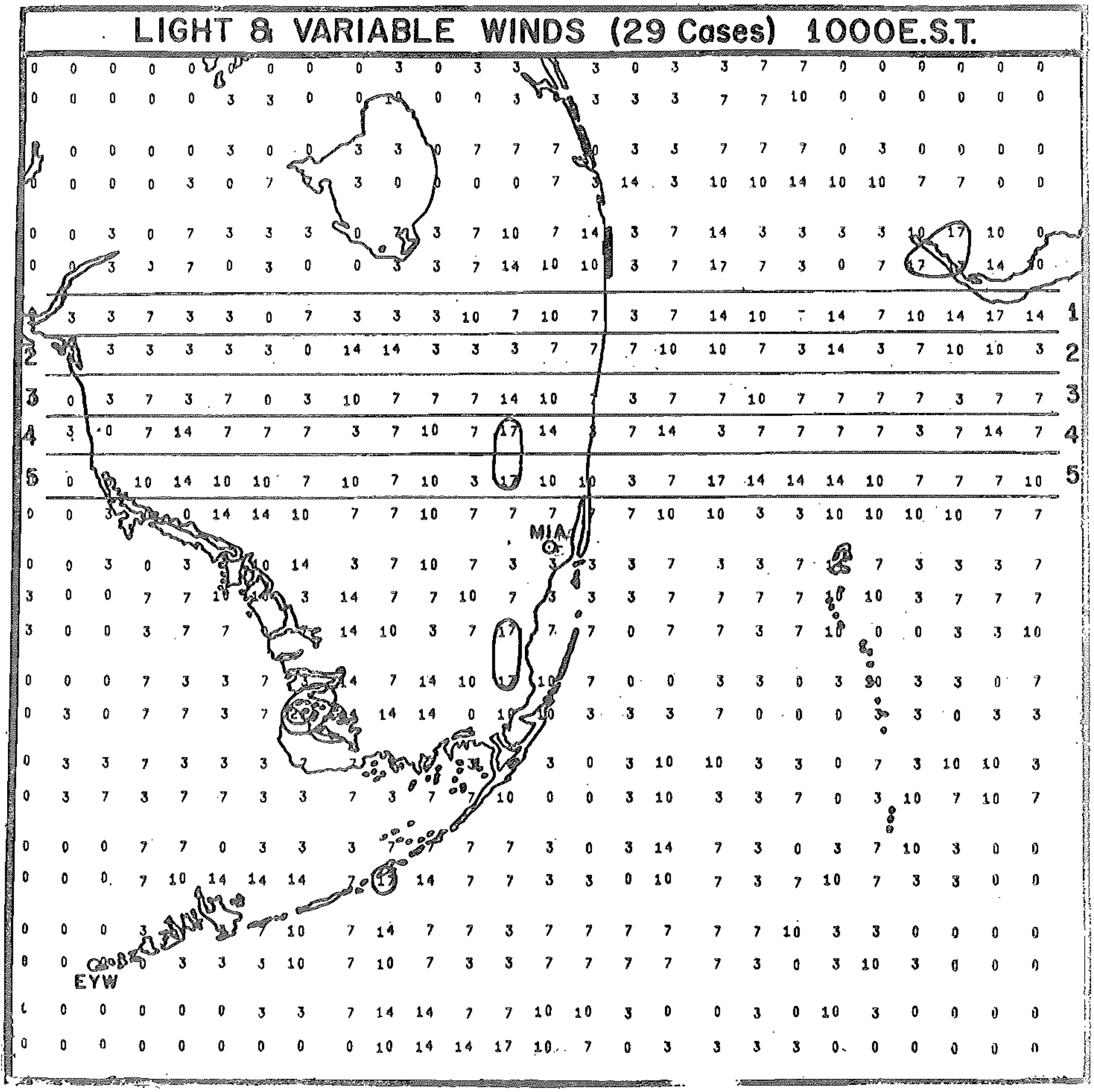


Figure 6(a). The radar echo frequency (expressed in %) maps for the light and variable regime at Miami for 1000 E.S.T. Isolines of frequency are drawn in 5 percent intervals beginning with the 15 percent line.

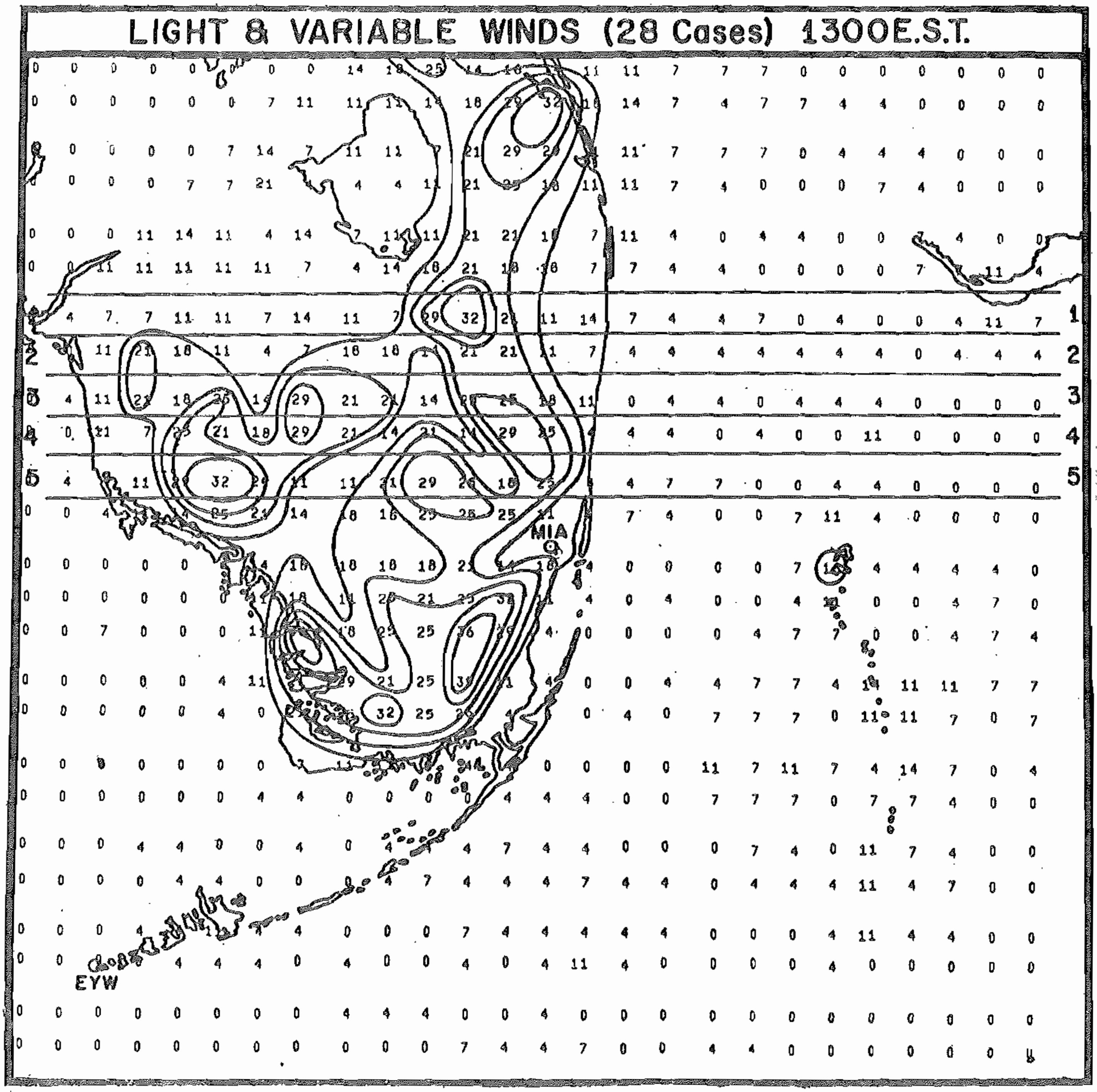


Figure 6(b). The radar echo frequency (expressed in %) maps for the light and variable regime at Miami for 1300 E.S.T. Isolines of frequency are drawn in 5 percent intervals beginning with the 15 percent line.

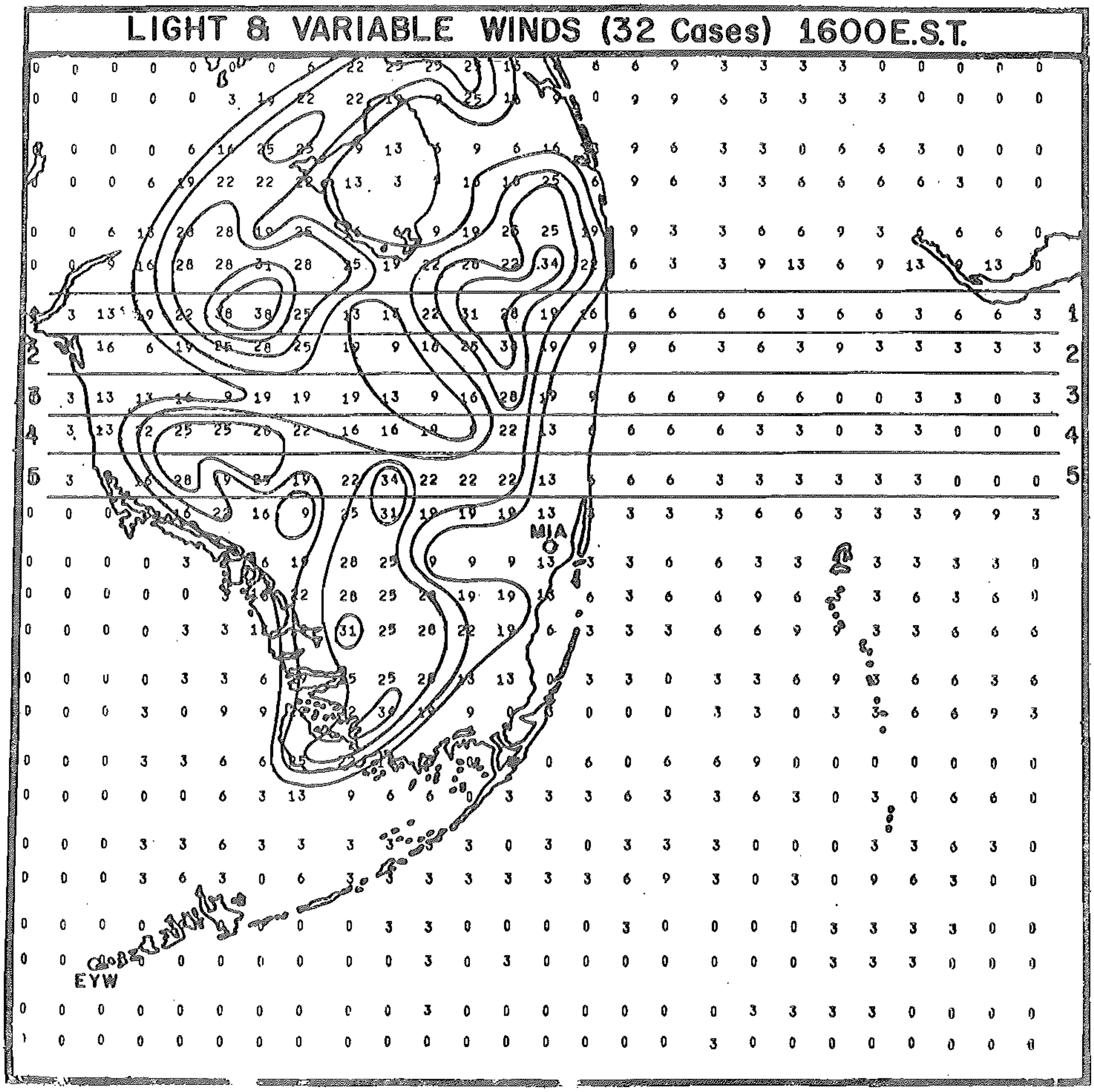
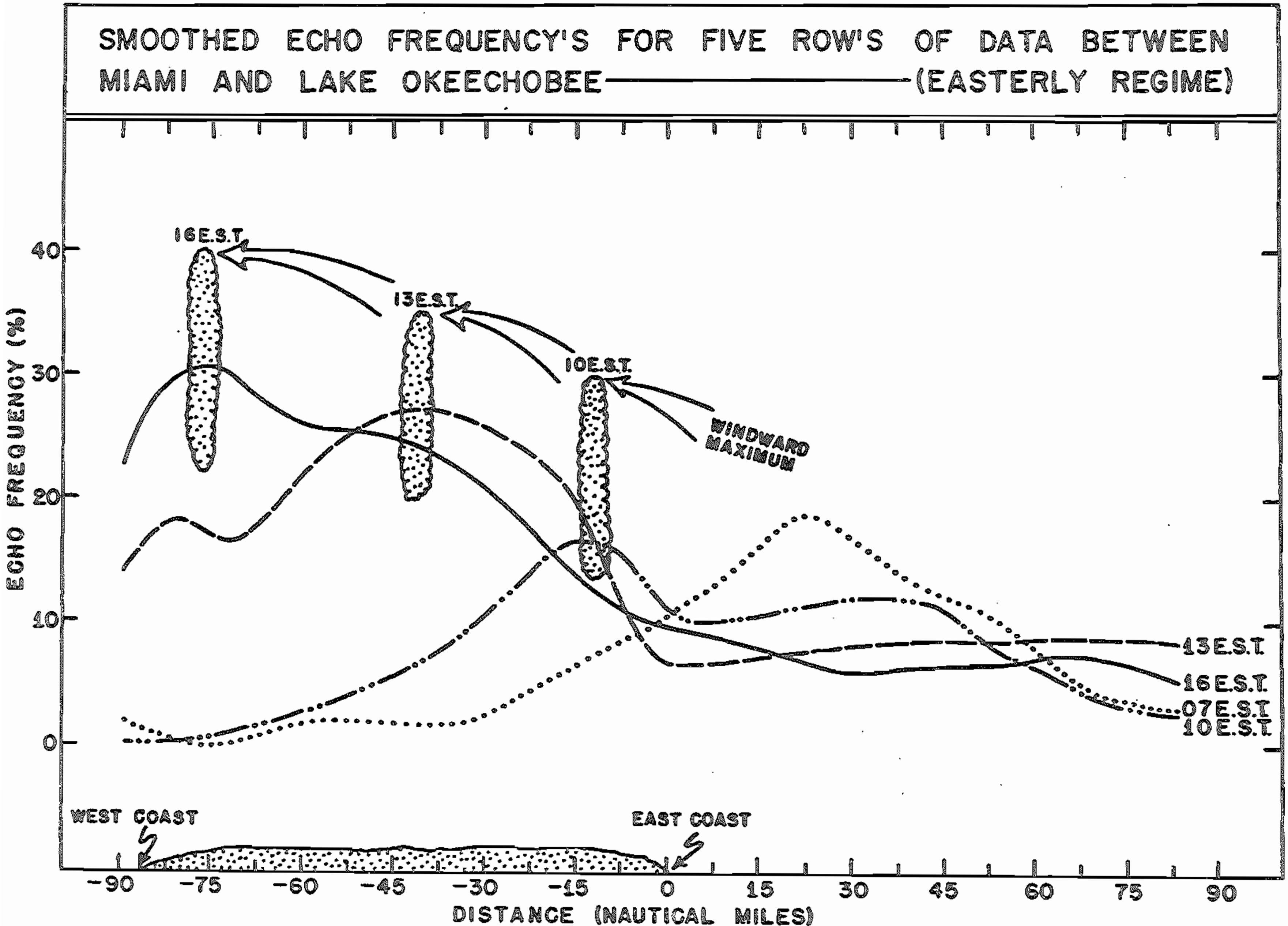
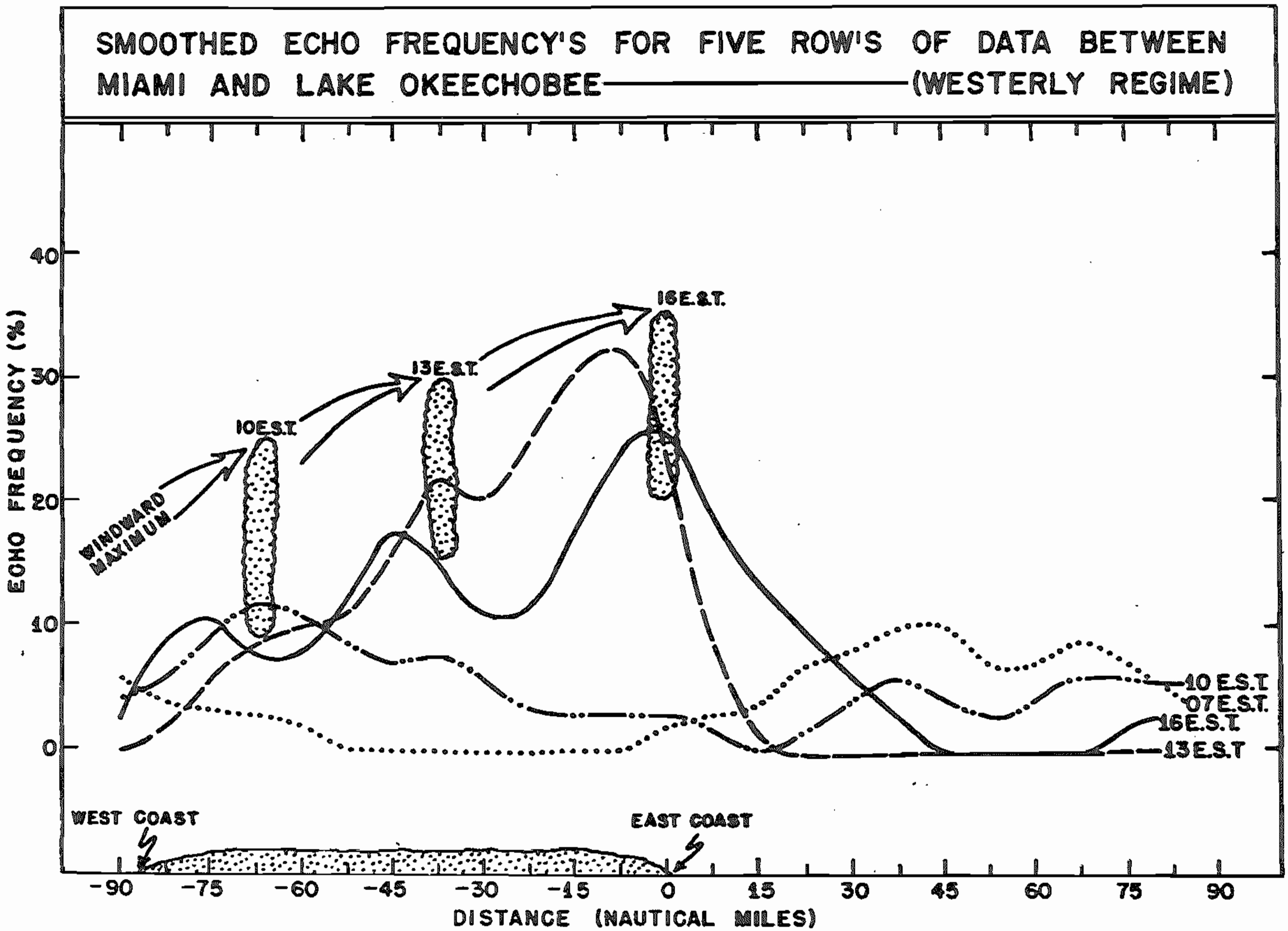


Figure 6(c). The radar echo frequency (expressed in %) maps for the light and variable regime at Miami for 1600 E.S.T. Isolines of frequency are drawn in 5 percent intervals beginning with the 15 percent line.



SMOOTHED ECHO FREQUENCY'S FOR FIVE ROW'S OF DATA BETWEEN MIAMI AND LAKE OKEECHOBEE —— (EASTERLY REGIME)
ECHO FREQUENCY (%)
40
30
20
10
0
16E.S.T.
13E.S.T.
10E.S.T.
WINDWARD MAXIMUM
13E.S.T.
16E.S.T.
07E.S.T.
10E.S.T.
WEST COAST
EAST COAST
-90
-75
-60
-45
-30
-15
0
15
30
45
60
75
90
DISTANCE (NAUTICAL MILES)

Figure 7.


SMOOTHED ECHO FREQUENCY'S FOR FIVE ROW'S OF DATA BETWEEN MIAMI AND LAKE OKEECHOBEE — (WESTERLY REGIME)
ECHO FREQUENCY (%)
40
30
20
10
0
WINDWARD MAXIMUM
10E.S.T.
13E.S.T.
16E.S.T.
10 E.S.T.
07 E.S.T.
16 E.S.T.
13 E.S.T.
WEST COAST
EAST COAST
-90
-75
-60
-45
-30
-15
0
15
30
45
60
75
90
DISTANCE (NAUTICAL MILES)
Figure 8.

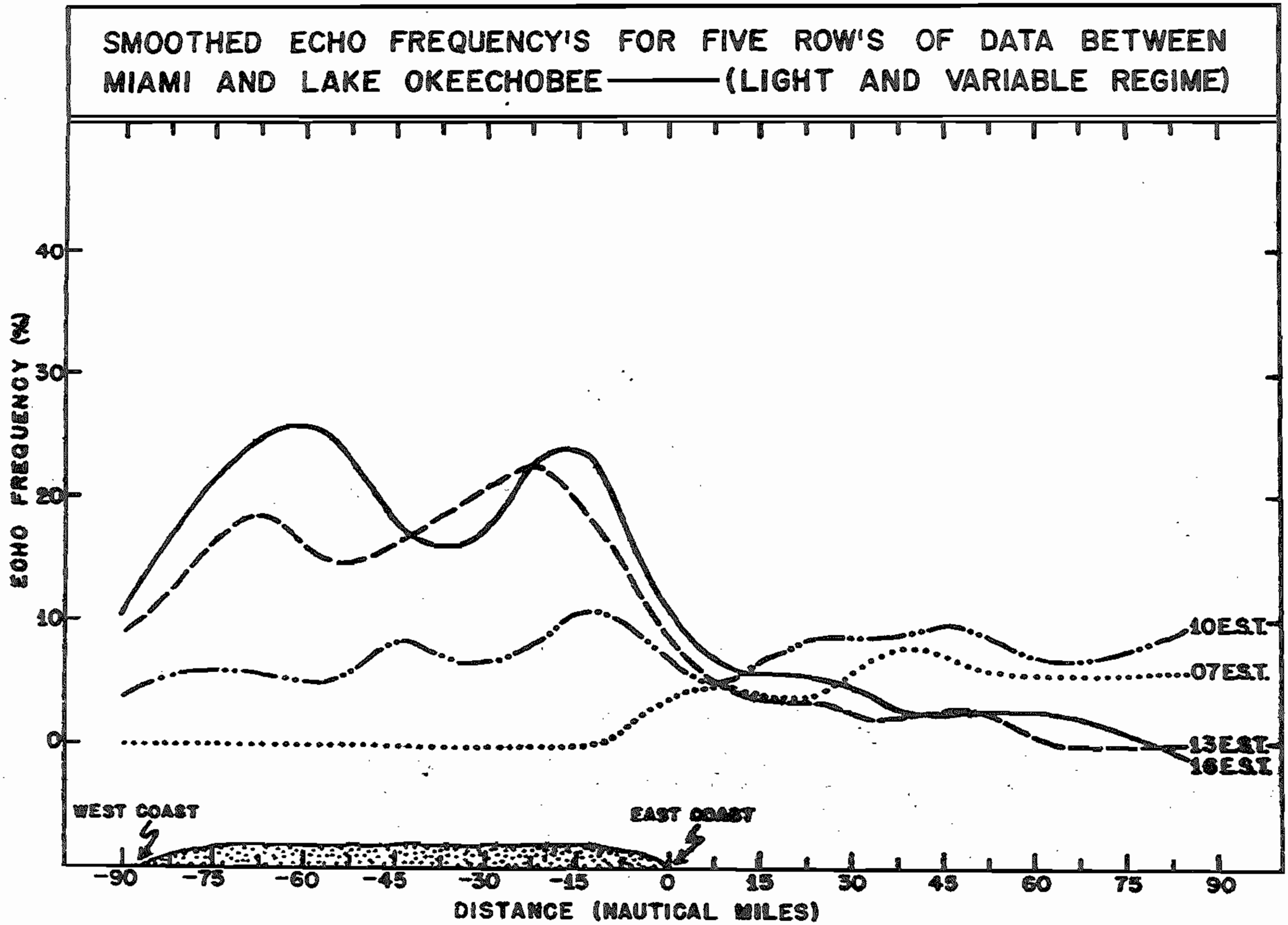

SMOOTHED ECHO FREQUENCY'S FOR FIVE ROW'S OF DATA BETWEEN MIAMI AND LAKE OKEECHOBEE ——— (LIGHT AND VARIABLE REGIME)
ECHO FREQUENCY (%)
40
30
20
10
0
10 E.S.T.
07 E.S.T.
13 E.S.T.
16 E.S.T.
WEST COAST
EAST COAST
-90
-75
-60
-45
-30
-15
0
15
30
45
60
75
90
DISTANCE (NAUTICAL MILES)

Figure 9.

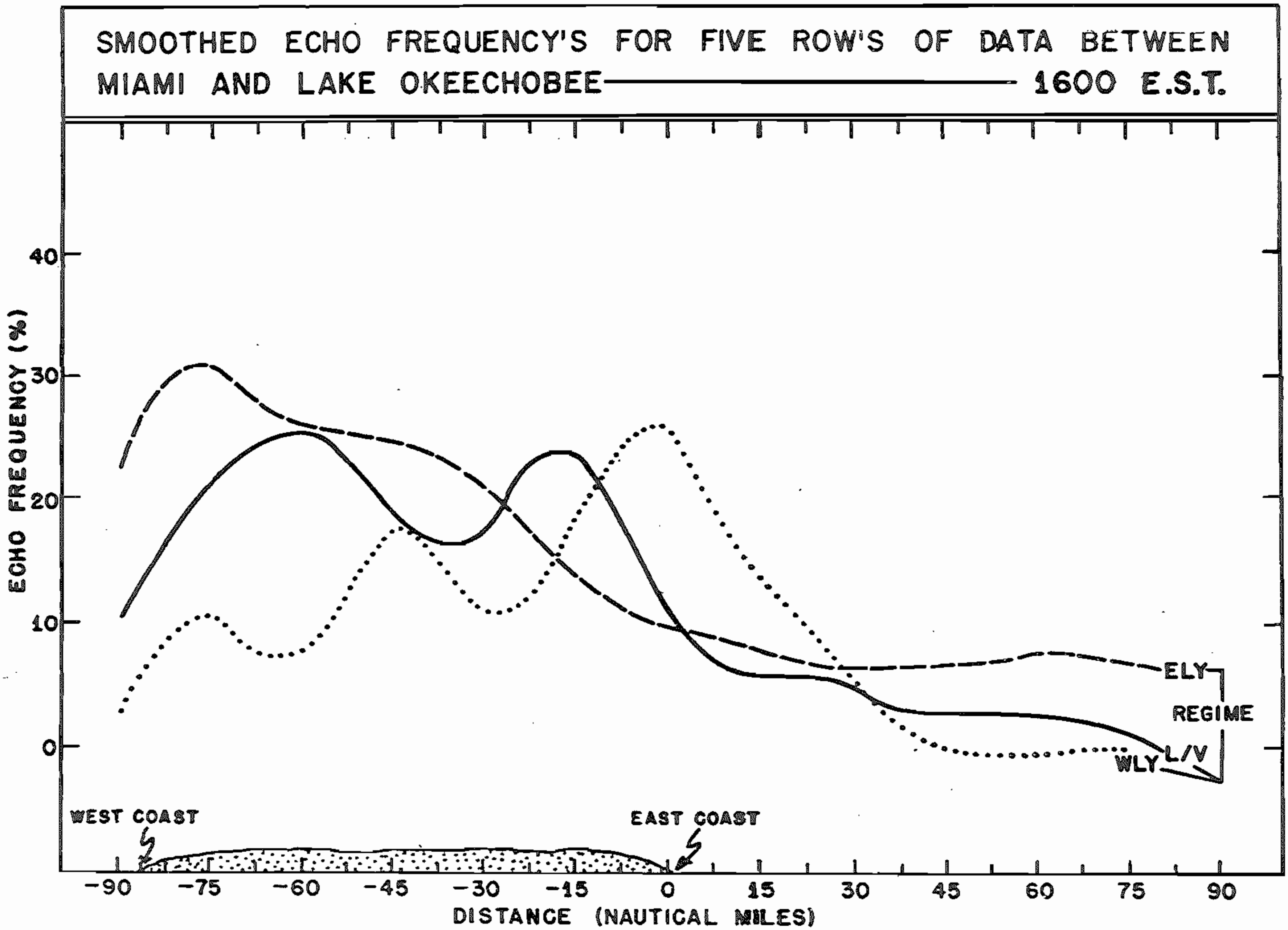

SMOOTHED ECHO FREQUENCY'S FOR FIVE ROW'S OF DATA BETWEEN
MIAMI AND LAKE OKEECHOBEE——1600 E.S.T.
ECHO FREQUENCY (%)
40
30
20
10
0
WEST COAST
EAST COAST
ELY
REGIME
L/V
WLY
-90
-75
-60
-45
-30
-15
0
15
30
45
60
75
90
DISTANCE (NAUTICAL MILES)

Figure 10.

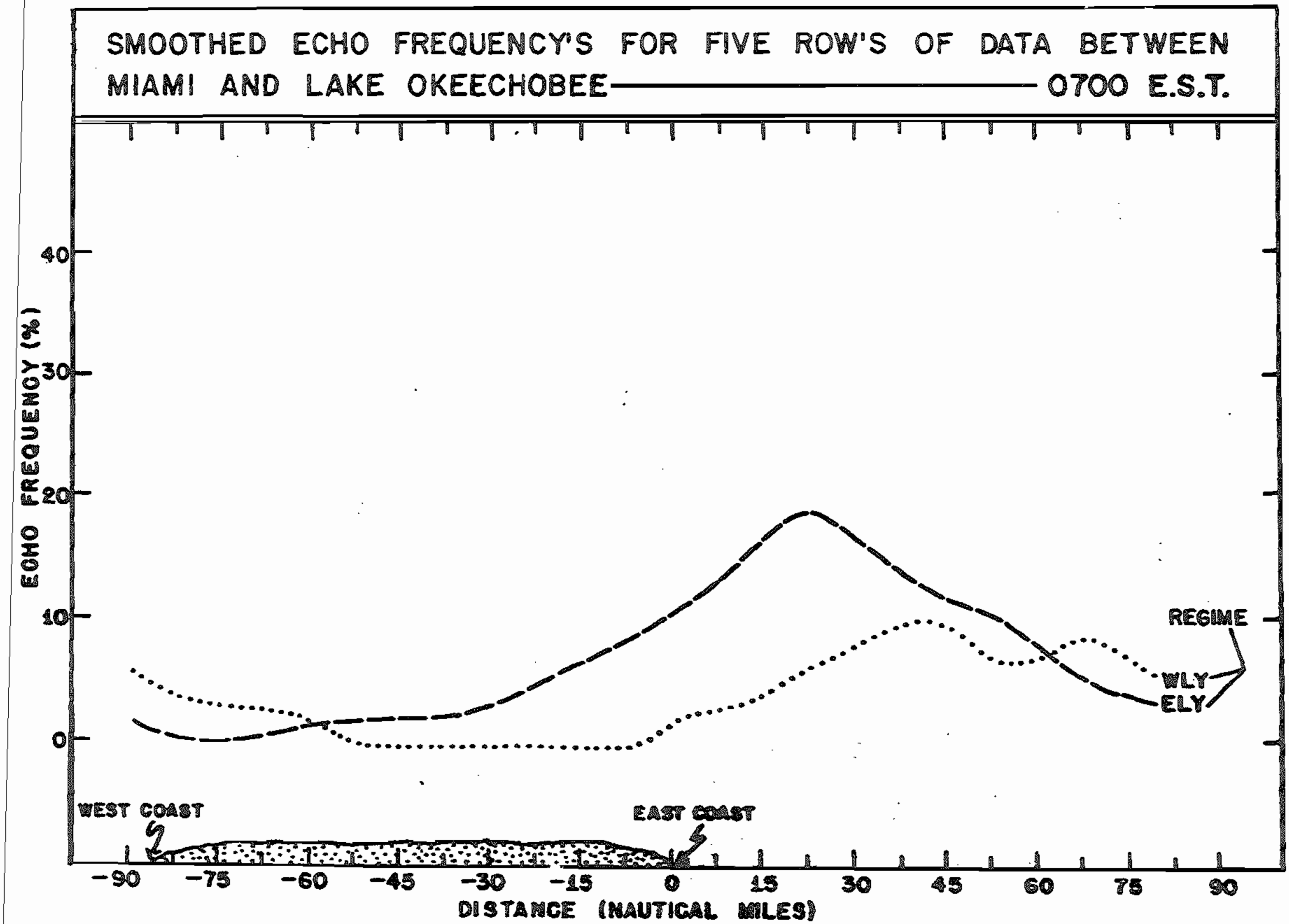

SMOOTHED ECHO FREQUENCY'S FOR FIVE ROW'S OF DATA BETWEEN
MIAMI AND LAKE OKEECHOBEE — 0700 E.S.T.
ECHO FREQUENCY (%)
40
30
20
10
0
REGIME
WLY
ELY
WEST COAST
EAST COAST
-90
-75
-60
-45
-30
-15
0
15
30
45
60
75
90
DISTANCE (NAUTICAL MILES)

Figure 11.

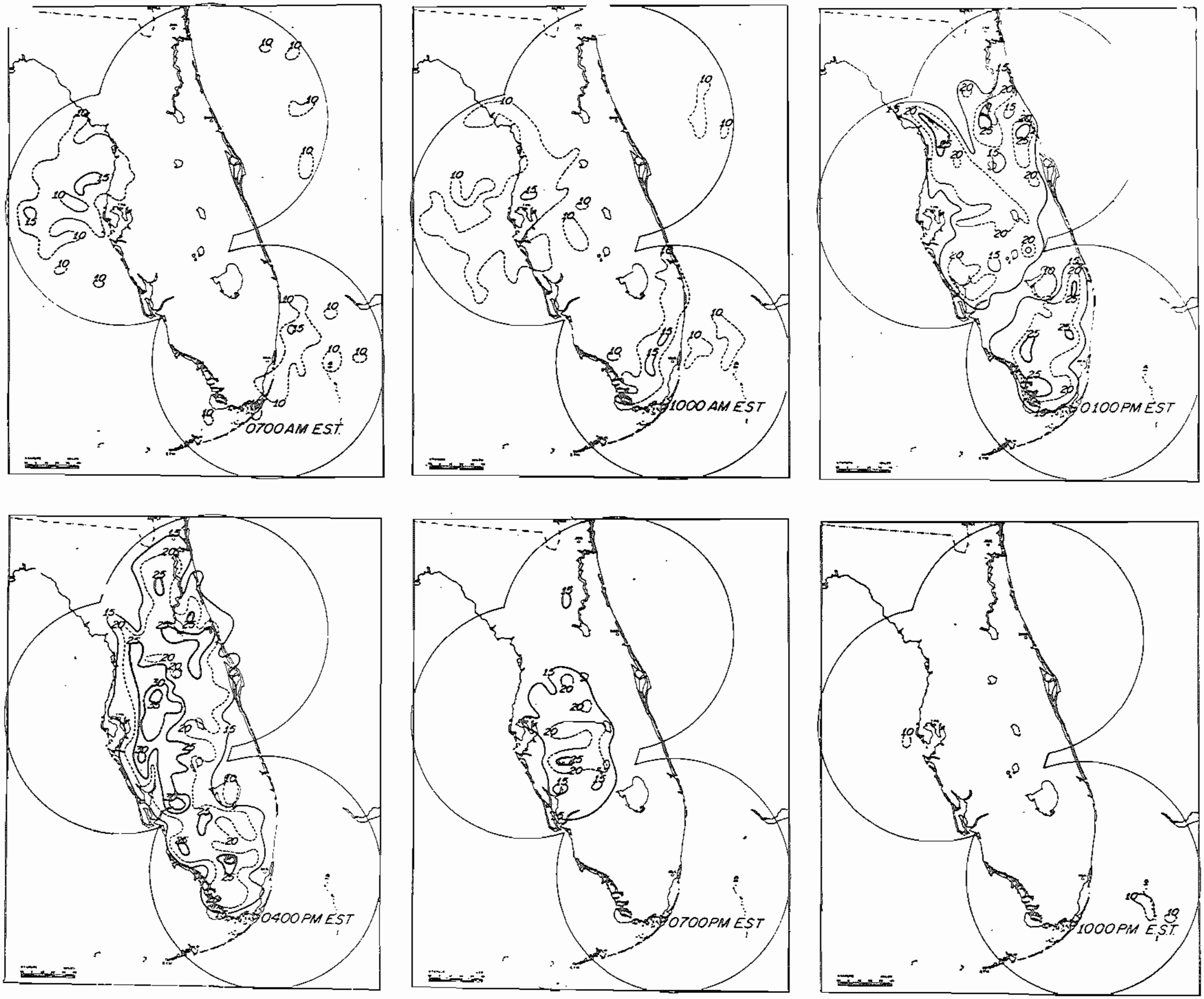


Figure 12. The seasonal diurnal cycle of echo frequencies over the Florida peninsula for the months May through August, 1963, excluding the 1 AM and 4 AM charts. Frequency isolines have been drawn in 5 percent intervals beginning with the 10 percent line.