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FORECASTING LOCAL SHOWERS IN FLORIDA DURING THE SUMMER

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ABSTRACT

July and August precipitation records for 5 years from 10 stations within 25 miles of Miami are analyzed to obtain an indication of the frequency of summer showers in that area. Several meteorological parameters for forecasting showers are examined. A quasi-objective method is developed which can be used to forecast the proportion of the Miami area which should expect showers during a 24-hour period 9 to 33 hours in advance. Several parameters are listed which were tested, but did not improve the forecasts. Verification results using independent data are included.

CONTENTS

INTRODUCTION

Local showers occur so frequently in Florida during the summer that most forecasters give up trying to forecast variations in shower activity and instead put out a standard forecast—"Partly Cloudy with Scattered Showers"—every day, except for the very rare occasion when fair weather is indicated. Although this forecast of partly cloudy with scattered showers will verify for Florida about 90 percent or more of the time, it doesn't give the public much information not already known. As a result, the Florida public consults the weather forecast infrequently during the summer, unless there is a tropical storm. This paper presents an approach to making precipitation forecasts for Florida in the summer months that will have more meaning. It is a pilot project worked out for an area of about 25 miles radius centered around Miami. However, it is hoped that ideas which were found to work for this area will also work, when properly applied, to other sections of the Florida Peninsula.

An examination of climatological data reveals that there is a shower somewhere in Florida almost every day during the summer season. However, the percentage of stations reporting showers during any 24-hour period varies widely from day to day. Data from 10 raingages located near Miami (fig. 1) were compiled for July and August for 5 years. Thus there were data for 310 days. Table 1 gives the frequency that showers were observed during July and August, 1944, 1945, 1947, 1948, and 1949.

TABLE 1.—*Frequency of showers reported by stations near Miami, July and August, 1944, 1945, 1947, 1948, and 1949*

Tenths of stations near Miami reporting rain	Number of days (July and Aug.)	Percent of all days	Percent of days having value or less
0	32	10.3	10
1	28	9.0	19
2	19	6.1	25
3	24	7.7	33
4	31	10.0	43
5	20	6.5	50
6	32	10.3	60
7	35	11.3	71
8	25	8.1	79
9	37	11.9	91
10	27	8.7	100

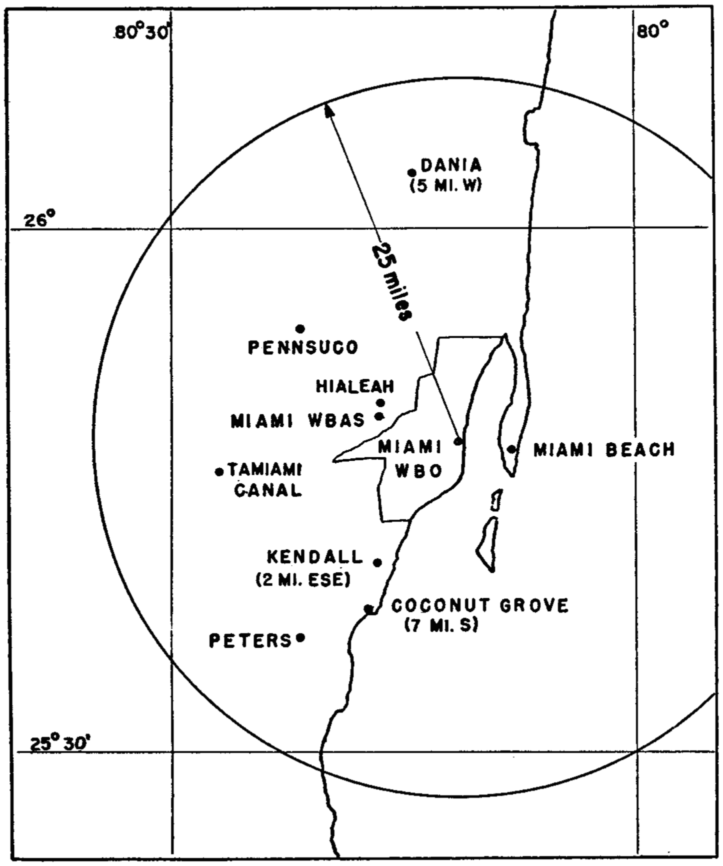

FIGURE 1.—Location of stations near Miami at which precipitation was observed.

During this period, there were almost equal numbers of days in which no stations reported rain, 4 stations reported rain, 10 stations reported rain, etc. The standard forecast of partly cloudy with scattered showers would have verified about 90 percent of the time; and, if it is assumed that some showers occurred without rain falling in any of the 10 raingages, the forecast would have verified over 90 percent of the time. However, data in table 1 show how meangingless is the "standard" forecast. Price [1] has emphasized the usefulness of the probability forecasts of thunderstorms. The present writer believes that Miami forecasts would have more meaning than the "standard" forecast and be of more service to the public if they contained a statement indicating the proportion of the area that was expected to have showers during the period. The forecast procedure explained in this paper is adaptable to that type of forecast.

SELECTION OF DATA

To insure that the precipitation records used in developing the forecast procedure would be representative of the area, data from 10 stations near Miami (fig. 1) were examined and compiled. Some of the stations were operated by cooperative observers of the Weather Bureau, and the rain was measured once a day—usually at about 0800 EST. At the Miami Beach station the accumulated precipitation was measured at about 1700 EST, and during part of the period records were available showing the amount measured at about 0700 EST. At the Miami Airport measurements were made at about 0115, 0715, 1315, and 1915 EST. At stations where recording raingages were used, hourly amounts of precipitation were available. Since raingages do not record traces, a trace was considered as no rain.

Since at several of the stations measurements were made at about 0700 or 0800 EST, it was decided to use a 24-hour period from 0730 EST on 1 day to 0730 EST of the following day. The only station that presented difficulties in using this period was the one at Miami Beach. During the period when records of the 0700 EST measurements were available, its data could be easily adjusted to be approximately concurrent with the others. During the time when 0700 EST measurements were not available, times of occurrence of precipitation were noted at neighboring stations and a decision was made as to which 24-hour period rain measured at 1700 EST should be assigned. Of course this introduces some errors, and the fact that observations at all stations were not made regularly at the same time, i. e., 0730 EST, would introduce some errors. However, it is believed that none of these would be great enough or occur frequently enough to seriously affect any of the results.

Although 10 stations were used in the study, occasionally one or two were missing. For such days the percentage of the remaining stations reporting was computed and that percentage was used.

Data used in making the forecasts were the upper air data observed at about 0330 GMT, and surface data observed at about 0030 GMT. The forecast period was for the 24-hour period beginning at 0730 EST (1230 GMT). Thus the forecast period began about 9 hours after the latest observations were taken. As already noted, this period was chosen because of convenience in handling the precipitation records. However, the forecasting method should work about as well for any other period, because none of the forecast parameters (see p. 44–46) vary very much diurnally with the possible exception of the average relative humidity above Miami.

SELECTION OF PARAMETERS

Following the selection of data for use in developing the forecast procedure, meteorological parameters useful in segregating the days of general showers from those with few or no showers were sought. Since very few air mass changes occur in south Florida in the summertime, one would suspect high correlation between number of showers, and the lapse rate and humidity. An examination of about 150 July and August soundings taken at Miami, however, showed that the lapse rate was always between the wet and dry adiabatic lapse rates. Furthermore, there seemed to be very little correlation between the degree of conditional instability and the number of stations having showers. This agrees with results that Chalker [2] obtained when studying thunderstorm occurrence throughout the United States. Further analysis of the soundings indicated that percentage of stations reporting rain could not be determined with much accuracy from purely thermodynamic considerations even when the moisture content was also considered. A large group of soundings were analyzed, using both the parcel and slice methods of analysis. Both methods gave consistently poor results. This agrees with studies of the Thunderstorm Project as reported by Byers and Rodebush [3]. They concluded that in each case of widespread thunderstorm activity attributed to insolation in earlier literature there must be a dynamically induced source of low-level convergence, perhaps in some cases related to the diurnal heating. Since high-moisture content through a deep layer results from low-level convergence, that conclusion is in agreement with the well-known correlation between thunderstorm areas and the locations of moist tongues on isentropic or related charts.

From the vorticity theorem [4] it can be argued that horizontal convergence is associated with polar troughs, waves in the easterlies and closed cyclonic circulations. Polar troughs occasionally reach as far south as Miami during July and August, particularly at the 5,000-ft. and 10,000-ft. levels. Also waves in the easterlies affect the Miami vicinity frequently during the average July and August. Infrequently, but at least once almost every summer, closed cyclonic circulations—usually tropical storms—pass near enough to Miami to affect its weather. In addition to these, Byers and Rodebush [3] point out the low-level horizontal convergence which is due to the sea breeze. They maintain that this is particularly effective in Florida which, being a peninsula, has a sea breeze coming onto land from three sides.

Summer air masses over Miami are nearly always conditionally unstable and are usually convectively unstable. There is usually sufficient daytime heating to release any convective instability. The sea breeze blows on most days in July and August, and it should cause enough horizontal convergence near the surface to release the convective instability. For these reasons, it would appear, there should be general showers nearly every day. However, as indicated in table 1, there is a wide variation in the number of stations reporting showers from day to day. The problem then seemed to be (1) to identify general circulation patterns that encourage the release of convective instability and/or bring in moist air during the forecast period, and (2) to identify general circulation patterns which tend to suppress convective instability and/or bring in dry air during the forecast period.

Types of circulation which will usually give horizontal convergence are troughs approaching Miami, easterly waves approaching, cyclonically curved streamlines, and tropical storms. Types of circulations which will usually cause horizontal divergence and thus inhibit ascending motion, are ridges centered right over Miami, strong anticyclonically curved streamlines, and back sides of easterly waves and polar troughs. Any pattern which causes low-level horizontal convergence will probably increase the moisture in air over Miami.

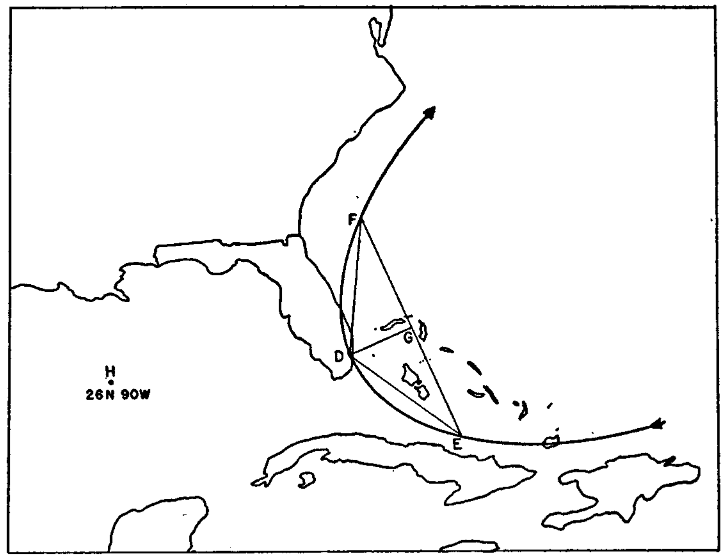

FIGURE 2.—Schematic representation of criteria for typing 700-mb. maps. Point D is at Miami, chords DE and DF are equal to 5° of latitude (25°–30°) and the arc EDF is the 700-mb. contour line.

After a number of parameters indicative of the circulation-stability-moisture conditions had been tried, the following were found to be most helpful in segregating the days of general showers from those with few or no showers: (1) the relative humidity, (2) distance from Miami of 700-mb. ridge, (3) degree and type of curvature of 850-mb. and 700-mb. contour lines near Miami, (4) direction and distance of nearest easterly wave, if any, (5) direction and distance from Miami of nearest tropical storm, if any, (6) direction and distance from Miami of nearest polar trough at 700 mb., and (7) general trajectory of air coming to Miami.

TYPING OF MAPS

The next step in developing the forecasting method was to type the 700-mb. maps [1] so that application of the meteorological parameters would be to data for similar synoptic situations. The maps were divided into three types: A—maps of predominantly zonal flow or of weak meridional flow; B—maps of moderate to strong meridional flow with Miami being under the flow from the south; C—maps of moderate to strong meridional flow with Miami being under the flow from the north. Since an effort was being made to make the method objective, definitions were set up to rigidly assign the maps to the respective types. Type B is illustrated in figure 2. Chords DE and DF are each equal to the distance between latitude circles 25 and 30. The point D is at Miami and the arc EDF is the 700-mb. contour line which passes over Miami.

[1] During the period from 1944 to 1949 the Weather Bureau changed from constant level maps to constant pressure maps. For convenience, the map will be called the 700-mb. map or 850-mb. map, etc., even though data from 1944 and 1945 were taken from 10,000-ft. maps or 4,000-ft. maps. (5,000-ft. maps were not easily obtainable for the study, so the 4,000-ft. maps were used instead for July and August, 1944 and 1945.)

Type B is defined by the following criteria:

1. The north component of EF is greater than the east or west component.
2. EF is greater than DG.
3. The height of the 700-mb. surface at Miami (D) is at least 50 feet greater than at H (26° N. 90° W.); or, if there is a minimum height between D and H, the height at D is at least 50 feet higher than the height at the minimum point.

Type C is similar to B, except that the chord EF will be oriented toward the south rather than the north, and the height at H will be at least 50 feet higher than at D.

Type A includes all cases not included in types B and C. This includes all cases in which the east or west component of chord EF is greater than the north or south component. It also includes all cases in which the north or south component is greatest but in which the east-west pressure gradient measured along a line from D to H is weak, or in which the anticyclonic curvature of the contour line from E to F is unusually intense.

CONSTRUCTION OF FORECAST GRAPHS

In developing the forecast method, graphs (scatter diagrams) similar to those given in figures 3–9 were prepared from data for July 1944, 1945, and August 1944, 1945, 1947. Data for July 1947, 1948, 1949, and August 1948 and 1949 were used as independent data to test results presented in the graphs. The graphs in figures 3–9, which give the basic forecasts, were prepared later and include all data both dependent and independent. However, they differ in minor details only from the original graphs. Details of the construction of the graphs for each 700-mb. map type follow.

TYPE A FORECASTS

Most of the maps were type A. The basic forecasts for type A are given in figures 3, 4, and 5. Forecast number 1A (fig. 3) uses average relative humidity as one parameter, entered on the graph as the abscissa. After various humidity measurements had been tried, it was decided that best results were obtained by using an average value. On the forecast charts (figs. 3, 6), relative humidity refers to the average of relative humidity values at 5,000 ft., 10,000 ft., and 15,000 ft. for 1944 and 1945 data, and for the average of humidity values at the 850-mb., 700-mb., and 500-mb. levels for the remainder of the data.

Forecast 1A (fig. 3) uses distance from Miami to the 700-mb. ridge as the second parameter, entered on the graph as the ordinate. If the 10,000-ft. wind at Miami has a westerly component, the ridge used is the one nearest to the south. If the 10,000-ft. wind at Miami has an easterly component, the ridge used is the one nearest to the north. The distance to the ridge line is measured along the meridian passing through Miami in units north or south of Miami. For convenience, a unit of distance equal to 1° of latitude (25° to 26°) was used for the measurements.

On the graph (fig. 3) at the intersection of the abscissa and ordinate values was plotted a number which gives tenths of stations near Miami reporting rain during the 24-hour period. After the data were plotted, isolines were so drawn that the majority of days on one side of a line have values $\geq n$, and the majority of days on the other side have values $< n$, where n is the labeled value of the line.

Forecast 2A (fig. 4) uses parameters which give a measurement of the type and degree of curvature at the 700-mb. and 850-mb. levels near Miami. On each map the contour line that passes over Miami was sketched. Then with Miami as a center and a radius equal to 5 units (5° of latitude) points were marked both upstream and downstream on the Miami contour line, e.g., points E and F in figure 2. Then the line EF was measured and this value was used as a radius of curvature factor. The maximum length of this line is 10. If it was less than 10 and the

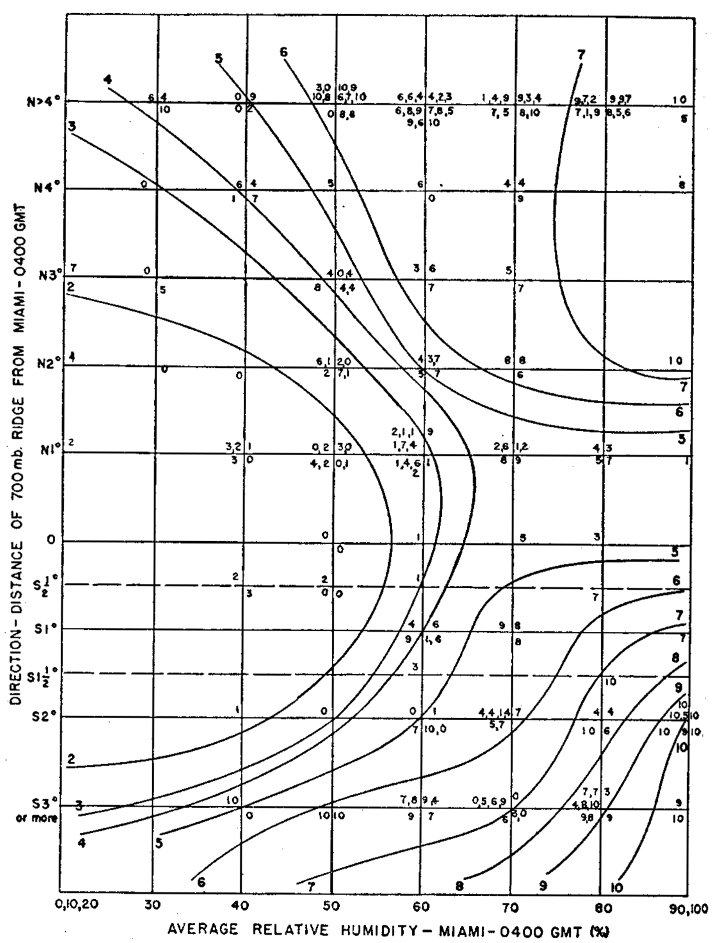

FIGURE 3.—Scatter diagram for type A, forecast 1A. Plotted numbers are tenths of stations near Miami reporting rain in the 24-hr. period 0730–0730 EST. Curves are so drawn that the majority of numbers on one side of a line have values $\geq n$ and the majority of numbers on the other side have values $< n$ where n is the labeled value of the line.

reason for its being less was cyclonic curvature of the contour lines, then radius of curvature factor was classed as cyclonic. It is possible for the curvature at Miami to be cyclonic and for the general curvature over the length of 10 units to be anticyclonic. It is the value for the entire 10 units which was considered in arriving at classification of the curvature. Admittedly this is somewhat arbitrary, but examination of maps in the series showed that it gave slightly more reliable results than taking the curvature at Miami.

If length of EF was less than 10 and curvature was anticyclonic, EF was measured and the value recorded as the radius of curvature factor. Values of this factor for 850-mb. and 700-mb. maps were used as coordinates in plotting figure 4. Values at the coordinate intersections are tenths of stations near Miami reporting rain. Isolines were drawn on this chart as in figure 3. Thus we have two forecasts for type A. These forecasts, 1A and 2A (figs. 3 and 4), were used in plotting figure 5 and isolines were drawn as before. Forecast 3A (fig. 5) is the basic forecast for type A.

Figure 3 shows that for type A situations showers are unlikely if the humidity is 50 percent or less and the 700-mb. ridge is within 2 units north or south of Miami. If the relative humidity is 70 percent or higher, showers are likely regardless of the position of the ridge. If the ridge is 3 or more units south of Miami, or more than 4 units north of Miami, showers are likely regardless of the humidity. This is to be expected. Since the lapse rate at Miami is nearly always conditionally unstable, the air mass will also be convectively unstable if there is sufficient moisture present. Thus there will usually be some showers if the humidity is high enough even though there is a ridge centered right over Miami. Also, if the ridge is well north or well south of Miami, the circulation is such that moist air will be brought into the Miami area during the forecast period. Thus showers will result even though the humidity is quite low 9 hours before the beginning of the forecast period.

In figure 4 the isolines indicate that showers are to be expected any time there is cyclonic curvature, as defined and measured in the radius of curvature factor, either at 850 mb. or 700 mb. Also there will usually be showers if the contour lines are curved slightly anticyclonically. However, if the contour lines at either level are curved sharply anticyclonically, there is reduced chance for showers; and if they are curved sharply anticyclonically at both levels, there is very little chance for showers.

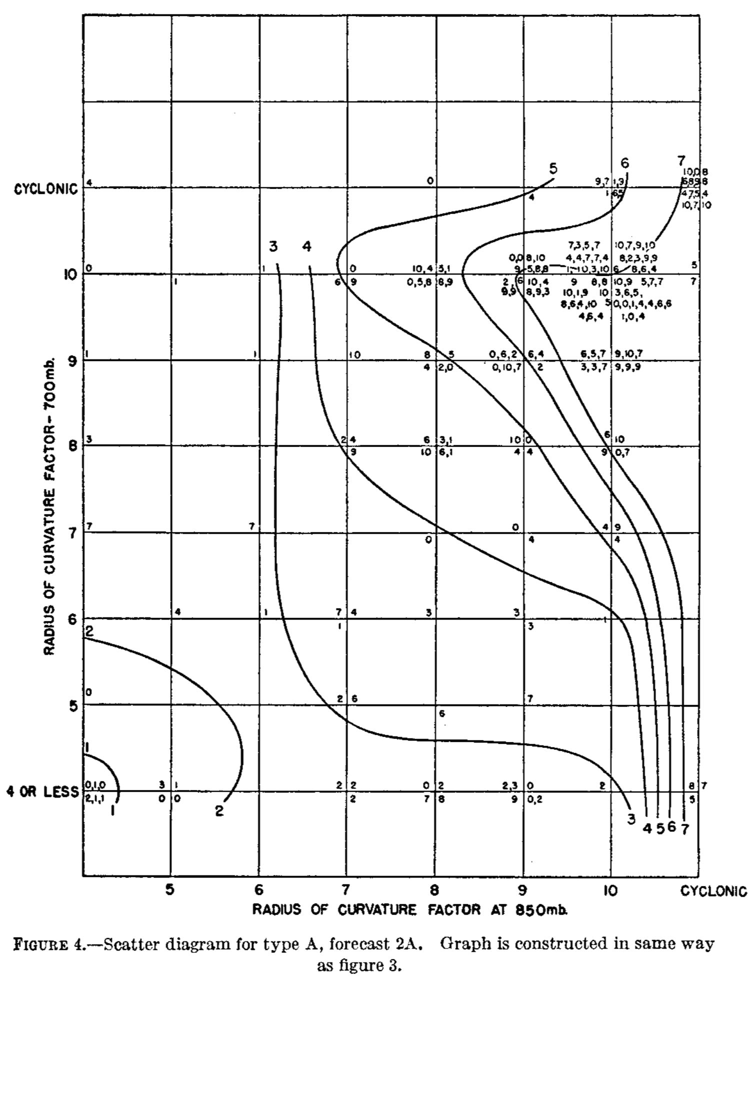

FIGURE 4.—Scatter diagram for type A, forecast 2A. Graph is constructed in same way as figure 3.

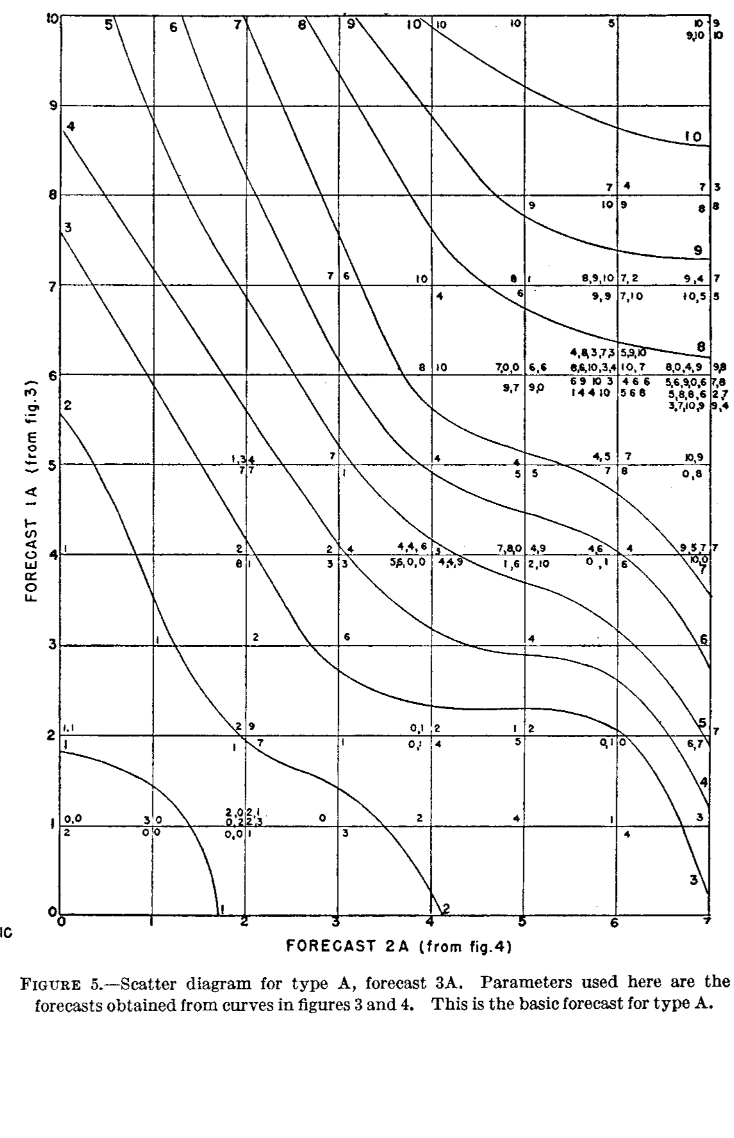

FIGURE 5.—Scatter diagram for type A, forecast 3A. Parameters used here are the forecasts obtained from curves in figures 3 and 4. This is the basic forecast for type A.

TYPE B FORECASTS

Forecast graphs for type B given in figures 6, 7, and 8 were made in a fashion similar to those for type A, except that distance to the ridge was measured along the latitude circle passing through Miami and was measured only to the east.

Similar conclusions to those for type A can be drawn for type B maps after a study of figures 6 and 7. Showers are more frequent when the humidity is high and when the ridge is several units distant from Miami. Type B as a whole is more showery than type A; so showers occur on almost all days except when the relative humidity is very low or when the ridge is within 4 units of Miami.

The radius of curvature factor has about the same effect on type B cases as on type A. Showers are frequent when the factor gives cyclonic curvature or when the anticyclonic curvature is slight. Chances for showers get progressively less with increase in the intensity of the anticyclonic curvature, i. e., decrease in the radius of curvature factor.

TYPE C FORECASTS

Forecasts for type C used a parameter not used in the type A and B forecasts. With Miami as the center, and a radius of 5 units, a mark was made upstream on the 700-mb. contour line passing over Miami. Another mark was made 10 units upstream. The longitude at each of these marks was read and the values averaged. The average value is the quantity used as the ordinate in forecast 1C (fig. 9). There were very few cases of type C, so reliability of the forecast 1C is somewhat doubtful. However, figure 9 indicates more probability of rain when the humidity is high and when the average trajectory estimated by the longitude factor is such as to have brought the air over water for a long distance before it reaches Miami. This seems logical and agrees with observations of experienced meteorologists.

MODIFICATION OF BASIC FORECASTS

CORRECTION RULES

Some other parameters were tested and found to improve the basic forecasts given in figures 5, 8, and 9. These other parameters do not occur every day. In fact, there were insufficient cases to justify drawing additional graphs. It was believed that about as good results could be obtained by stating them in forecast rules as corrections of the basic forecasts. Perhaps when additional data have been studied there will be sufficient cases to justify

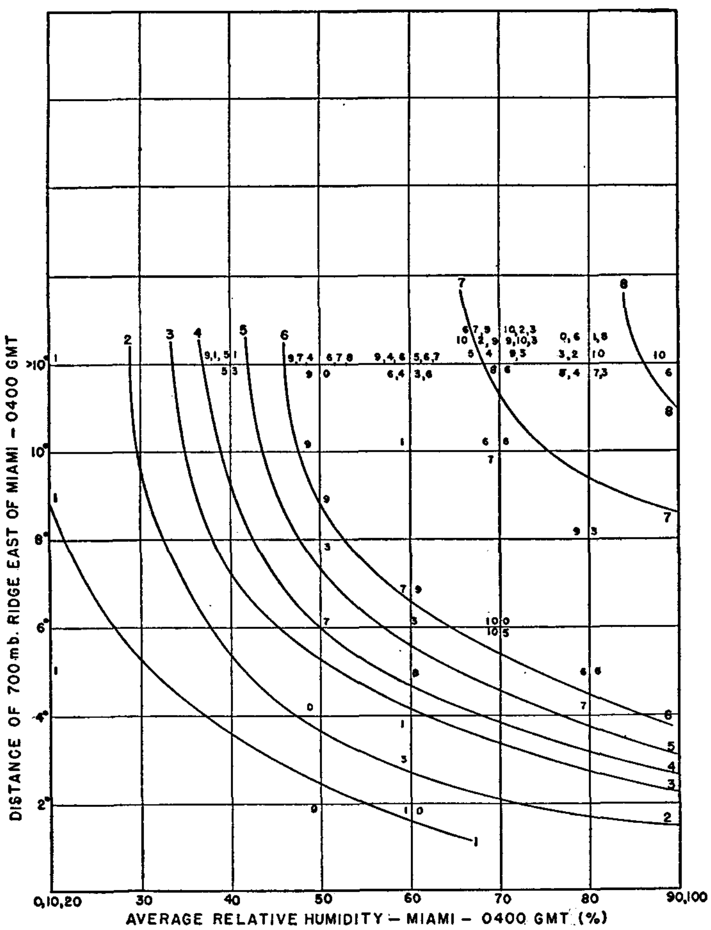

FIGURE 6.—Scatter diagram for type B, forecast 1B. Graph is constructed in same way as figure 3.

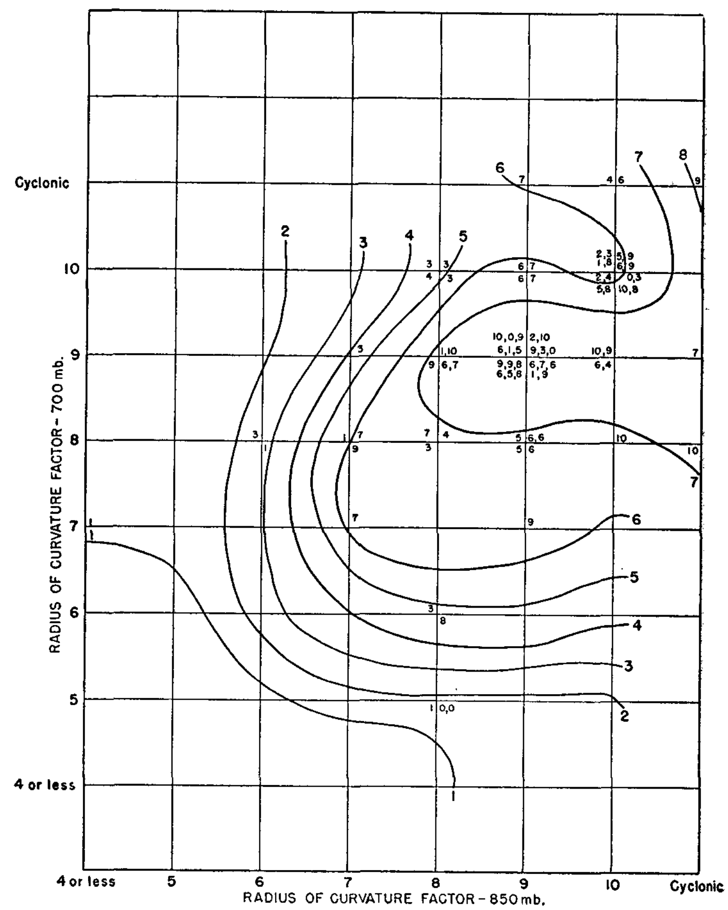

FIGURE 7.—Scatter diagram for type B, forecast 2B. Graph is constructed in same way as figure 3.

drawing additional graphs and preparing more accurate solutions. These rules are based partially on results found in studying the dependent data and partially on experience of the Miami forecasters. They are stated as corrections to the basic forecasts given in figures 5, 8, and 9. The rules follow:

(1) If there is an easterly wave at 2,000 ft. whose axis is located within 2 units to the west of Miami or within 6 units (1 unit equals 1 degree of latitude) to the east of Miami, add one-tenth to the basic forecast. (See Dunn [5] for a discussion of easterly waves.)

(2) If there is an easterly wave at 2,000 ft. whose axis is located within 4 to 8 units to the west of Miami, subtract two-tenths from the basic forecast.

(3) If there is an easterly wave at 2,000 ft. whose axis is within 2 to 6 units to the north or northwest of Miami, subtract two-tenths from the basic forecast.

(4) If Miami is in the westerlies at 700 mb. and there is a trough over Miami or within 10 units to the west, add one-tenth to the basic forecast.

(5) If Miami is in the westerlies at 700 mb. and there is a trough within 5 units to the northwest or 4 units to the north, add one-tenth to the basic forecast.

(6) If Miami is in the westerlies at 700 mb. and there is a trough 3 or 4 units to the east, subtract two-tenths from the basic forecast.

(7) When at 10,000 ft. there is a shear line north of Melbourne and the 10,000-ft. wind at Tallahassee is on or between ESE and ENE, subtract two-tenths from the basic forecast (fig. 10). Do not use this rule for those cases in which the streamline or contour line is curved cyclonically continuously from Miami to Tallahassee.

(8) If there is a tropical storm in areas X or Y (fig. 11), subtract the number of tenths indicated on the map.

OTHER PARAMETERS

Many other parameters were tried and found to have either little correlation with the number of showers or such a high correlation with the parameters already used in forming the basic forecasts that they added little or nothing to the skill. A list of these follows:

1. Sign of the curvature of the 850-mb. and 700-mb. contour lines at Miami.
2. Occurrence of precipitation up wind 12–18 hours preceding the forecast period.

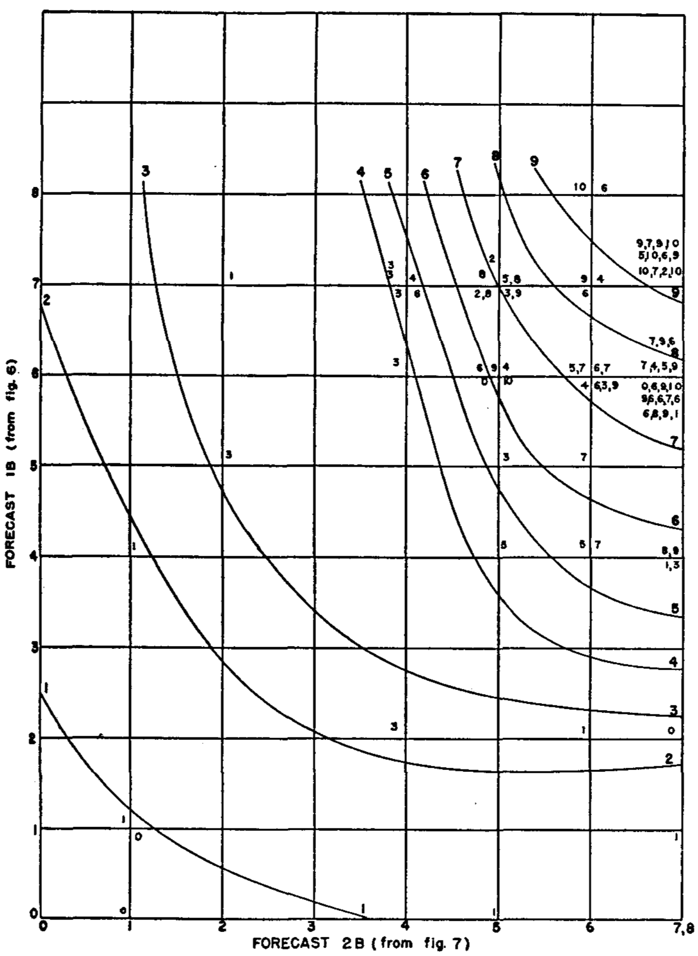

FIGURE 8.—Scatter diagram for type B, forecast 3B. Parameters used are forecasts obtained from curves in figures 6 and 7. This is the basic forecast for type B.

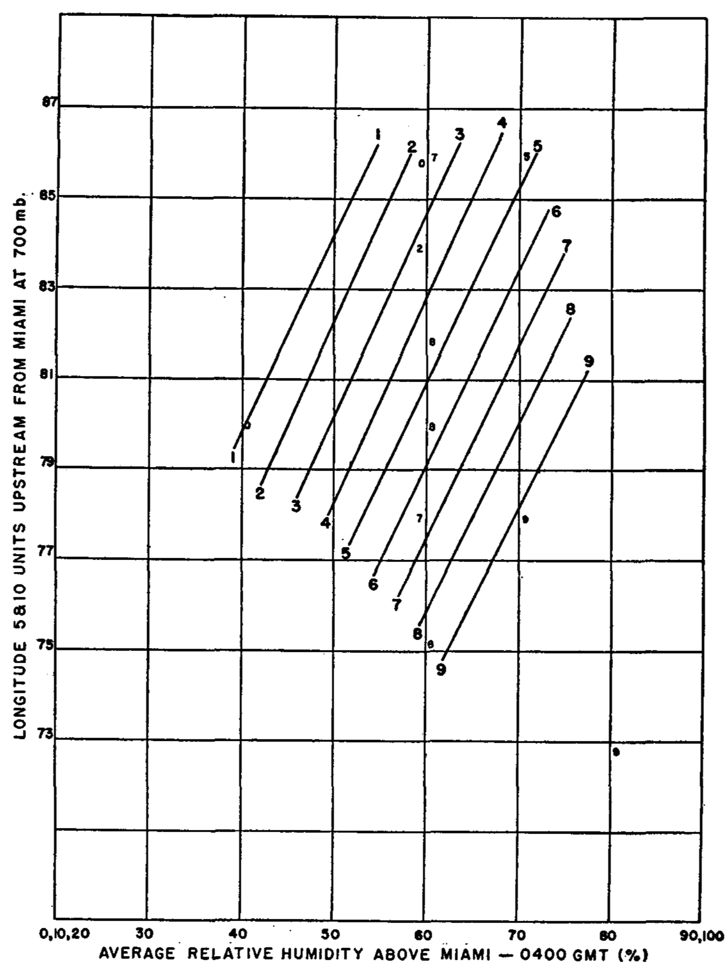

FIGURE 9.—Scatter diagram for type C, forecast 1C. The ordinate is the average of the two values of longitude read at points 5 and 10 units upstream from Miami at 10,000 ft.

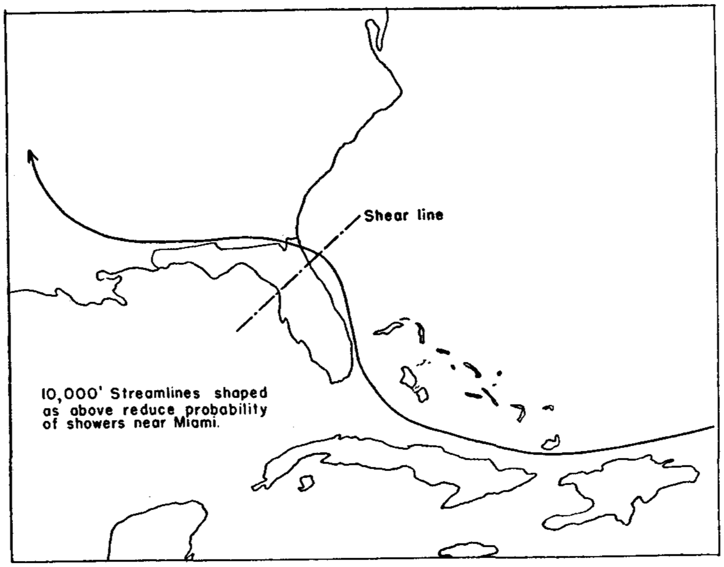

FIGURE 10.—Schematic representation of rule number 7.

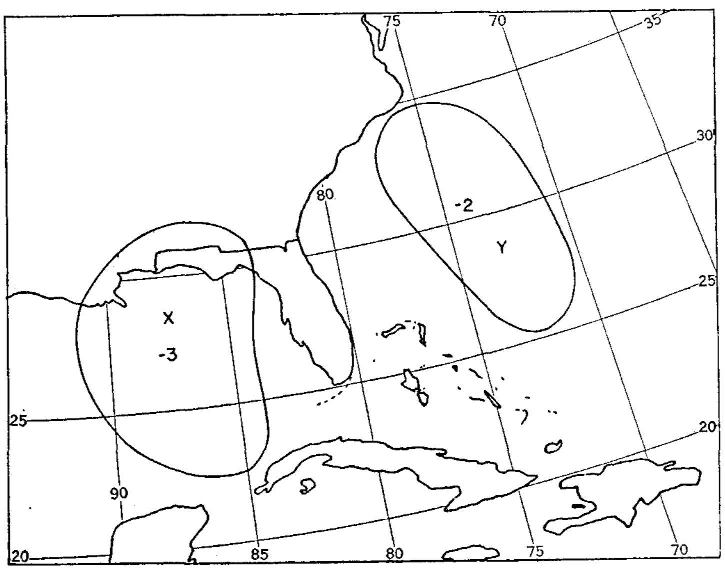

FIGURE 11.—Diagram showing correction to be made to basic forecast if tropical storm is centered in either of areas X or Y (rule 8).

3. Direction and speed of 2,000-ft. winds at Miami.
4. Direction and speed of 5,000-ft. winds at Miami.
5. Direction and speed of 10,000-ft. winds at Miami.
6. Direction and speed of 20,000-ft. winds at Miami.
7. Direction and speed of 8,000-ft. winds.
8. Wind shear from 2,000 ft. to 10,000 ft. and 5,000 ft. to 10,000 ft. (See Byers and Battan [6].)
9. 24-hour surface pressure change at Miami for 24 hours preceding forecast period.
10. Rain at Miami in preceding 24-hour period.
11. Direction of the chord EF (fig. 2).
12. Humidity at 5,000 ft.
13. Humidity at 10,000 ft.
14. Humidity at 15,000 ft.
15. Humidity at 20,000 ft.
16. Convergence in wind field over area immediately preceding forecast period. (Computed for a few cases only by a method developed by Bellamy [7].)
17. Instability as computed by slice method [8].
18. Instability as computed by parcel method [9].

SUMMARY OF FORECAST PROCEDURE

The forecast procedure which has been developed is summarized schematically in table 2.

TABLE 2.—*Summary of forecast procedure*

Type	Parameters	Forecasts [2]	
Type A (Zonal flow at 700 mb. or weak meridional flow).[1]	Distance to 700-mb. ridge.	1A (fig. 3)	3A (fig. 5)
	Average relative humidity.		
	Radius of curvature factor at 700 mb.	2A (fig. 4)	
	Radius of curvature factor at 850 mb.		
Type B (Moderate to strong meridional flow from some southerly component).[1]	Distance eastward to 700-mb. ridge.	1B (fig. 6)	3B (fig. 8)
	Average relative humidity		
	Radius of curvature factor at 700 mb.	2B (fig. 7)	
	Radius of curvature factor at 850 mb.		
Type C (Moderate to strong meridional flow from some northerly component).[1]	700-mb. air trajectory (longitude factor).	1C (fig. 9)	
	Average relative humidity.		

[1] See pages 43 for detailed criteria for typing 700-mb. maps.
[2] Forecasts 3A, 3B, and 1C are to be modified by use of rules 1-8 (see p. 47) when applicable.

TESTS

As stated previously, the basic forecasts and the rules were developed using 5 months of dependent data and checked with the 5 months of independent data. If we accept as correct those forecasts which were within two-tenths of what was observed, i. e., a forecast of four-tenths being accepted as correct if two- to six-tenths were observed, the skill score [2] is 55.

[2] Skill scores were computed from the formula

$$S=\frac{\text{No. correct}-\text{chance expectancy}}{\text{Total}-\text{chance expectancy}}\times 100$$

Chance expectancy was determined by the marginal totals of both predicted and observed classes. In a contingency table with subtotals P_i for predicted and O_i for observed and a total of N cases, the chance expectancy is

$$\frac{\Sigma\,(P_i\times O_i)}{N}$$

Table 3 gives the number of days of independent data for which the forecasts were exactly correct, the number and percentage of days that were within one-tenth of the observed, the number and percentage of days that were within two-tenths of the observed, etc. The eight-step error and all of the seven-step errors except one were cases in which frequent showers had been forecast and few or none occurred.

TABLE 3.—*Tabulation of number and percentage of days with various step errors in forecasting from independent data*

Step errors in forecasts (tenths)	Number of days	Percentage of days having this error or less
0	41	26
1	38	51
2	36	74
3	14	83
4	8	88
5	9	94
6	2	96
7	6	99
8	1	100
9	0	100
10	0	100

If it is desired not to make forecasts in terms of tenths or percentage, but to forecast either showers or no showers, the method can still be used. Since showers occur so frequently, we decided to test the method by assuming that any time two-tenths or less of the area was expected to have showers to give a forecast of no rain. Likewise, in verifying it was assumed that two-tenths or less would verify as no rain. With these assumptions, the skill score for the independent data was 57, and the forecasts were correct 86 percent of the time. Although most of the skill in the forecasts comes from the objective portions of the method, the forecast rules 1 through 8 added some skill. For example, the forecasts made from figures 5, 8, and 9 gave a skill score for independent data of 47 compared to the 57 for the forecasts when modified by the rules.

As stated previously, the graphs given in figures 3–9 were made with all of the data—both dependent and independent. Using them and the rules given for correcting the basic forecasts, with the exception of rules number 4 and 5 which didn't add any skill to forecasts made by the charts which were based on all data, the skill score for the two-step errors was 58. Assuming two-tenths or less as no rain, and forecasting either rain or no rain, the skill score was 63 with 87 percent of the forecasts correct.

CONCLUSIONS

It is concluded that by using the forecast procedures developed in this paper, one can forecast summer showers in Florida with a high degree of accuracy. It is not necessary to forecast, "Partly Cloudy with Scattered Showers" for southern Florida almost every day in the summer. The forecaster can give the public much more information by predicting what percentage of the area will have showers during the period, and he can do it with considerable accuracy.

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REFERENCES

1. Saul Price, "Thunderstorm Today?—Try a Probability Forecast," *Weatherwise,* vol. 2, No. 3, June 1949, pp. 61–63.
2. Wm. R. Chalker, "Vertical Stability in Regions of Air Mass Showers," *Bulletin of the American Meteorological Society,* vol. 30, No. 4, April 1949, pp. 145–147.
3. H. R. Byers and H. R. Rodebush, "Causes of Thunderstorms of the Florida Peninsula," *Journal of Meteorology,* vol. 5, No. 6, December 1948, pp. 275–280.
4. C.-G. Rossby, "Planetary Flow Patterns in the Atmosphere," *Quarterly Journal of the Royal Meteorological Society,* vol. 66, Supplement, 1940, pp. 68–87.
5. Gordon E. Dunn, "Cyclogenesis in the Tropical Atlantic," *Bulletin of the American Meteorological Society,* vol. 21, No. 6, June 1940, pp. 215–217.
6. H. R. Byers and Louis J. Battan, "Some Effects of Vertical Wind Shear on Thunderstorm Structure," *Bulletin of the American Meteorological Society,* vol. 30, No. 5, May 1949, pp. 168–175.
7. John C. Bellamy, "Objective Calculations of Divergence, Vertical Velocity and Vorticity," *Bulletin of the American Meteorological Society,* vol. 30, No. 2, February 1949, pp. 45–49.
8. Norman R. Beers "Atmospheric Stability and Instability" in *Handbook of Meteorology,* ed. by F. A. Berry, Jr., E. Bollay, and N. R. Beers, McGraw-Hill Book Co., Inc., New York, 1940, pp. 693–725.
9. Sverre Petterssen, *Weather Analysis and Forecasting,* McGraw-Hill Book Co. Inc., New York, 1940.