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U.S. DEPARTMENT OF COMMERCE
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Environmental Research Laboratories

An Observational Study of Cumulus Convection Patterns in Relation to the Sea Breeze Over South Florida

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Office
of the Director
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VIRONMENTAL RESEARCH LABORATORIES

OFFICE OF THE DIRECTOR

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AN OBSERVATIONAL STUDY OF CUMULUS CONVECTION PATTERNS IN RELATION TO THE SEA BREEZE OVER SOUTH FLORIDA

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Office of the Director
Boulder, Colorado
January 1973

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ABSTRACT

The organization of convection over south Florida under different large-scale flow regimes was examined in detail using radar and surface observations for 4 days during the summer of 1971. On 2 of the days, satellite photographs from the ATS-3 were also available. A detailed examination of the 4 case-study days revealed organized patterns in the convection that seem to be generated by the geographical shape of Florida and the prevailing large-scale wind. The general patterns on the case study days agree with the results of Frank, Moore, and Fisher (1967). The patterns were best defined on the days with a small time variation in the mean winds and a small difference in mean wind between Miami and Tampa. The case studies will be used to verify a three-dimensional numerical model of the sea breeze being developed by the author.

Radar depiction charts for June, July, and August, prepared hourly by the National Hurricane Center, were examined subjectively by the author. Good or excellent organization, similar to that on the case study days, occurred on over 43 percent of the days during that period. Less than 28 percent of the days had no evidence of organization.

The analysis of the echo organization during 4 case-study days suggests that the development and movement of convection over south Florida are to a large extent controlled by the geographical shape of the peninsula and by the large-scale prevailing winds. The subjective examination of the echo organization during June, July, and August 1971 suggests that such organization exists on many days during the summer.

AN OBSERVATIONAL STUDY OF CUMULUS CONVECTION PATTERNS IN RELATION TO THE SEA BREEZE OVER SOUTH FLORIDA

Roger Pielke

1. INTRODUCTION

South Florida, particularly during the late spring and summer, is often unaffected significantly by large-scale organized synoptic disturbances. Rather, the primary determinant of weather over the area during these periods is the differential heating between the ocean and the peninsula and its interaction with the larger scale synoptic flow. This observational study will present data from several days over south Florida during the summer of 1971 to examine the effect of wind direction on the development and movement of regions of cumulus convection that apparently form in response to sea-breeze convergence zones.

2. PREVIOUS STUDIES

Byers and Rodebush (1948), Gentry (1950), Day (1953), and Gentry and Moore (1954) established the significance of the sea breeze over southern Florida in determining shower occurrence. Frank, Moore, and Fisher (1967) used a compilation of echo frequency maps to estimate the locations and movements of the sea-breeze convergence zones. They found that lines of echoes form on the windward and leeward coasts of south Florida. The windward line of echoes, which forms earlier in the day than the leeward line, moves toward the lee coast during the day and tends to merge with the leeward line in the late afternoon. When the winds are light, echoes form along both coasts and move little during the day. They maintain that the lines of echoes form in response to the sea breeze.

Frank and Smith (1968) correlated the echo areal coverage with a number of meteorological parameters. The only significant correlations involved moisture. The echo areal coverage during the day was best correlated with 650-mb humidity observations at 0700 EST. Their conclusion was that showers are more likely with a deep moist layer. The correlations were obtained using Jacksonville, Tampa, and Miami radiosonde observations.

Frank, Moore, and Fisher and Frank and Smith examined a large number of cases to develop a descriptive statistical model of the three-dimensional aspects of the sea breeze over Florida. This report will examine the echo distribution for different wind regimes on individual days.

3. OBSERVATIONAL STUDY

3.1 Determination of Case Studies

The National Hurricane Center in Miami regularly analyzes fields of mean horizontal wind and mean mixing ratio in a lower tropospheric layer, defined as 1000 to 600 mb, and in an upper tropospheric layer, defined as 600 to 200 mb, for the Northern Hemisphere tropical Atlantic, Caribbean, and Gulf of Mexico. Mean vertical wind-shear charts are prepared from these analyses. The observational results obtained in this study will be used to verify a three-dimensional numerical model of the sea breeze being developed by the author. The basic state of the model is barotropic. Therefore, days where a significant baroclinity is evident in the vertical shear of the horizontal mean winds will not be considered in this study.

Case studies were selected from the period May through August 1971, based on the following criteria:

(a) Radiosonde observations made every 12 hours (0700 and 1900 EST) at Miami and Tampa were used to select cases. An observation period was defined to be sufficiently barotropic when

$$|\Delta\overline{V}| \leq 10 \text{ kt} \tag{1}$$

at both Miami and Tampa. $|\Delta\overline{V}|$ is the magnitude of the wind shear determined from the vector difference between the winds in the upper and lower tropospheric layer analyses. The fraction of observation periods which fit this criteria is tabulated in table 1 for the period May through August 1971. There were no observation periods which satisfied criteria (a) before June 15. A strong upper level westerly jet stream blew across Florida during May and early June.

Table 1. Fraction of Days With Mean Shear Less Than 10 Knots

Month	Fraction of Observations $\|\Delta\overline{V}\| \leq 10$ kt at Both Miami and Tampa
May	.00
June	.48
July	.37
August	.44

The remaining criteria were investigated subjectively.

(b) The lower and upper tropospheric mean winds were used to determine cases with fairly uniform wind directions and wind speeds between Tampa and Miami at the 0700 EST observation.

(c) The lower and upper tropospheric mean charts were investigated at the previous and succeeding radiosonde observation periods to determine cases with a small time variability of the wind.

(d) Twenty-one cases were selected using criteria (a) through (c). Several different wind directions were included. The National Hurricane Center WSR-57 radar depiction charts, which are prepared hourly, were examined for these days. A qualitative interpretation of the organization of echoes based on the charts was made. The results are tabulated in table 2.

Table 2. Degree of Organization of Echoes as Interpreted by the Author

Good	Fair	Poor	None
9	3	6	3

The degree of organization was defined as the degree with which the southern Florida peninsula appeared to control the development and evolution of convection.

Cases were selected according to wind direction from the 12 cases with good or fair degrees of organization.

The subjective selection of cases using criteria (b) through (d) admittedly introduces a bias. However, the organization patterns determined from the individual cases will be used to examine radar depiction charts on a daily basis for the period June through August. The degree of apparent organization will be investigated. These results are given in section 5.

3.2 Light Wind Case (June 29, 1971)

The large-scale winds on June 29, 1971, at both Miami and Tampa were very light. The 1000-600 mb mean winds at Miami at 0700 EST and at Miami and Tampa at 1900 EST on June 29 were slightly south of east at a low wind speed. The 1000-600 mb mean winds, 600-200 mb mean winds, mean vertical wind shears between these two layers, 1000-400 mb mean winds, and 1000-600 mb mean mixing ratios are tabulated in table 3.

Table 3. Mean Winds, Mean Vertical Wind Shear, and Mean Mixing Ratio at Miami and Tampa

	1900 EST June 29		0700 EST June 29		1900 EST June 29	
	Tampa	Miami	Tampa	Miami	Tampa	Miami
$\lvert\Delta\overline{V}\rvert$	12702	13403	05207	03605	02105	01405
1000-600 mb $\overline{V}$	28203	30302	29201	11302	11504	10806
600-200 mb $\overline{V}$	25201	16801	04807	05606	06107	06908
1000-400 mb $\overline{V}$	27903	22902	33901	12201	11304	11407
1000-600 mb $\bar{q}$	9.1	9.8	8.4	10.0	9.3	11.0

The synoptic surface analyses for 0700, 1300, and 1900 EST on June 29 are given in figures 1, 2, and 3. The analyses were plotted and contoured by the National Hurricane Center.

The synoptic pressure gradient over south Florida was weak. A broad Bermuda high was located to the east of the State. A very light east-southeasterly or southeasterly wind would be expected from the pressure distribution. The surface isobars were difluent over the peninsula.

The lower tropospheric mean circulation charts for 0700 and 1900 EST on the 29th are given in figures 4 and 5. The streamlines revealed an

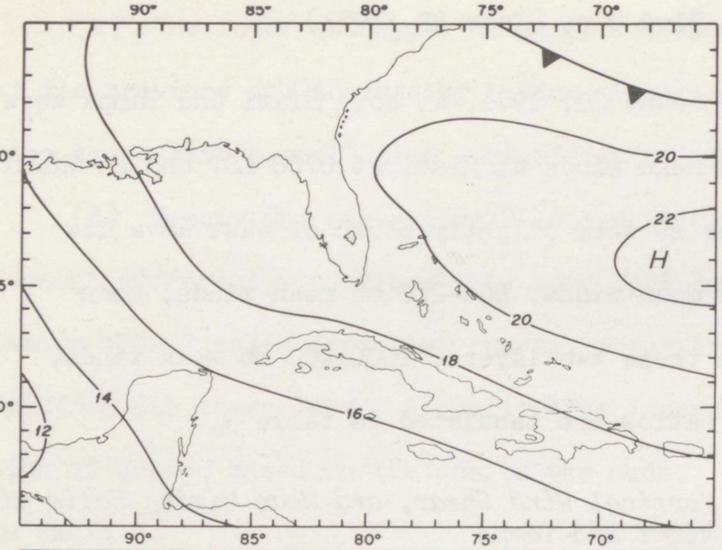


Figure 1. The surface analysis at 0700 EST on June 29, 1971.

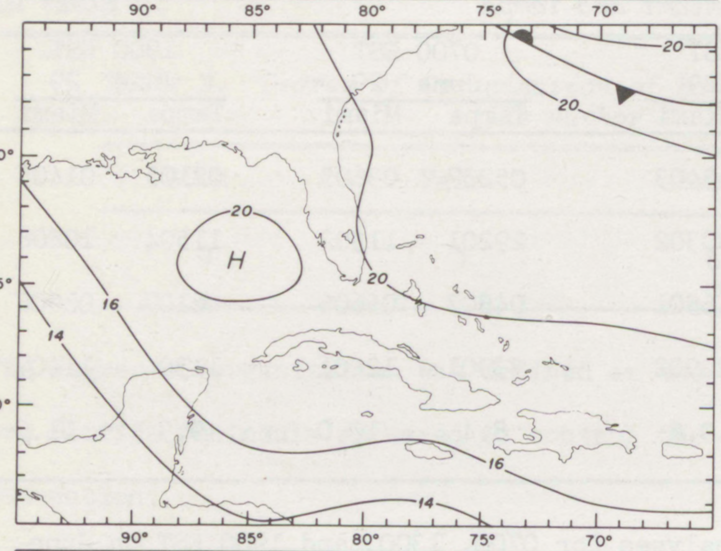


Figure 2. The surface analysis at 1300 EST on June 29, 1971.

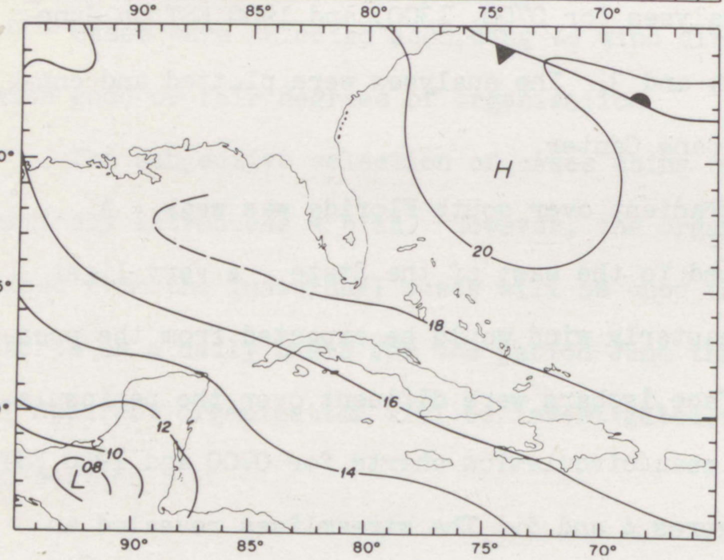
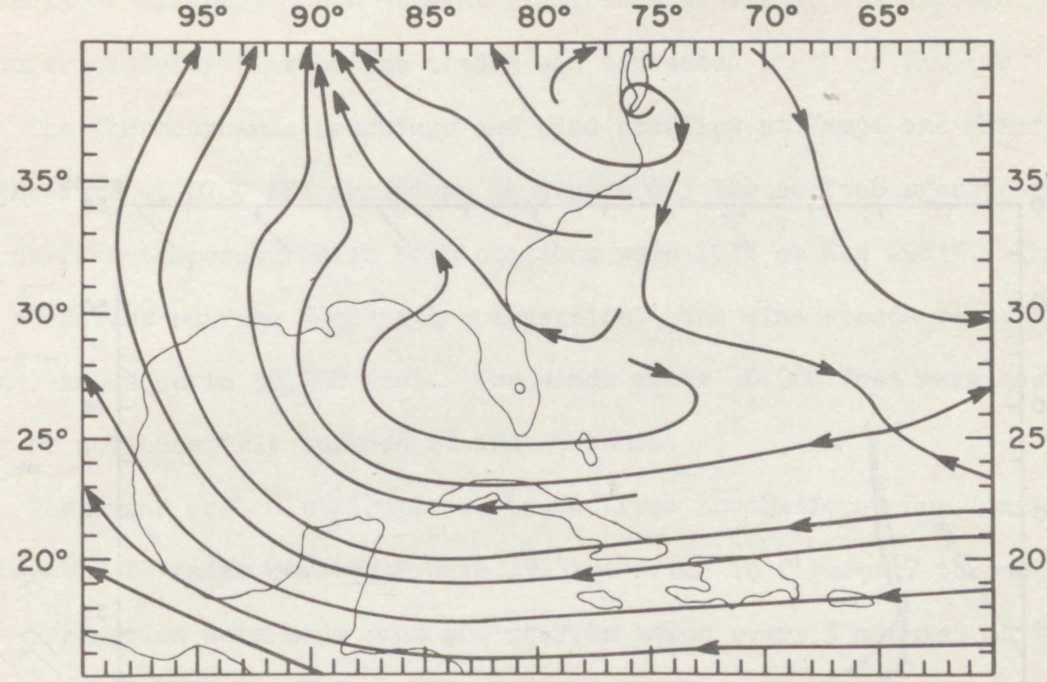


Figure 3. The surface analysis at 1900 EST on June 29, 1971.



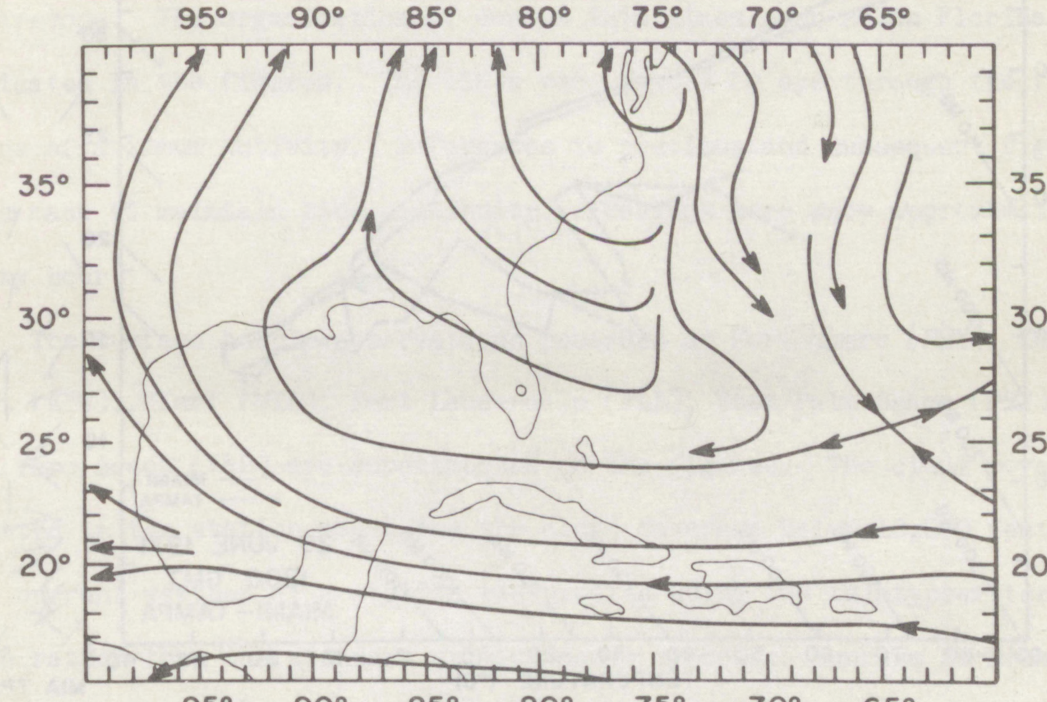


Figure 4. (top) Lower troposphere mean circulation 1000-600 mb layer at 0700 EST on June 29, 1971.

Figure 5. (bottom) Lower troposphere mean circulation 1000-600 mb layer at 1900 EST on June 29, 1971.

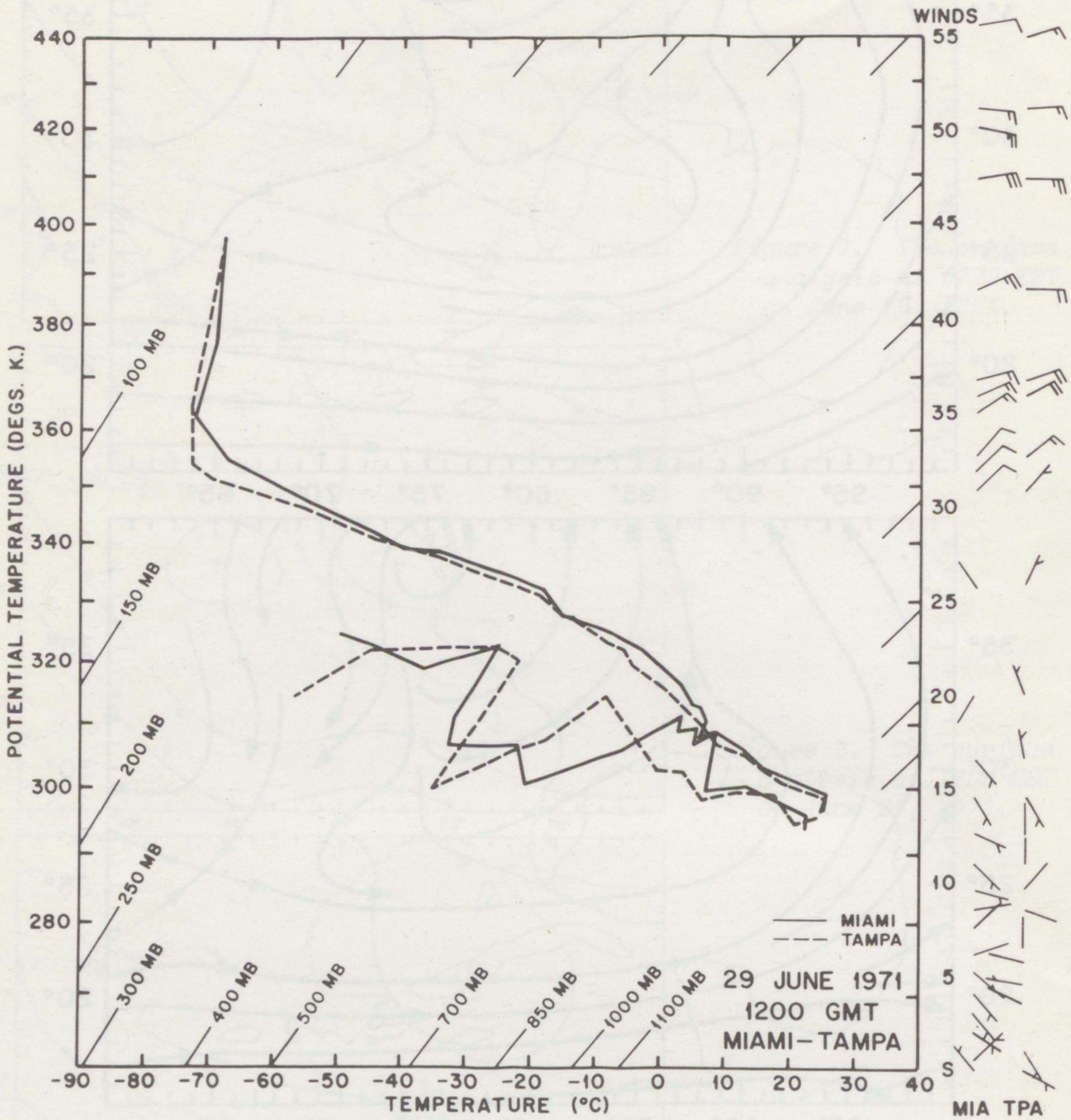


Figure 6. The radiosonde soundings at Miami and Tampa at 0700 EST on June 29, 1971.

easterly or slightly south of east light flow of air across Florida. The stronger easterly flow of the trades was depressed south of Florida.

The thermodynamic soundings and wind profiles at Tampa and Miami on the 29th at 0700 EST are given in figure 6. The surface pressures and surface temperatures at both stations were 1018 mb and 298°K. There was a shallow surface temperature inversion. The wind speeds were less than 5 knots up to 30,000 feet. The winds above 30,000 feet were easterly or northeasterly between 10 and 30 knots.

The radar echo distributions, traced from the National Hurricane Center WSR-57 radar movies of June 29, are given in figures 7 through 15. The movies were made from photographs taken every 5 minutes of the radarscope. The organization of echoes into lines over south Florida is indicated in the figures. The lines were fitted by eye through the regions of maximum activity. References to previous and subsequent figures were made to maintain time continuity. Tracings were made approximately every hour.

The surface hourly observations recorded at Fort Myers (FMY), Key West (EYW), Miami (MIA), Fort Lauderdale (FLL), West Palm Beach (PBI), and Vero Beach (VRB) are superimposed on the figures. The cloud coverage plotted in the station model was the cloud coverage below 10,000 feet. The current weather at a station was plotted using the teletypewriter code rather than the standard station model symbols. Sunrise at Miami on June 29 is at 0532 EST; sunset is at 1916 EST.

Close to the radar site in Miami, the echoes were lost in the ground clutter. Subsequently, information, particularly within 25 miles of Miami, was lost in the radar movies.

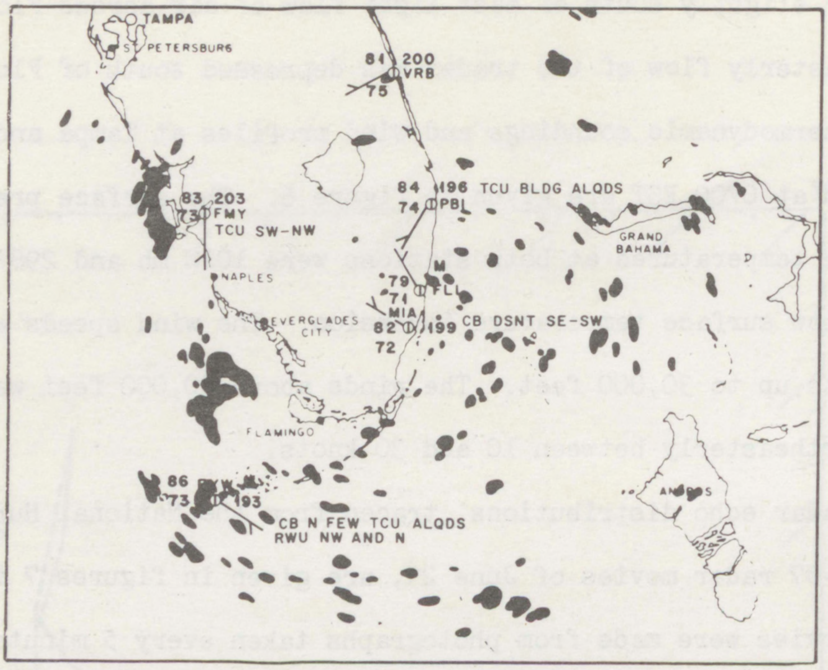


Figure 7. Miami WSR-57 radar echo coverage at 0850 EST and surface observations at 0900 EST on June 29, 1971.

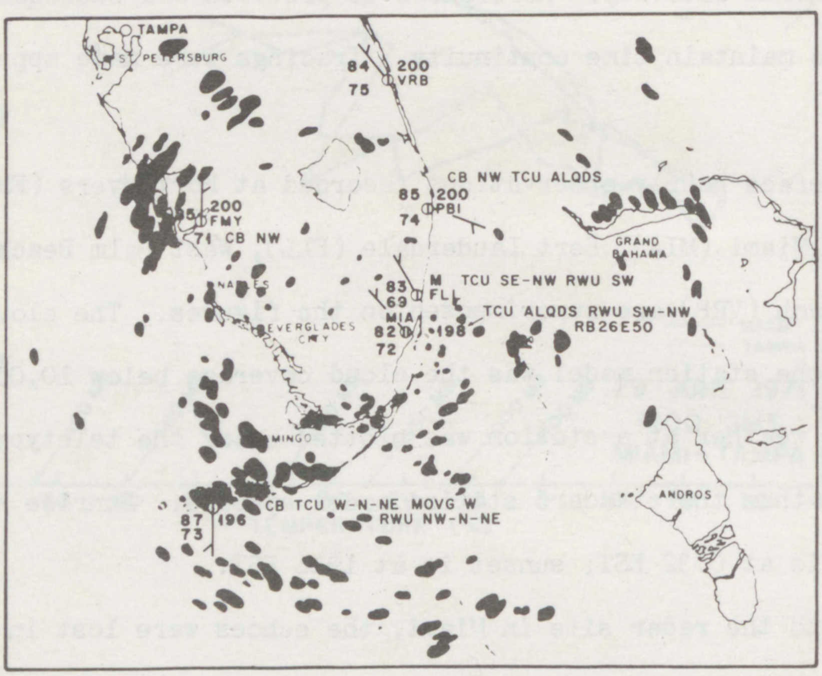


Figure 8. Miami WSR-57 radar echo coverage at 1000 EST and surface observations at 1000 EST on June 29, 1971.

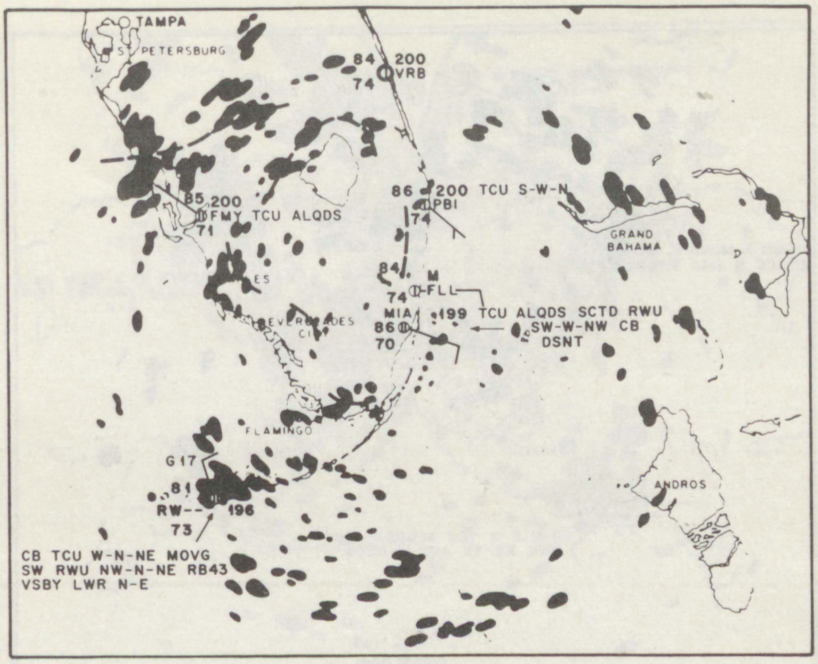


Figure 9. Miami WSR-57 radar echo coverage at 1101 EST and surface observations at 1100 EST on June 29, 1971.

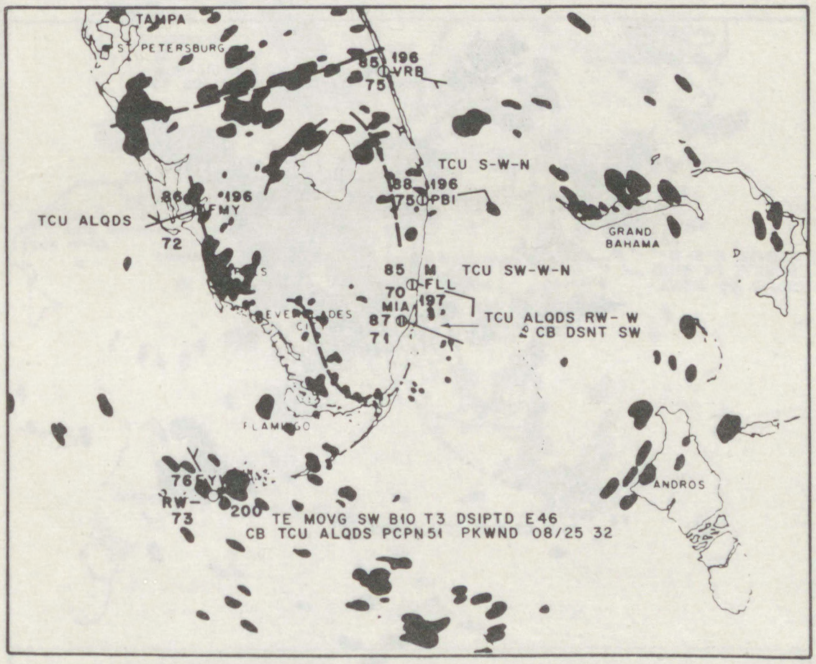


Figure 10. Miami WSR-57 radar echo coverage at 1204 EST and surface observations at 1200 EST on June 29, 1971.

Figure 11. Miami WSR-57 radar echo coverage at 1300 EST and surface observations at 1300 EST on June 29, 1971.

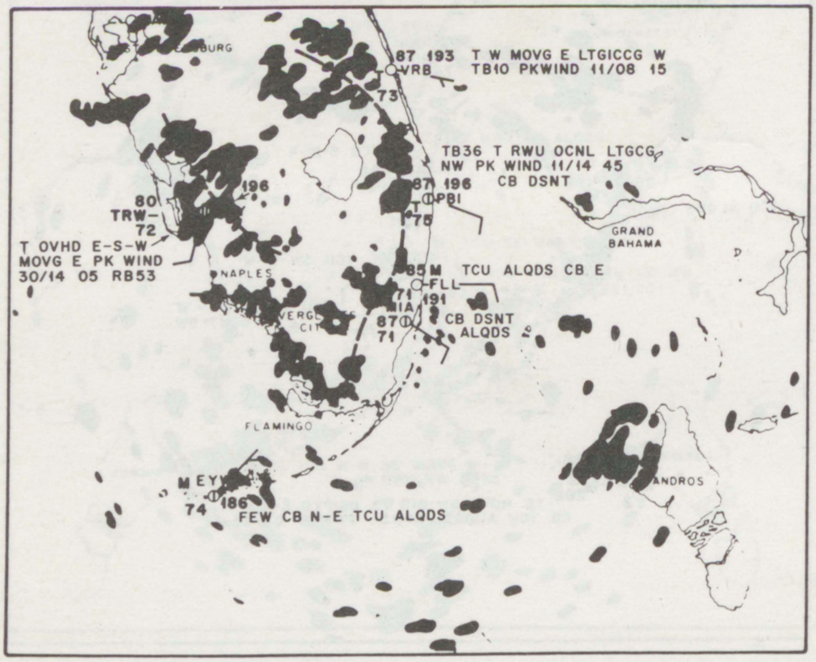


Figure 12. Miami WSR-57 radar echo coverage at 1401 EST and surface observations at 1400 EST on June 29, 1971.

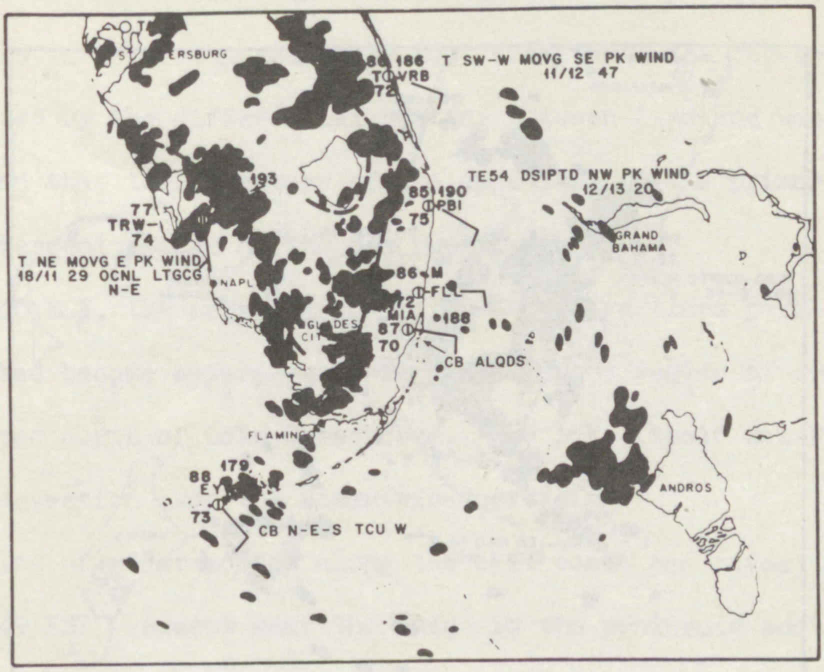


Figure 13. Miami WSR-57 radar echo coverage at 1449 EST and surface observations at 1500 EST on June 29, 1971.

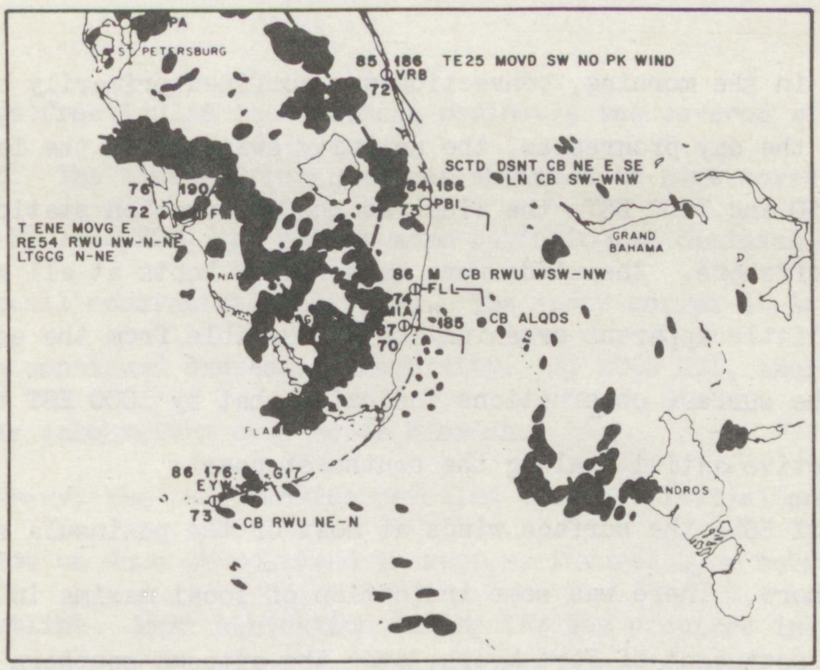


Figure 14. Miami WSR-57 radar echo coverage at 1544 EST and surface observations at 1600 EST on June 29, 1971.

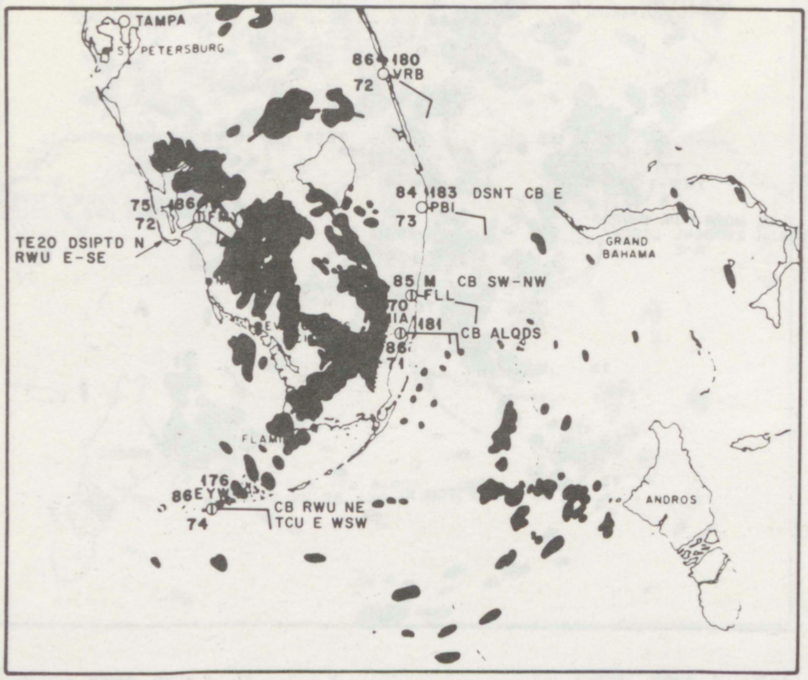


Figure 15. Miami WSR-57 radar echo coverage at 1644 EST and surface observations at 1700 EST on June 29, 1971.

Early in the morning, convection was confined primarily over the ocean. As the day progresses, the activity switched to the land.

At 0850 and 1000 EST, the winds at the observation stations were generally offshore. The winds were less than 7 knots at all stations. There was little apparent organization discernible from the echo distribution. The surface observations indicated that by 1000 EST there was some convective activity along the southeast coast.

By 1101 EST, the surface winds at most of the peninsula stations had become onshore. There was some indication of local maxima in convection over land, southeast of Fort Myers, over the extreme southern tip of the peninsula, as well as north and east of Fort Myers. The first two maxima appeared to be associated with convex bulges in the peninsula. In these regions, the shape of the coastline must accentuate the convergence patterns created by the differential heating between land and water. Neumann (1951) found that the curvature of the coastline is the primary determinant of the convergent nature of the sea breeze.

By 1300 EST, the organization into convective lines paralleling the coastline had become apparent. A large amorphous region of convection had developed north of Lake Okeechobee. The lake itself was free of echoes. Convection over the ocean was decreasing.

The line of radar echoes along the east coast had moved inland somewhat by 1449 EST. Except near the bulge in the peninsula southeast of Fort Myers on the west coast, the radar echoes were confined primarily along the coast. The onshore winds were around 10 knots. The convection northwest of Andros Island in the Bahamas was apparently generated by the island.

A large fraction of the southern peninsula was covered with echoes by 1544 EST. The lines of radar echoes appeared to have moved inland somewhat. By 1644 EST, the echoes were beginning to diminish although there was still considerable activity. The radar movies at later times indicated a continued decrease in activity. By 2000 EST, there was very little radar echo return over south Florida.

In summary, the radar movies revealed that the initial development of convection on June 29 occurred in regions favored by a convex shape of the coastline. Most convection during the day occurred in lines paralleling the coastline of south Florida. The lines moved inland very slowly.

The Applications Technology Satellite (ATS-3) geostationary spacecraft, located 22,500 miles from earth approximately over latitude 3°S and longitude 76°W, takes photographs approximately every 26 minutes. The Satellite Applications Section of the National Hurricane Center made blowups of a portion of the photographs centered over south Florida for June 29.

Woodley and Sancho (1971) have used a color densitometer to contour the brightness of satellite photographs. They found a high correlation between radar echoes and brightness of clouds as seen from the ATS-3. The correspondence was best when the cloud system was young and vigorous and worst when it was old and decaying. Similarly, the satellite photographs of south Florida on June 29 were brightness contoured by a Model 702 Datacolor System of Spatial Data Systems, Inc., of Goleta, Calif. This is the same machine used by Woodley and Sancho. The densitometer has 12 color levels corresponding to brightness levels. Woodley and Sancho argued that quantitative comparison among densitometer photographs was unwise because of the lack of normalization of brightness between photographs.

The photographs of the color contours, obtained from the densitometer cathode ray screen, cannot be reproduced in this report because the photographs are in color. The densitometer photographs are used in the interpretation of the cloud patterns as seen by the satellite. The satellite photographs are reproduced in figures 16 through 27. The approximate outline of Florida, as gridded by the Satellite Applications Section, is traced on the figures. An accurate gridding of the photographs was impossible. The Satellite Applications Section informed the author that

Figure 16. ATS-3 photograph at 0852 EST on June 29, 1971.

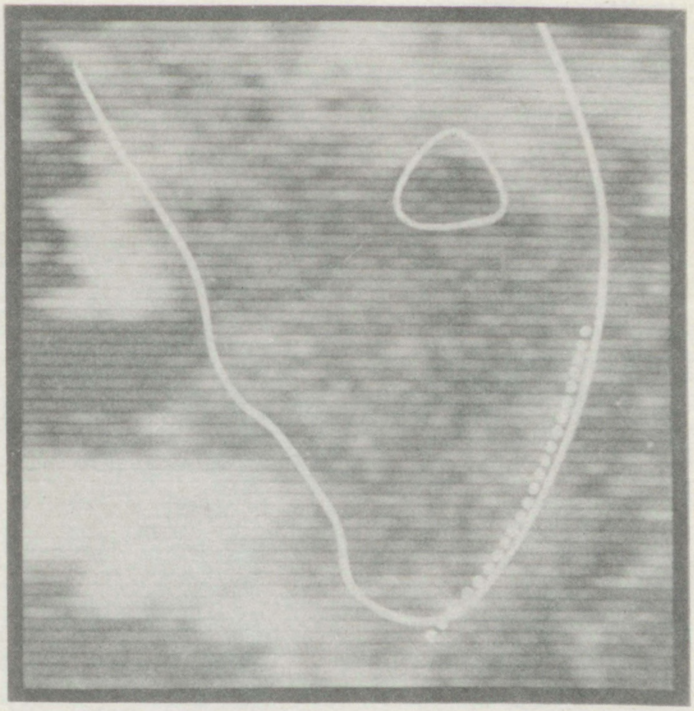


Figure 17. ATS-3 photograph at 0919 EST on June 29, 1971.

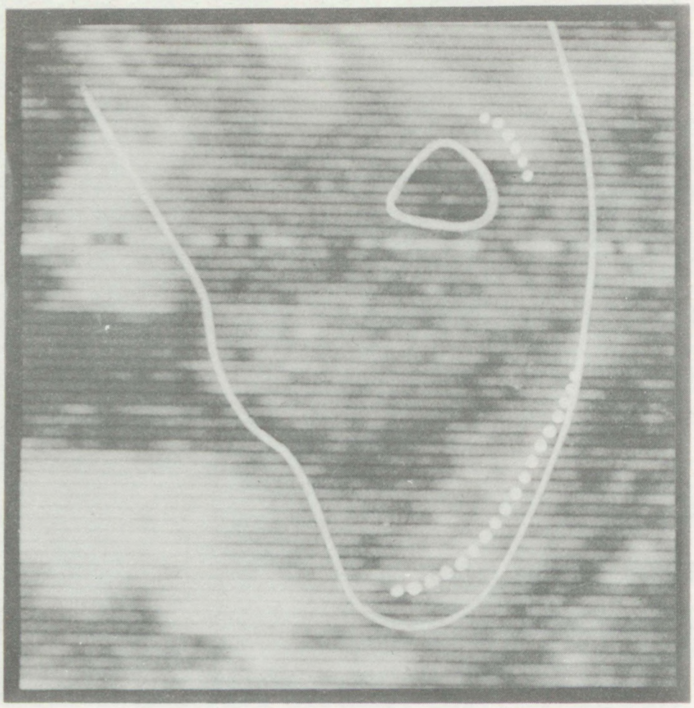


Figure 18. ATS-3 photograph at 0946 EST on June 29, 1971.

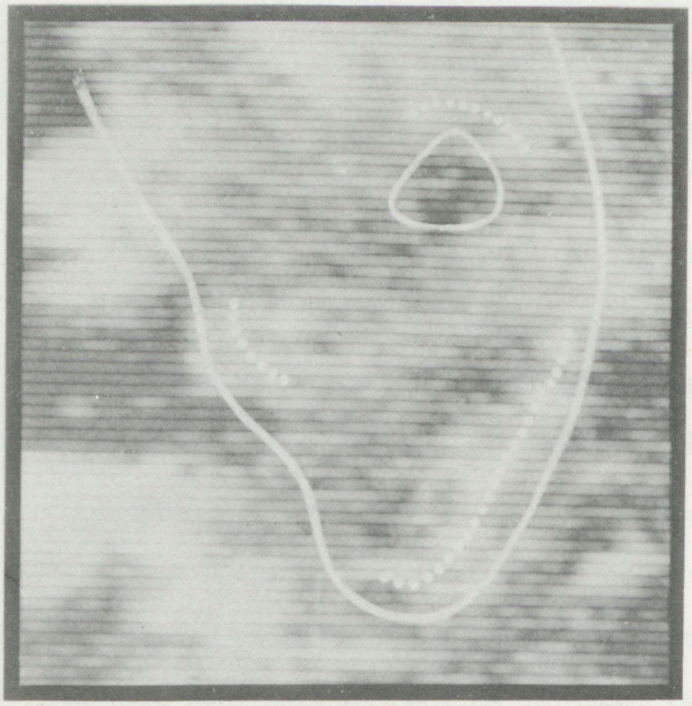


Figure 19. ATS-3 photograph at 1012 EST on June 29, 1971.

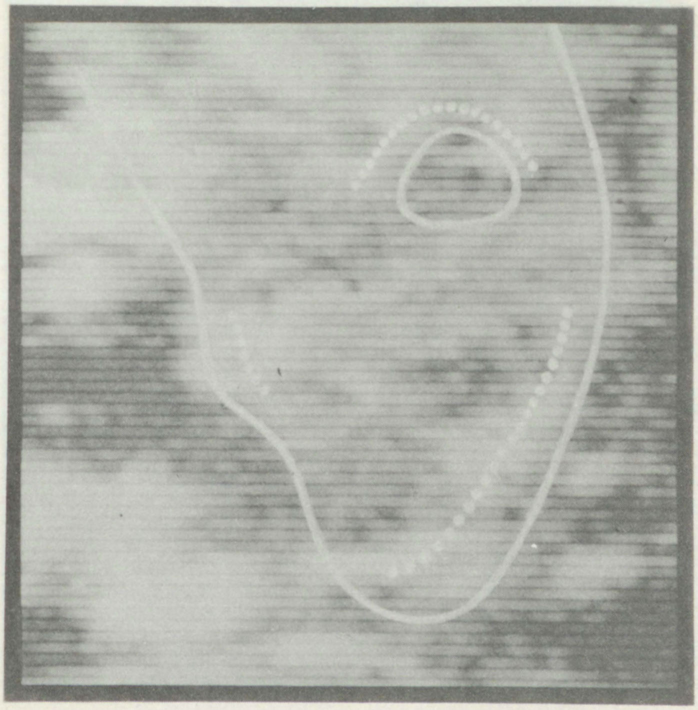


Figure 20. ATS-3 photograph at 1036 EST on June 29, 1971.

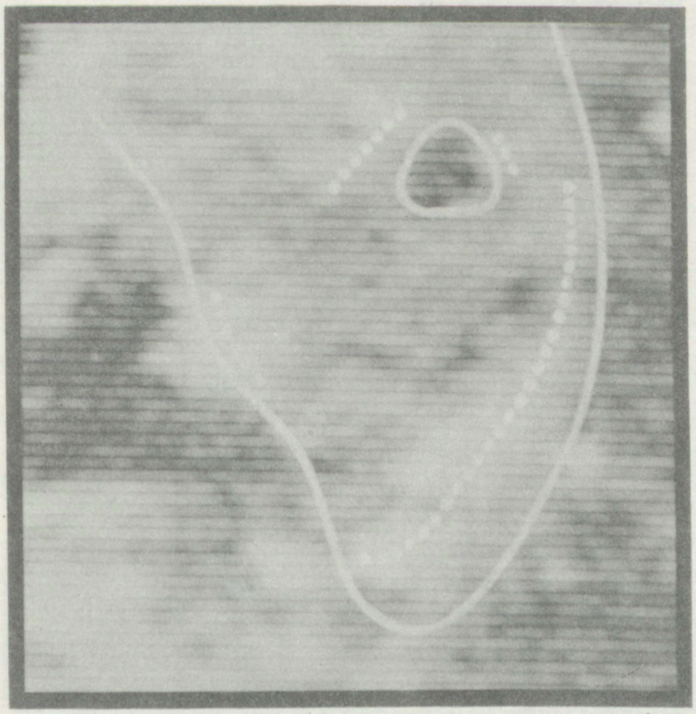


Figure 21. ATS-3 photograph at 1129 EST on June 29, 1971.

Figure 22. ATS-3 photograph at 1153 EST on June 29, 1971.

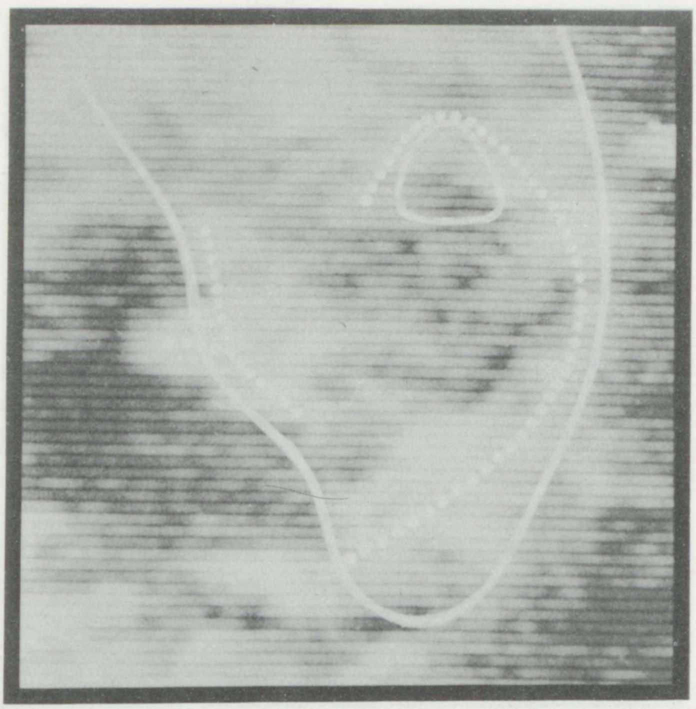


Figure 23. ATS-3 photograph at 1223 EST on June 29, 1971.

Figure 24. ATS-3 photograph at 1249 EST on June 29, 1971.

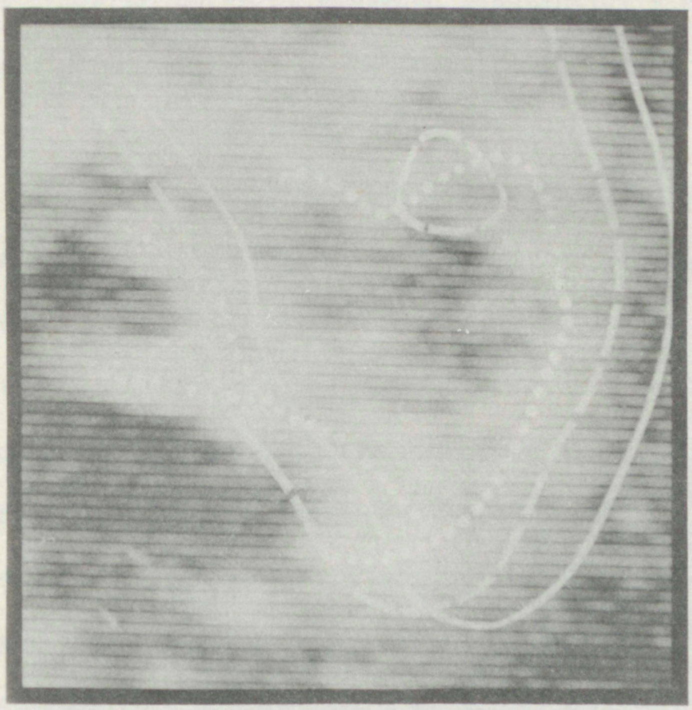


Figure 25. ATS-3 photograph at 1316 EST on June 29, 1971.

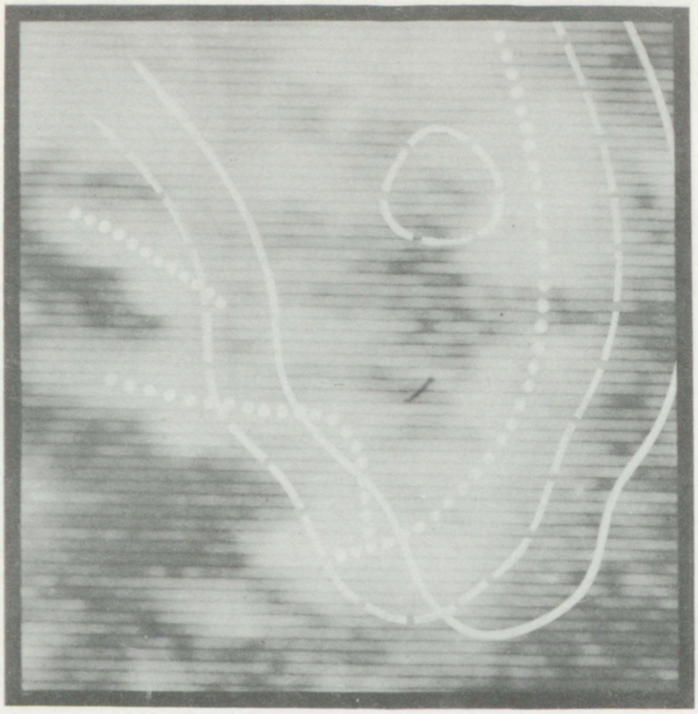


Figure 26. ATS-3 photograph at 1343 EST on June 29, 1971.

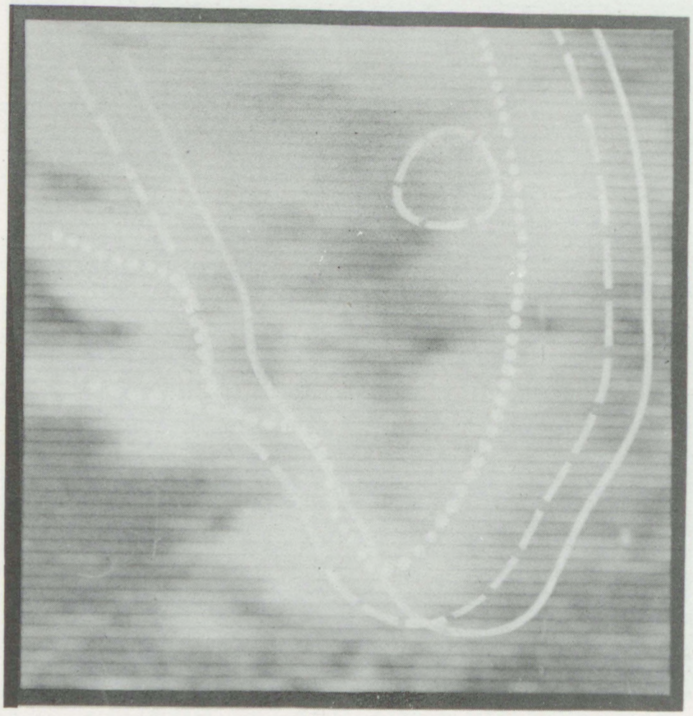


Figure 27. ATS-3 photograph at 1410 EST on June 29, 1971.

the outline of Florida may be off by as much as 30 miles. Florida appears to be gridded too far east in the last several figures. A dashed line is sketched onto the last few satellite photographs to indicate the approximate actual location of the peninsula as estimated by the author. When Lake Okeechobee is visible as a cloud-free region, proper alinement is comparatively east. During the last few satellite photographs, however, the lake was obscured by cirrus anvils from thunderstorms. Nevertheless, a qualitative description of the development and evolution of the cloud systems was possible using the satellite photographs and the densitometer representation of brightness of the clouds.

The organization of the cloud masses into lines over south Florida is sketched on the figures. The lines were fitted by eye through the brighter cloud regions as revealed by the color densitometer. The lines of cloud masses appeared to shift westward substantially during the last few satellite photographs. Most of this apparent motion resulted from the inaccuracy of gridding the photographs. Because no proper benchmark can be used to locate Florida exactly, the satellite photographs will be reproduced as gridded by the Satellite Applications Section.

The earlier satellite pictures revealed no significant cloudiness over south Florida. At 0852 EST, most cloud activity appeared off the southwestern coast. The radar at about the same time indicated a local maximum in echo coverage in the same area, although it was somewhat smaller than in the satellite photograph. By 0919 EST, an area of clouds had developed along the southeast coast. The area off the southwest coast was still quite pronounced.

By 0946 EST, an area of cloud activity developed in the bulge on the west coast. The area along the southeast coast was becoming more pronounced. By 1129 EST, several very pronounced areas were definable. Activity was concentrated in the bulge on the west coast, slightly inland on the east coast, and east of the lake. A broad area of cloud stretched across the central portion of the State. This pattern was evident until 1223 EST when the activity in the bulge on the west coast appeared to shift offshore somewhat.

After 1223 EST, clouds covered a large portion of south Florida. There was evidence of two regions of activity along the coasts with a minimum in the interior. The activity through the central portion of the State continued and was traced to a synoptic-scale cloud feature which stretched westward from the Atlantic through central Florida.

An examination of the satellite photographs suggested that the cirrus anvils generated by the convection significantly obscure the active convective regions after 1223 EST. The anvils were being sheared off toward the west. The radar echo coverage and cloud brightness seemed less correlated after this period. This supports Woodley and Sancho's observation that the older cloud systems have a smaller correspondence between locations of radar echoes and of brightest cloud masses. It also reflects the inaccuracy of the gridding of the satellite photographs.

The satellite photographs early in the day are most useful in describing the location of the active convection. This is the time the convection has not developed sufficiently to produce many radar echoes. The satellite photographs reveal a very organized pattern to the convection. However, the inaccuracy of the gridding of the photographs makes precise location of the organization with respect to the Florida peninsula impossible. Later in the day, radar coverage becomes more useful. At that time, the existence of copious quantities of thunderstorm anvils obscures the organization as seen by the satellite.

The radar, satellite, and surface observations suggest a characteristic model of convection on light wind days over south Florida. The convection develops in geographically favored regions. The convex shape of the bulge on the west coast and the tip of extreme southern Florida accentuate the convergence patterns created by the differential heating of land and water. Moreover, the interaction of a Lake Okeechobee lake breeze and the sea breeze create a maximum in convergence east of Lake Okeechobee. These regions of maximum activity persist throughout most of the day. The regions of activity move inland very slowly. The activity in the bulge on the west coast moves inland somewhat more rapidly than elsewhere.

3.3 Southeast Wind Case (August 19, 1971)

The large-scale winds for the radiosonde observation periods, 1900 EST on August 18 and 0700 and 1900 EST on August 19, were primarily from the southeast or east-southeast. The higher level mean winds tended to be more southeasterly than the lower mean winds. The wind speeds at Miami were somewhat higher than at Tampa. The 1000-600 mb mean winds, 600-200 mb mean winds, mean vertical wind shears between these two levels, 1000-400 mb mean winds, and 1000-600 mb mean mixing ratios are tabulated in table 4.

Table 4. Mean Winds, Mean Vertical Wind Shear, and Mean Mixing Ratio at Miami and Tampa

	1900 EST August 18		0700 EST August 19		1900 EST August 19	
	Tampa	Miami	Tampa	Miami	Tampa	Miami
$\lvert\Delta\overline{V}\rvert$	16012	14108	20905	13003	21909	12908
1000-600 mb $\overline{V}$	10509	09413	12311	12016	11311	10212
600-200 mb $\overline{V}$	13719	11220	14513	12219	15913	11320
1000-400 mb $\overline{V}$	11811	10116	13112	12017	13012	10714
1000-600 mb $\bar{q}$	9.6	11.0	10.0	10.0	10.0	10.0

The synoptic surface analysis for 0700, 1300, and 1900 EST on August 19 are given in figures 28, 29, and 30. The synoptic pressure gradient would indicate a fairly light east-southeasterly or southeasterly flow of air across south Florida. The isobars became oriented more east-west with time, although the change from 0700 to 1900 EST was slight. A flat Bermuda high lay to the east of the State.

The lower troposphere mean circulation charts for 0700 and 1900 EST on the 19th are given in figures 31 and 32. The flow was southeasterly at 0700 EST, but had backed to east-southeasterly by 1900 EST. South Florida was situated on the northern edge of a fairly uniform easterly flow.

The thermodynamic soundings and wind profiles on the 19th at 0700 EST at Miami and Tampa are given in figure 33. The surface pressures and temperatures at that time were 1017 mb and 300°K at Miami and 1018 mb and 297°K at Tampa. The soundings were very similar. The winds at all levels were predominantly southeasterly at both stations. The winds were somewhat higher at Miami.

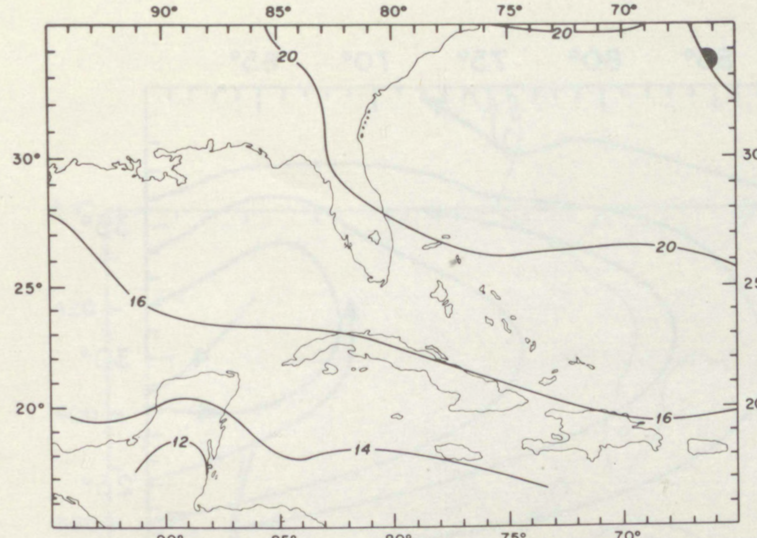


Figure 28. The surface analysis at 0700 EST on August 19, 1971.

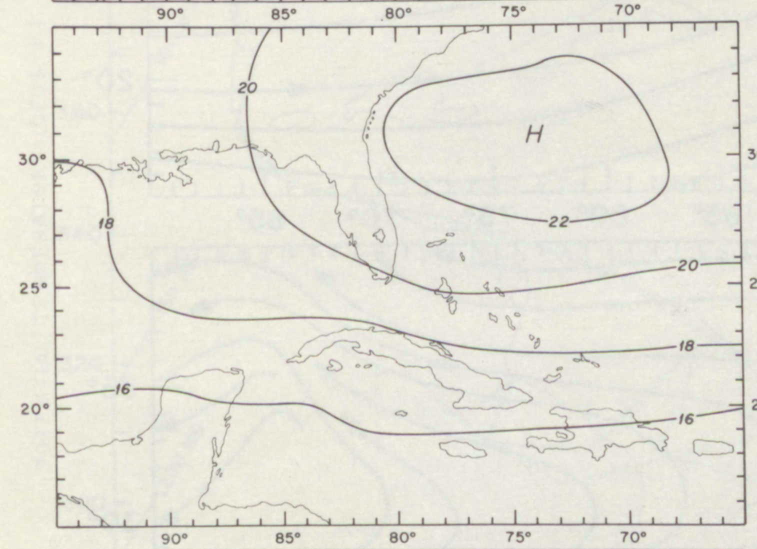


Figure 29. The surface analysis at 1300 EST on August 19, 1971.

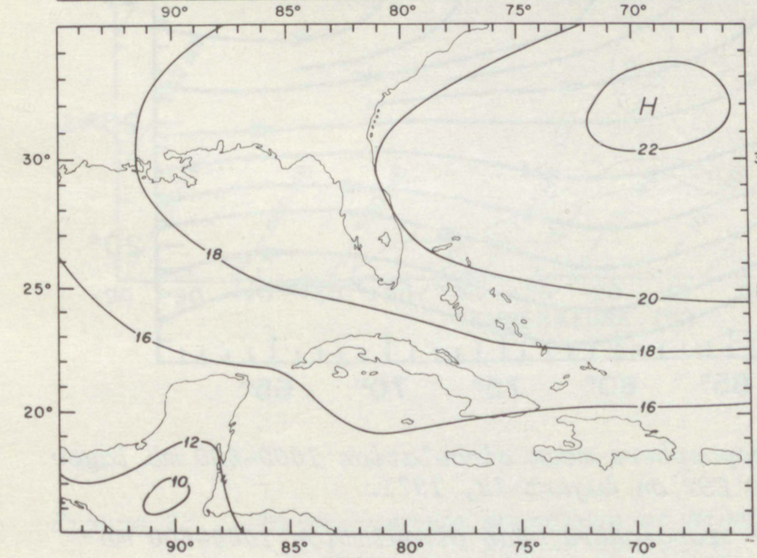
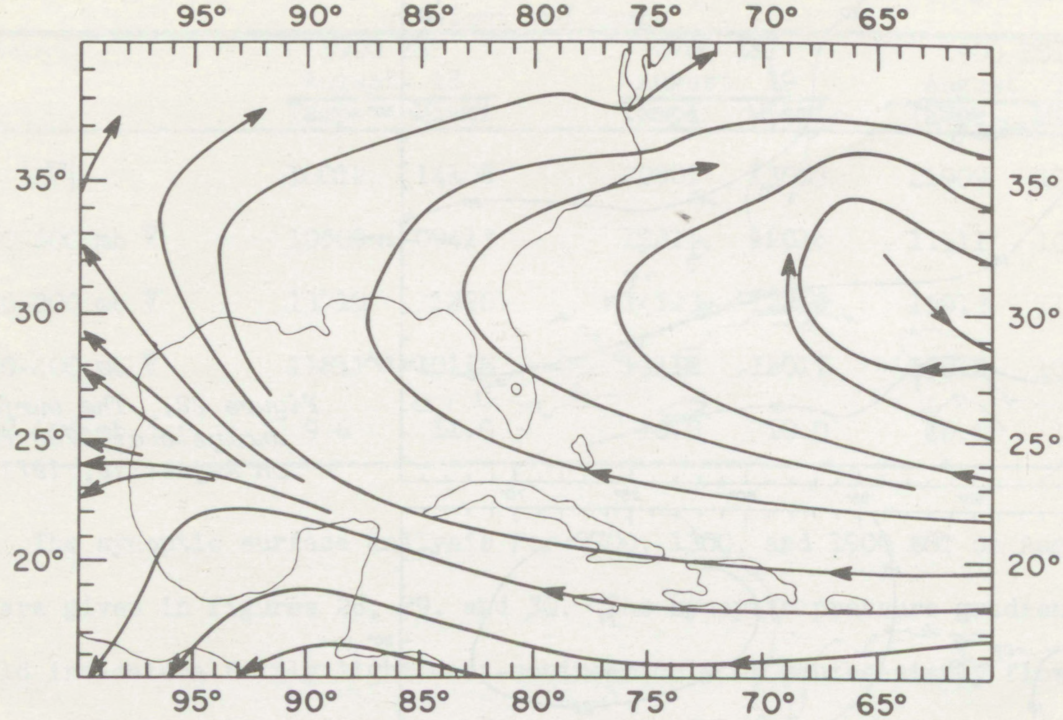


Figure 30. The surface analysis at 1900 EST on August 19, 1971.



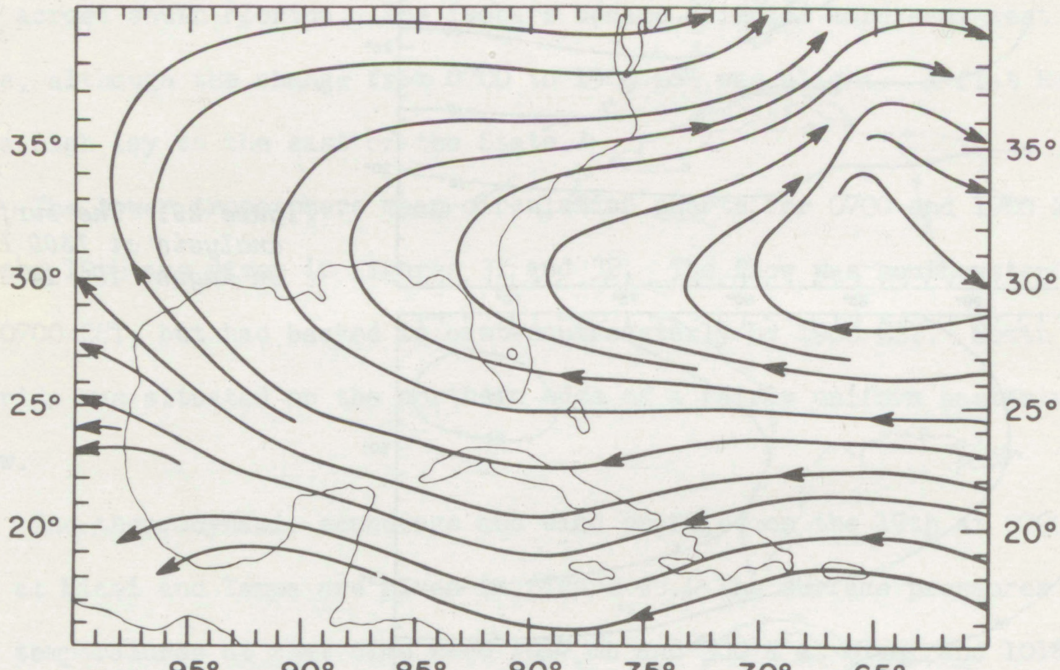


Figure 31. (top) Lower troposphere mean circulation 1000-600 mb layer at 0700 EST on August 19, 1971.

Figure 32. (bottom) Lower troposphere mean circulation 1000-600 mb layer at 1900 EST on August 19, 1971.

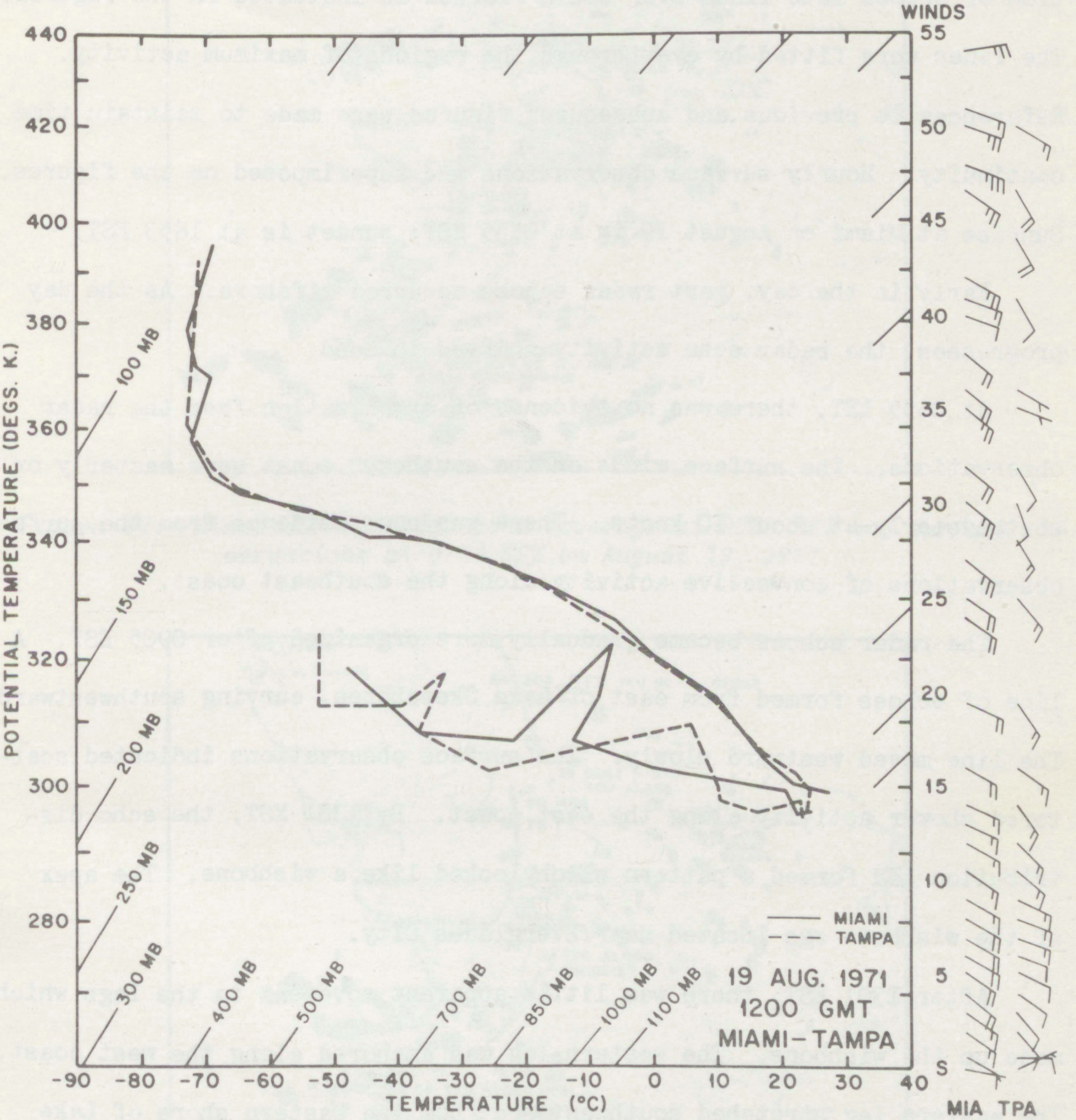


Figure 33. The radiosonde soundings at Miami and Tampa at 0700 EST on August 19, 1971.

The radar echo distributions, traced from the Miami WSR-57 radar movies of August 19, are given in figures 34 through 45. The organization of echoes into lines over south Florida is indicated in the figures. The lines were fitted by eye through the regions of maximum activity. References to previous and subsequent figures were made to maintain time continuity. Hourly surface observations are superimposed on the figures. Sunrise at Miami on August 19 is at 0555 EST; sunset is at 1853 EST.

Early in the day, most radar echoes occurred offshore. As the day progresses, the radar echo activity shifted to land.

At 0655 EST, there was no evidence of organization from the radar observations. The surface winds on the southeast coast were easterly or southeasterly at about 10 knots. There was some evidence from the surface observations of convective activity along the southeast coast.

The radar echoes became gradually more organized after 0905 EST. A line of echoes formed from east of Lake Okeechobee, curving southwestward. The line moved westward slowly. The surface observations indicated scattered shower activity along the east coast. By 1301 EST, the echo distribution had formed a pattern which looked like a wishbone. The apex of the wishbone was located near Everglades City.

After 1301 EST, there was little apparent movement to the legs which made up the wishbone. The western leg was anchored along the west coast. The eastern leg stretched southwestward from the eastern shore of Lake Okeechobee to near Everglades City. Around 1333 EST, there was a rapid development of echoes near the apex of the wishbone. By 1559 EST, the activity had decreased considerably. After 1702 EST, there was no evidence of organization.

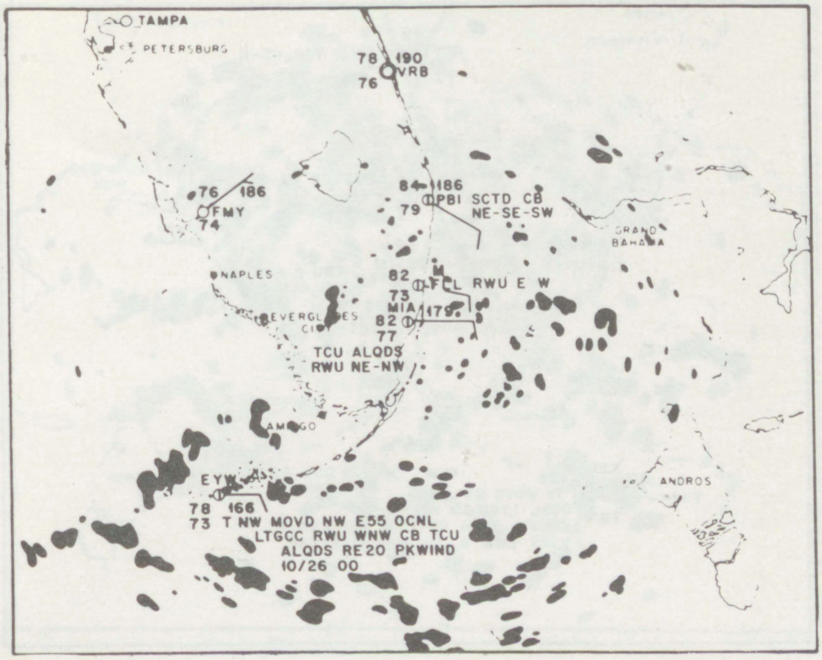


Figure 34. Miami WSR-57 radar echo coverage at 0655 EST and surface observations at 0700 EST on August 19, 1971.

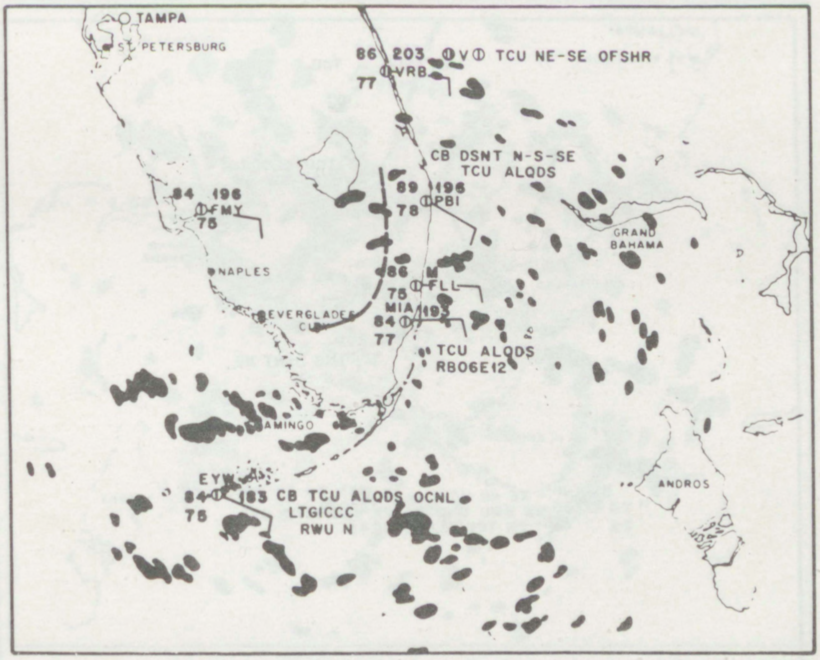


Figure 35. Miami WSR-57 radar echo coverage at 0905 EST and surface observations at 0900 EST on August 19, 1971.

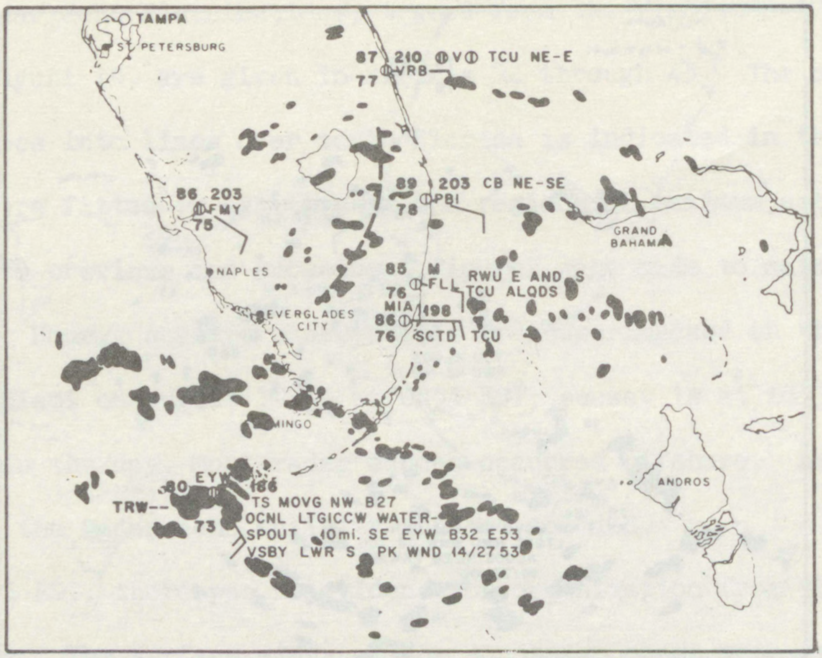


Figure 36. Miami WSR-57 radar echo coverage at 1002 EST and surface observations at 1000 EST on August 19, 1971.

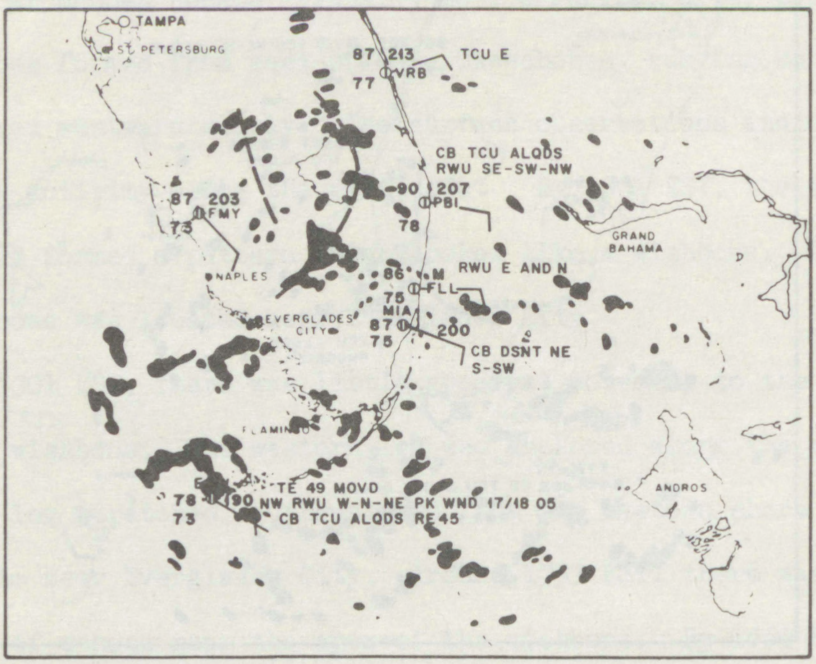


Figure 37. Miami WSR-57 radar echo coverage at 1100 EST and surface observations at 1100 EST on August 19, 1971.

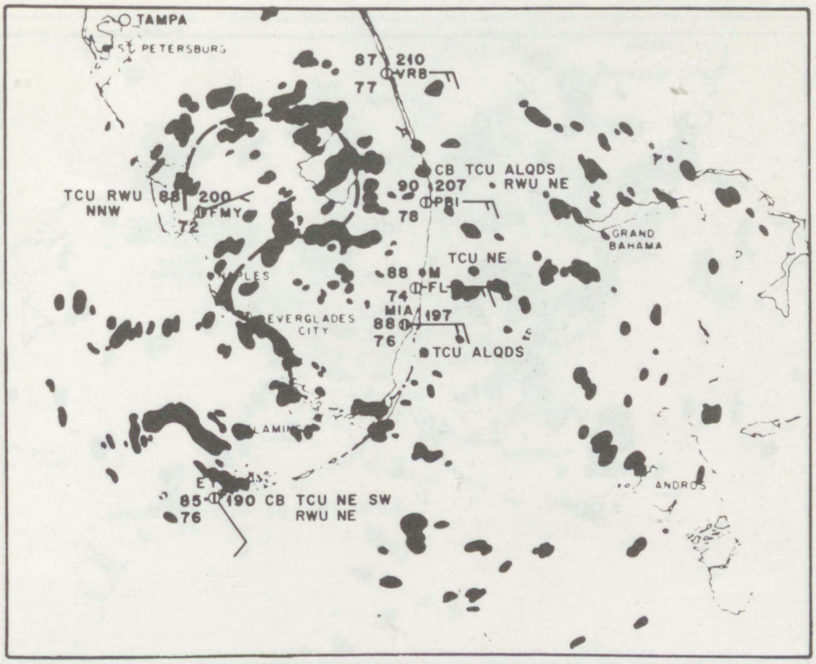


Figure 38. Miami WSR-57 radar echo coverage at 1202 EST and surface observations at 1200 EST on August 19, 1971.

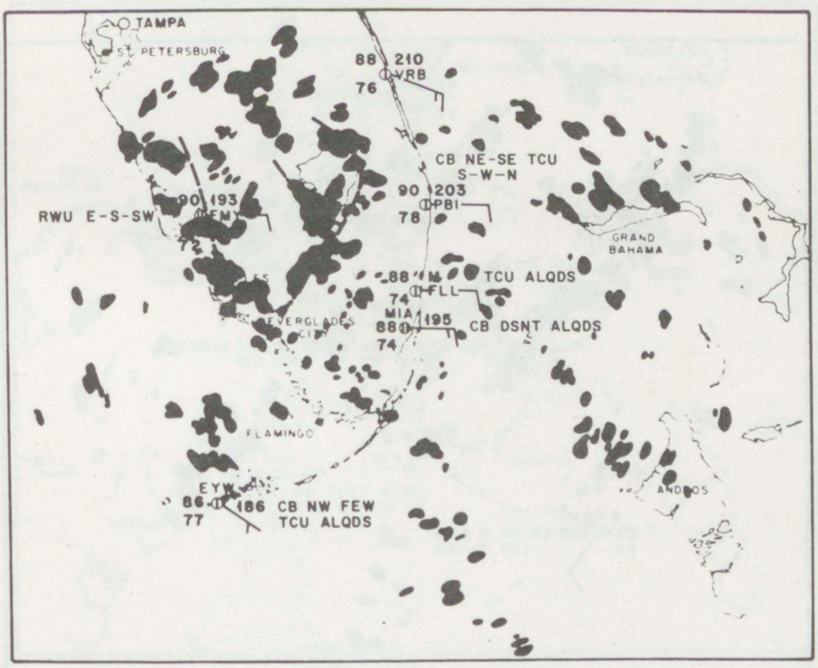


Figure 39. Miami WSR-57 radar echo coverage at 1301 EST and surface observations at 1300 EST on August 19, 1971.

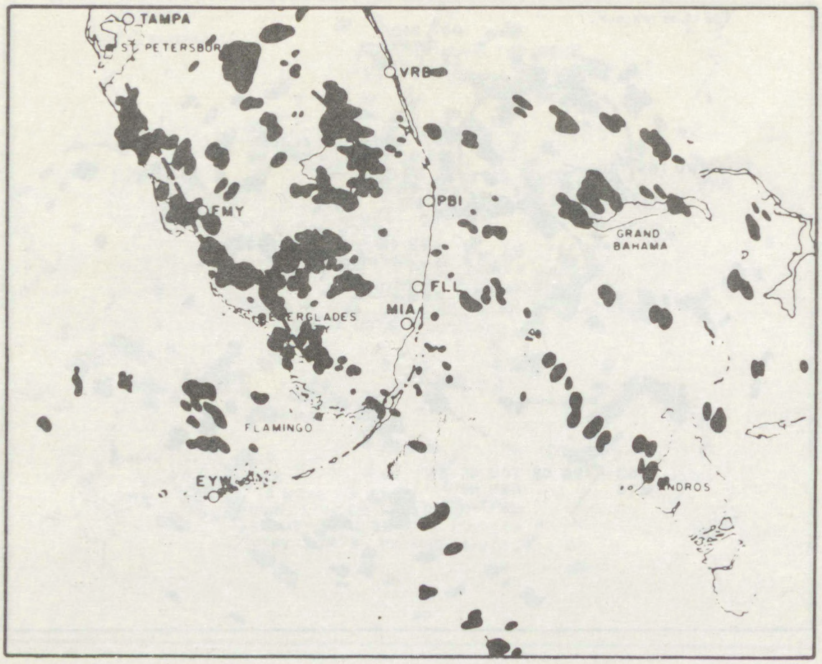


Figure 40. Miami WSR-57 radar echo coverage at 1333 EST on August 19, 1971.

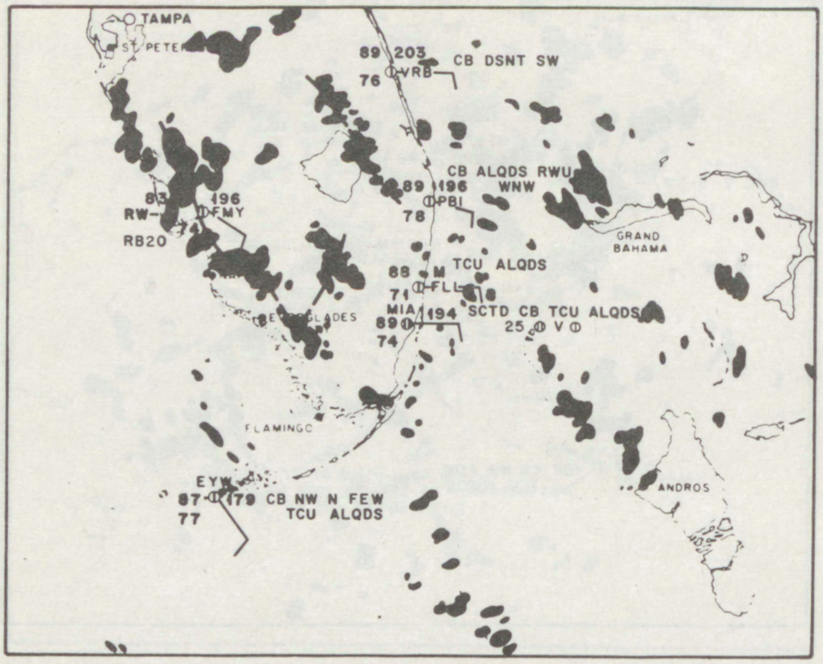


Figure 41. Miami WSR-57 radar echo coverage at 1402 EST and surface observations at 1400 EST on August 19, 1971.

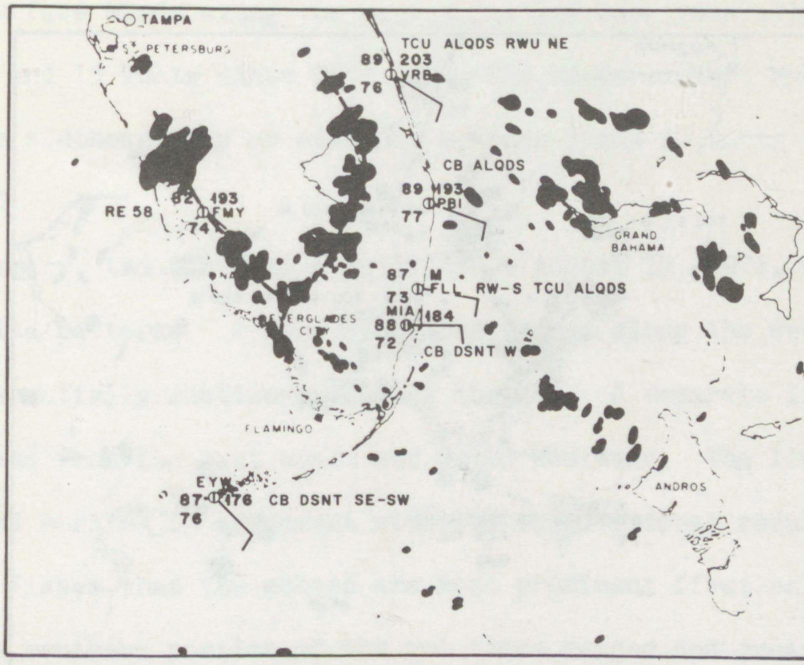


Figure 42. Miami WSR-57 radar echo coverage at 1501 EST and surface observations at 1500 EST on August 19, 1971.

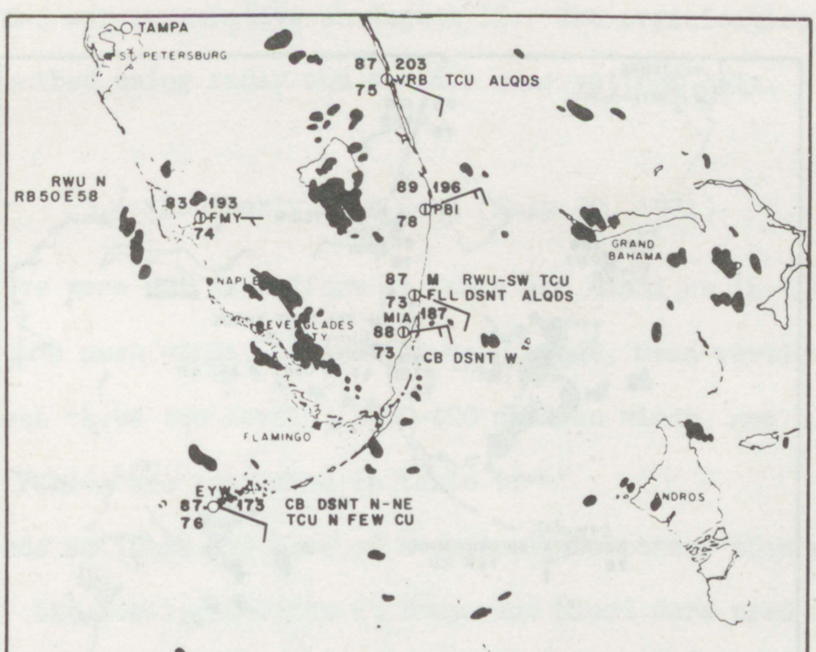


Figure 43. Miami WSR-57 radar echo coverage at 1559 EST and surface observations at 1600 EST on August 19, 1971.

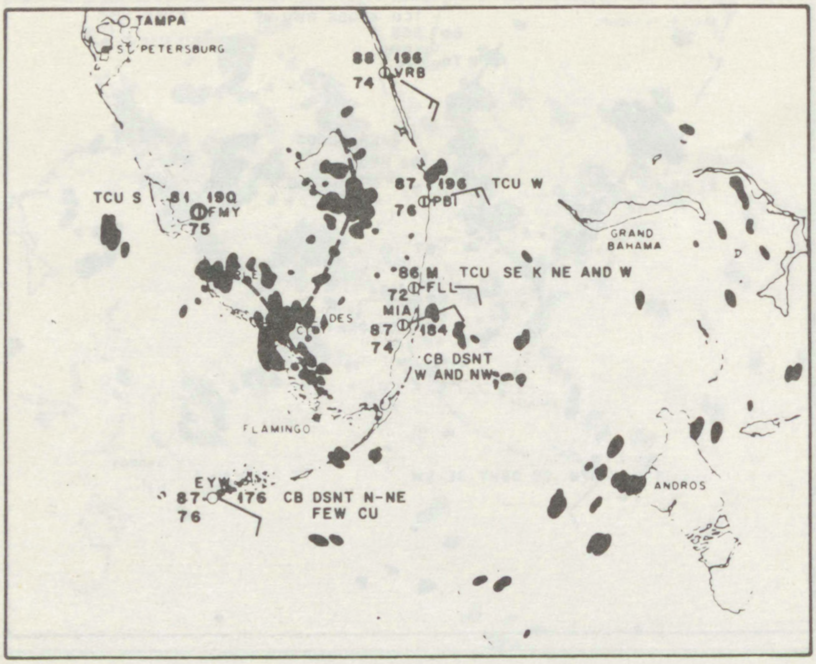


Figure 44. Miami WSR-57 radar echo coverage at 1702 EST and surface observations at 1700 EST on August 19, 1971.

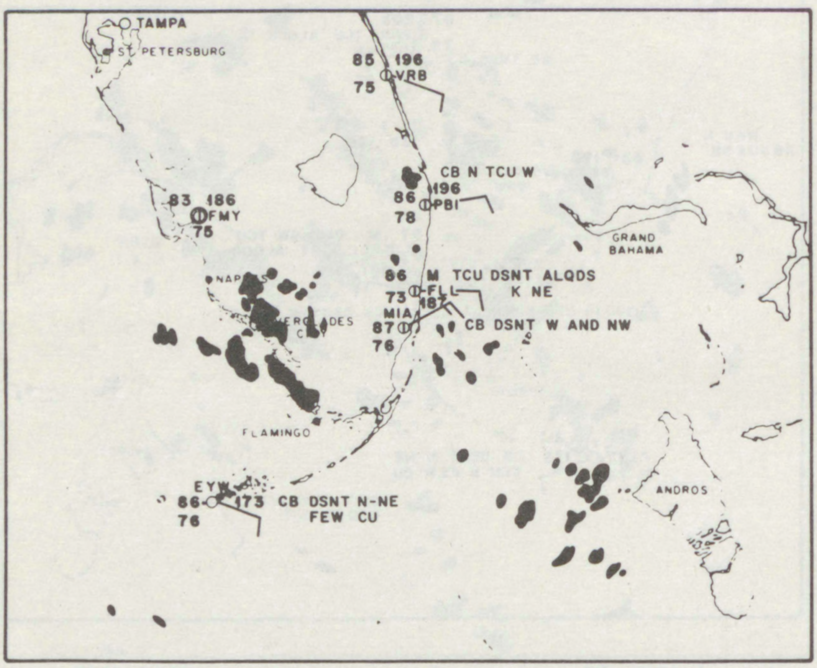


Figure 45. Miami WSR-57 radar echo coverage at 1802 EST and surface observations at 1800 EST on August 19, 1971.

The surface winds along the east coast had been generally easterly between 10 and 15 knots since 0655 EST. The winds at Fort Myers had been principally southeasterly or easterly between 5 and 10 knots during the same period.

In summary, the convective activity on August 19, 1971, was organized into definite patterns. A line of echoes formed along the west coast and remained essentially stationary during the day. A separate line of echoes formed inland from the east coast and moved westward. The line on the east coast formed earlier in agreement with the observational results of Frank, Moore, and Fisher that the echoes are most prominent first on the windward coast. The southern portion of the two lines merged and created a wishbone-type pattern. The wishbone was essentially stationary during the afternoon.

The ATS-3 was inoperative on August 19. The organization on that day must be described using radar and surface observations only.

3.4 Southerly Wind Case (July 20, 1971)

The winds were not as uniform at Tampa and Miami as in the last case. The 1000-600 mb mean winds, 600-200 mb mean winds, mean vertical wind shears between these two levels, 1000-400 mb mean winds, and 1000-600 mb mean mixing ratios are tabulated in table 5.

The winds at Tampa had more of a westerly component than at Miami. At 0700 EST, the low-level winds at Tampa and Miami were predominantly southerly. The winds at Tampa at that time were west of south; at Miami, they were east of south. The lower winds became more westerly with time.

Table 5. Mean Winds, Mean Vertical Wind Shear, and Mean Mixing Ratio at Miami and Tampa

	1900 EST July 19		0700 EST July 20		1900 EST July 20	
	Tampa	Miami	Tampa	Miami	Tampa	Miami
$\lvert\Delta\overline{V}\rvert$	04206	06715	02907	05608	12507	10518
1000-600 mb $\overline{V}$	23408	15705	20908	16807	24509	21903
600-200 mb $\overline{V}$	26403	08616	21001	10408	19408	11417
1000-400 mb $\overline{V}$	24307	12706	20506	16106	23410	18905
1000-600 mb $\bar{q}$	9.7	10.0	11.0	11.0	9.7	11.0

By 1900 EST, the lower winds were southwesterly. The vertical wind shears at Miami at 1900 EST on July 19 and at 1900 EST on July 20 were greater than 10 knots.

The synoptic surface analysis for 0700, 1300, and 1900 EST on July 20 are given in figures 46, 47, and 48. The synoptic pressure gradient would indicate a light south-southeasterly or southerly flow of air across south Florida. A ridge of high pressure extended from the Bermuda high across southern Florida into the Gulf of Mexico. The winds would tend to be more westerly north of the ridge axis.

The lower troposphere mean circulation charts for 0700 and 1900 EST on the 20th are given in figures 49 and 50. At 0700 EST, the flow was predominantly southerly. The winds became more westerly with increase in latitude over Florida. By 1900 EST, the winds were southwesterly over Florida, although south of Lake Okeechobee the winds were light.

The thermodynamic soundings and wind profiles on the 20th at 0700 EST at Miami and Tampa are given in figure 51. The surface pressures and temperatures at that time were 1017 mb and 300°K at Miami and 1016

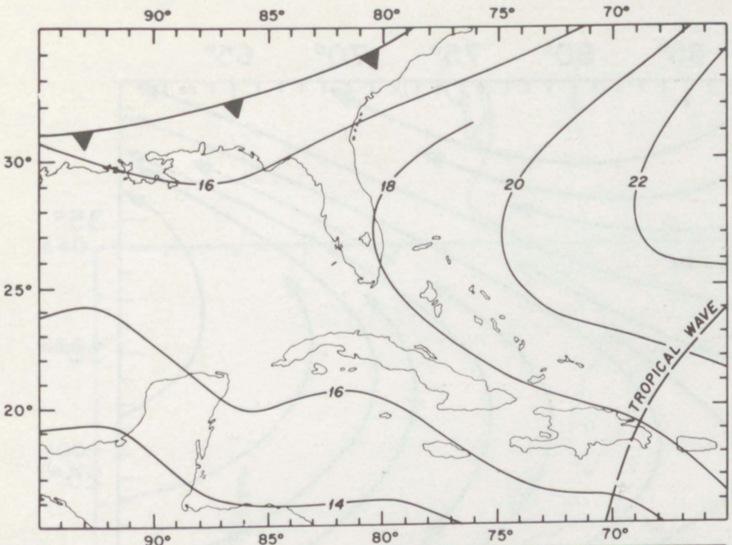


Figure 46. The surface analysis at 0700 EST on July 20, 1971.

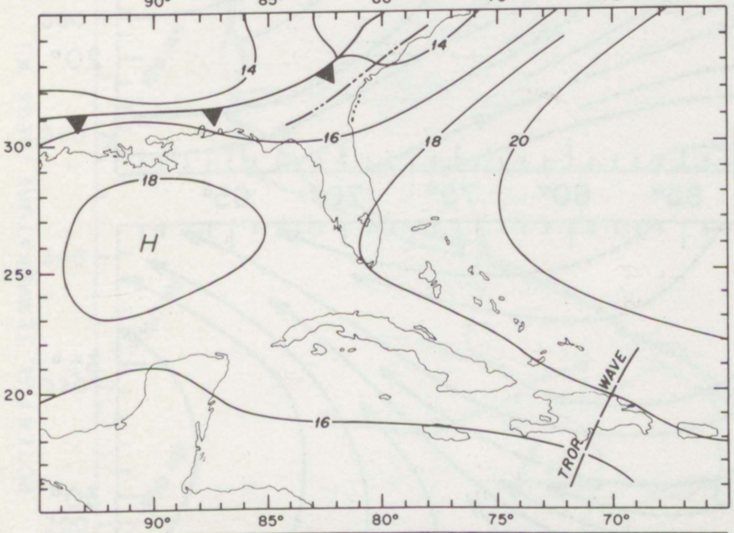


Figure 47. The surface analysis at 1300 EST on July 20, 1971.

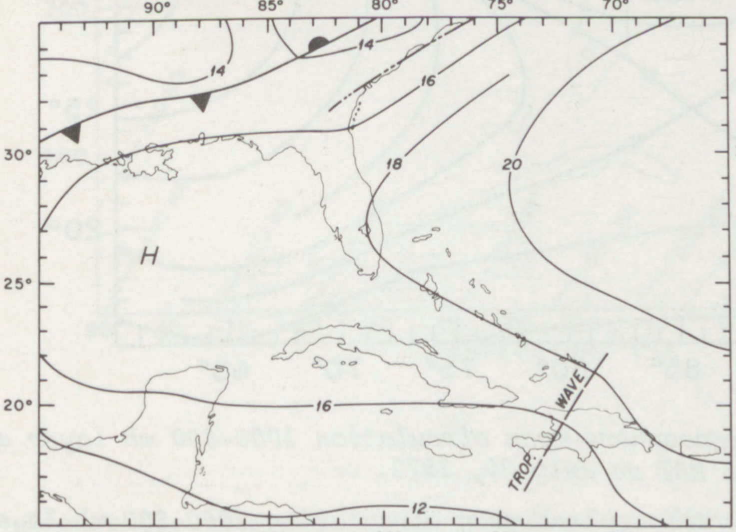
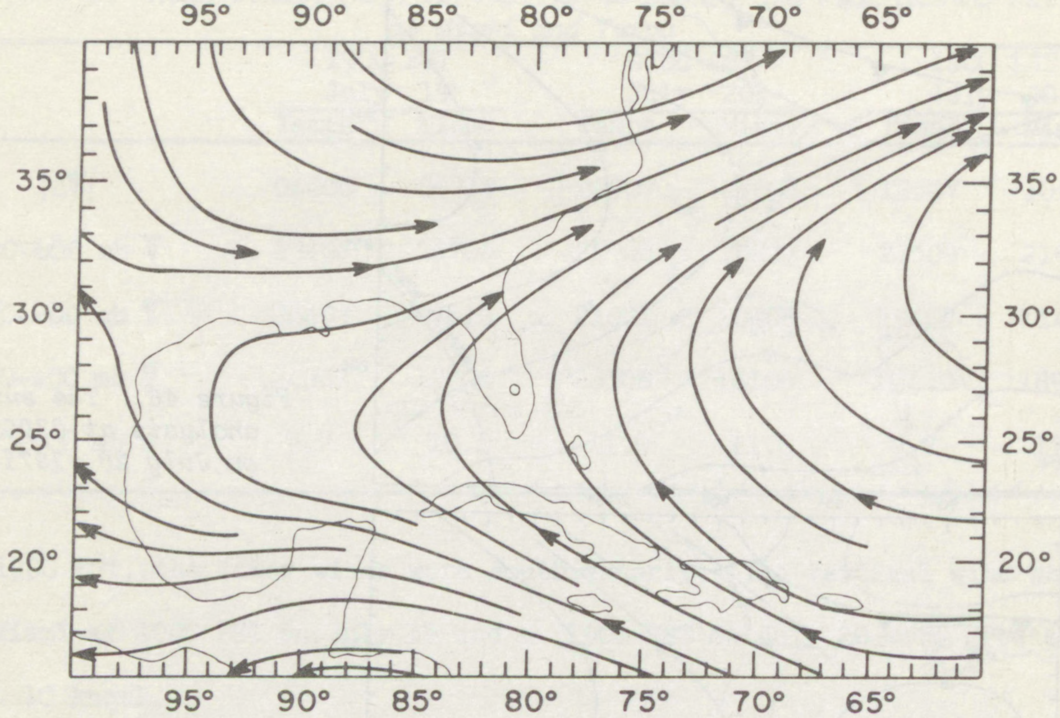


Figure 48. The surface analysis at 1900 EST on July 20, 1971.



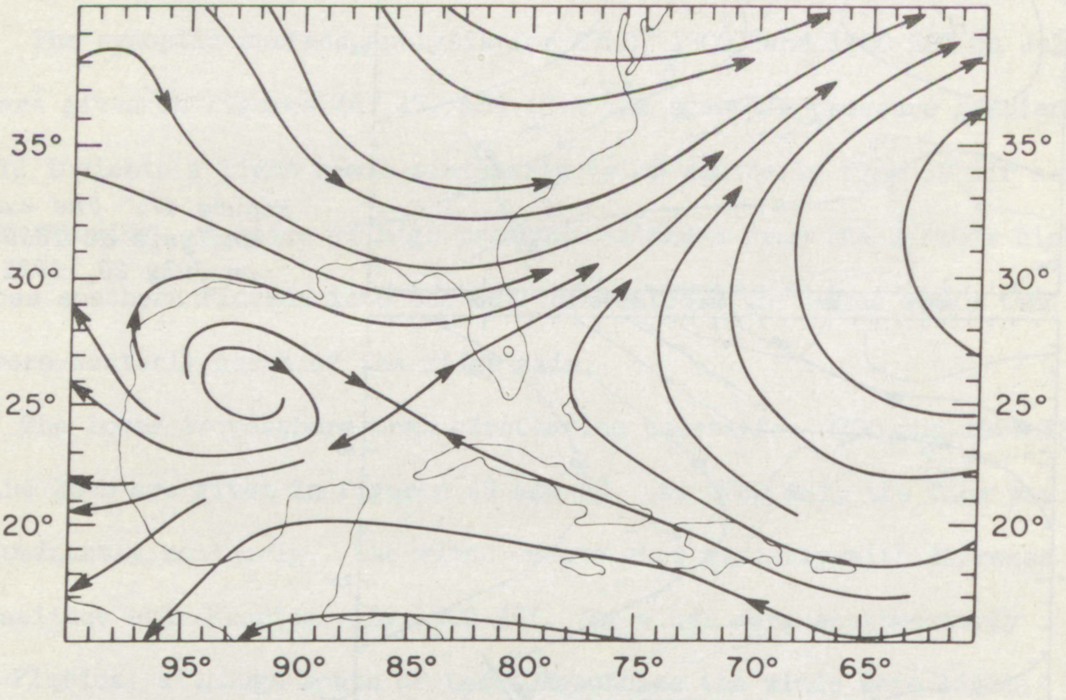


Figure 49. (top) Lower troposphere mean circulation 1000-600 mb layer at 0700 EST on July 20, 1971.

Figure 50. (bottom) Lower troposphere mean circulation 1000-600 mb layer at 1900 EST on July 20, 1971.

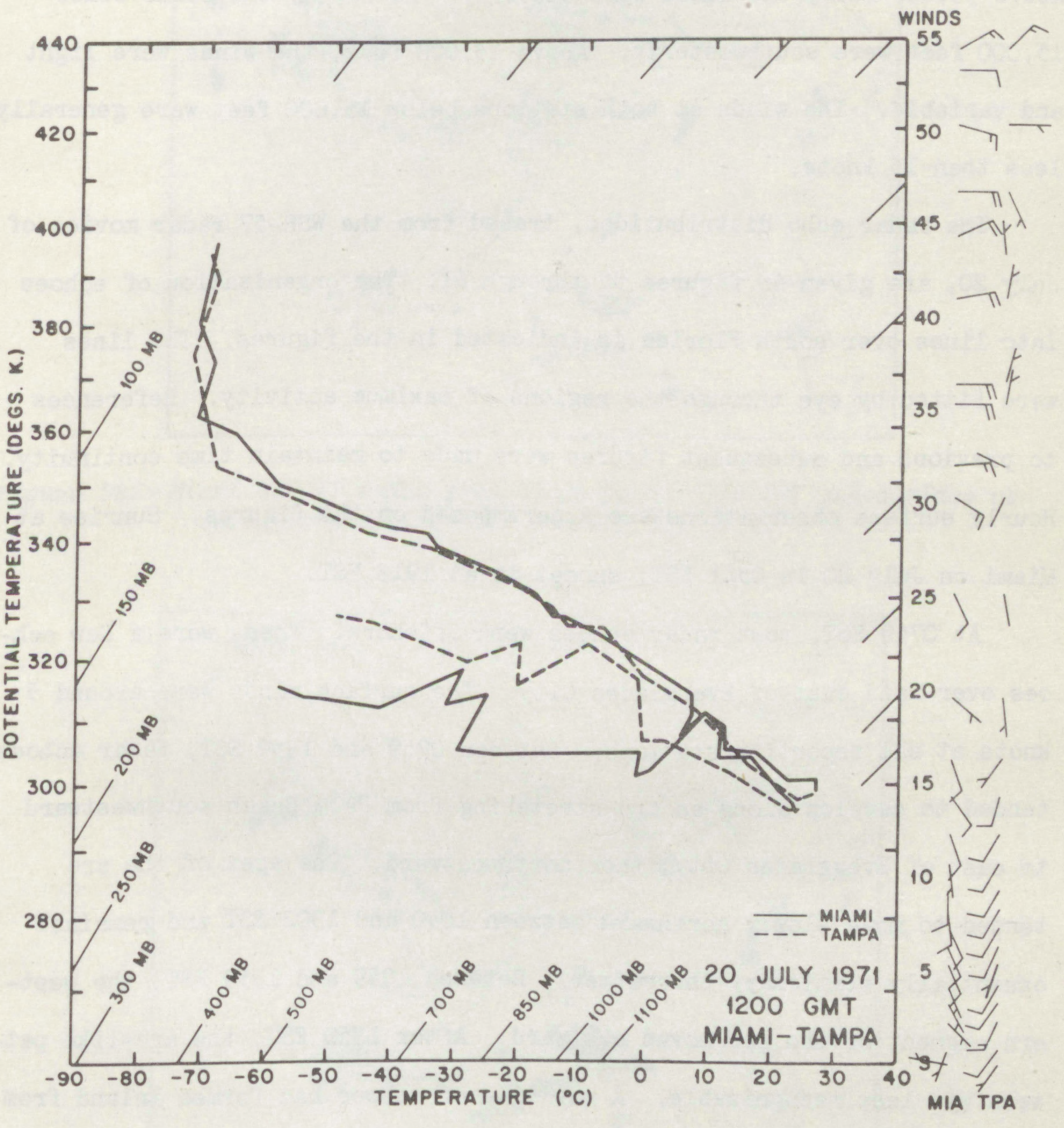


Figure 51. The radiosonde soundings at Miami and Tampa at 0700 EST on July 20, 1971.

mb and 300°K at Tampa. The thermal structure at both stations was almost identical. The sounding at Tampa, however, was considerably more moist. The winds at Miami below 15,000 feet were south-southeasterly or southerly. Above 30,000 feet, the winds were easterly. At Tampa, the winds below 15,000 feet were southwesterly. Above 15,000 feet, the winds were light and variable. The winds at both stations below 15,000 feet were generally less than 15 knots.

The radar echo distributions, traced from the WSR-57 radar movies of July 20, are given in figures 52 through 61. The organization of echoes into lines over south Florida is indicated in the figures. The lines were fitted by eye through the regions of maximum activity. References to previous and subsequent figures were made to maintain time continuity. Hourly surface observations are superimposed on the figures. Sunrise at Miami on July 20 is 0541 EST; sunset is at 1913 EST.

At 0759 EST, most radar echoes were offshore. There were a few echoes over land east of Everglades City. The surface winds were around 5 knots at all reporting stations. Between 0759 and 1359 EST, radar echoes tended to develop along an arc stretching from Palm Beach southwestward to east of Everglades City, then northwestward. The apex of the arc tended to move slowly northward between 1059 and 1302 EST and remained essentially stationary thereafter. Between 1059 and 1359 EST, the western segment of the arc moved eastward. After 1359 EST, the arc-like pattern was less recognizable. A new line of echoes had formed inland from the west coast at 1459 EST. This line also moved eastward and appeared to merge with the convective region along the east coast by 1657 EST. After 1605 EST, there was no apparent arc-like organization pattern to

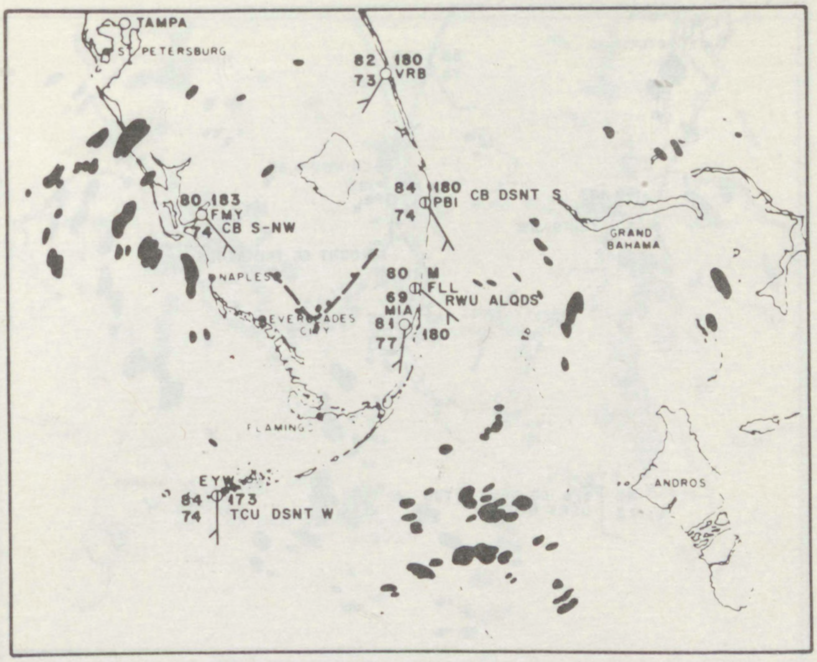


Figure 52. Miami WSR-57 radar echo coverage at 0759 EST and surface observations at 0800 EST on July 20, 1971.

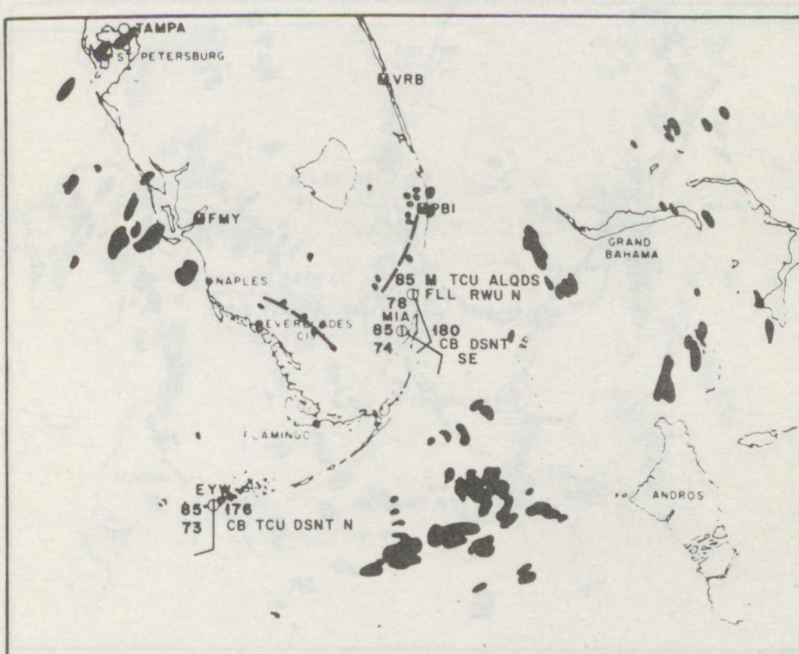


Figure 53. Miami WSR-57 radar echo coverage at 0901 EST and surface observations at 0900 EST on July 20, 1971.

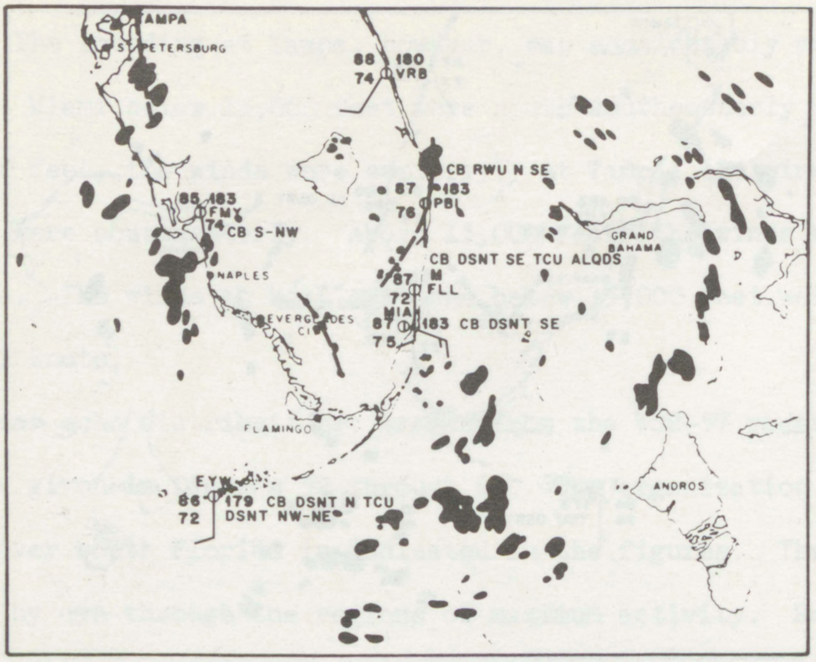


Figure 54. Miami WSR-57 radar echo coverage at 1002 EST and surface observations at 1000 EST on July 20, 1971.

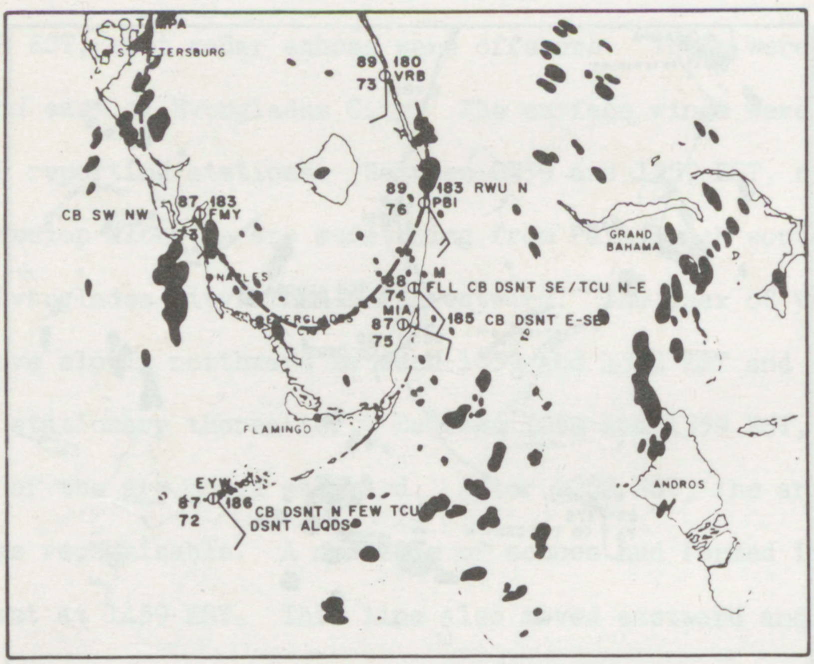


Figure 55. Miami WSR-57 radar echo coverage at 1059 EST and surface observations at 1100 EST on July 20, 1971.

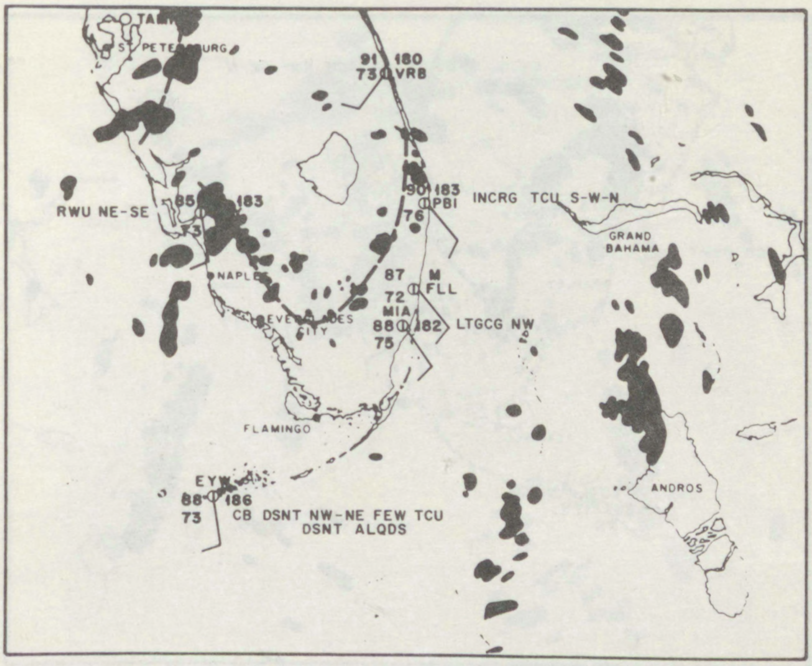


Figure 56. Miami WSR-57 radar echo coverage at 1203 EST and surface observations at 1200 EST on July 20, 1971.

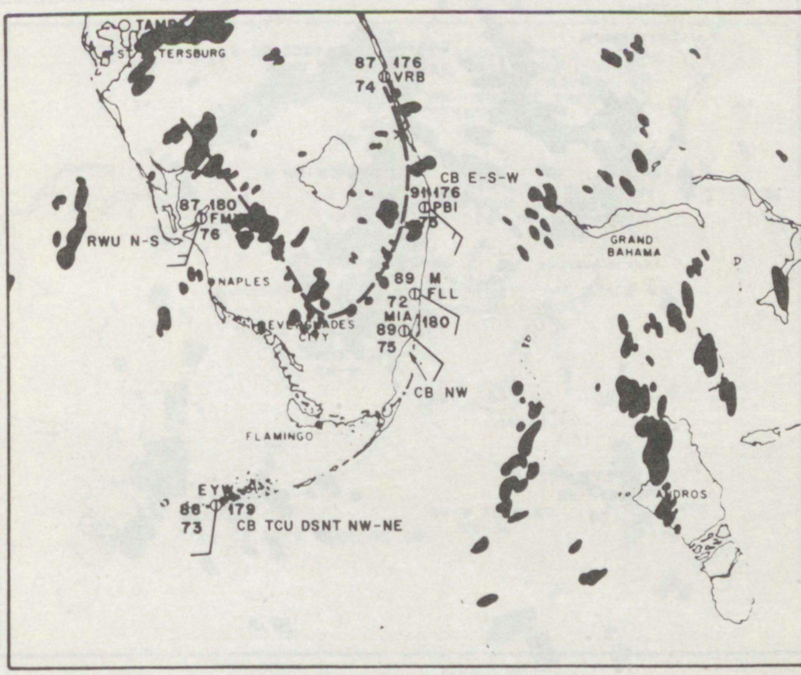


Figure 57. Miami WSR-57 radar echo coverage at 1302 EST and surface observations at 1300 EST on July 20, 1971.

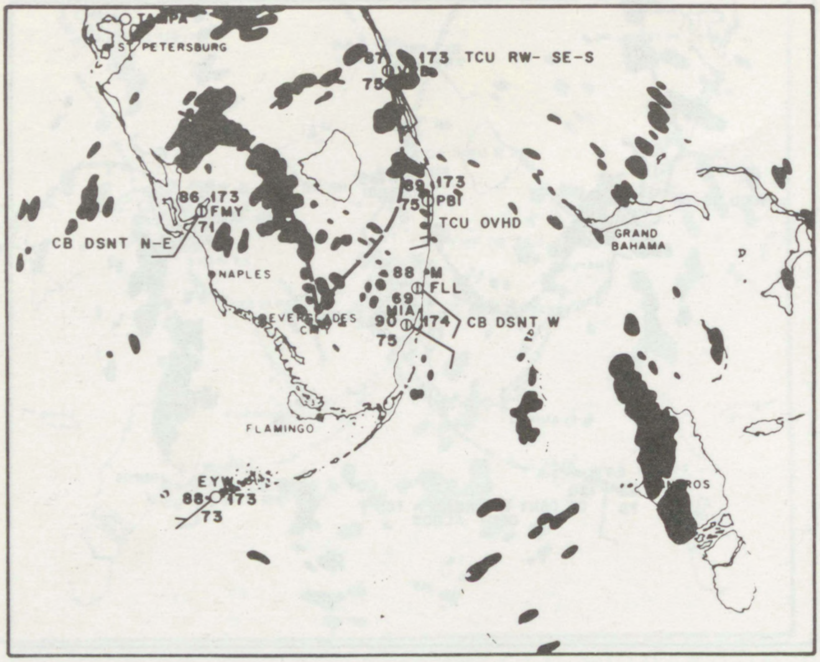


Figure 58. Miami WSR-57 radar echo coverage at 1359 EST and surface observations at 1400 EST on July 20, 1971.

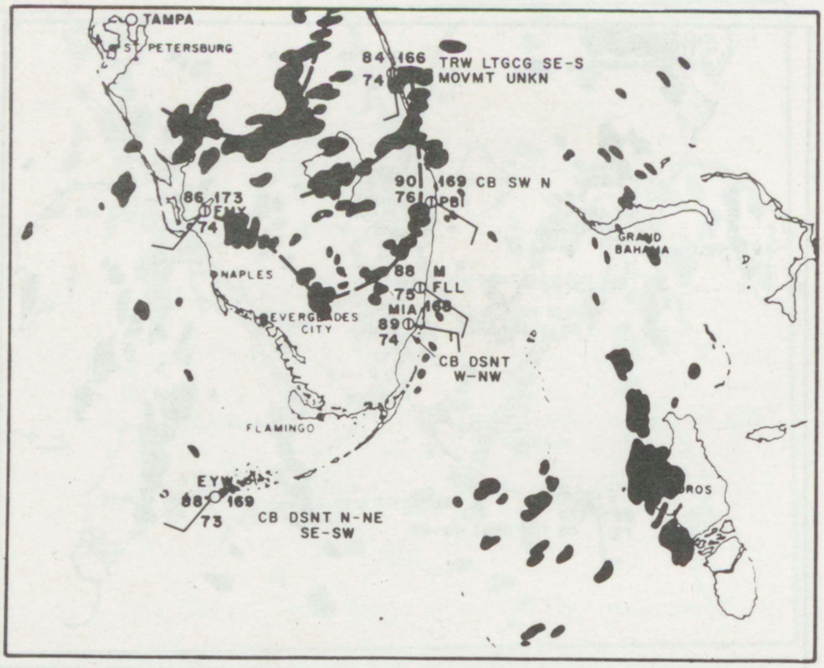


Figure 59. Miami WSR-57 radar echo coverage at 1459 EST and surface observations at 1500 EST on July 20, 1971.

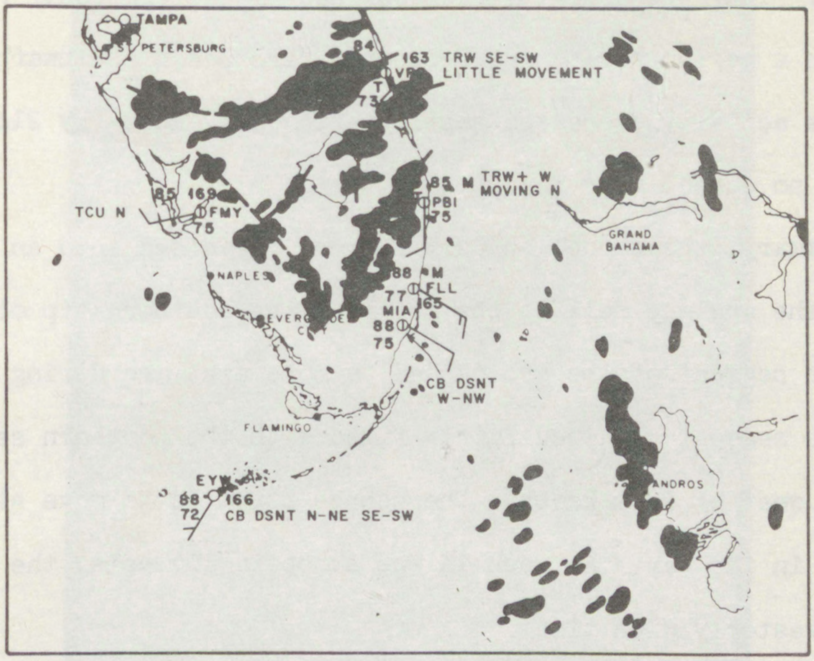


Figure 60. Miami WSR-57 radar echo coverage at 1605 EST and surface observations at 1600 EST on July 20, 1971.

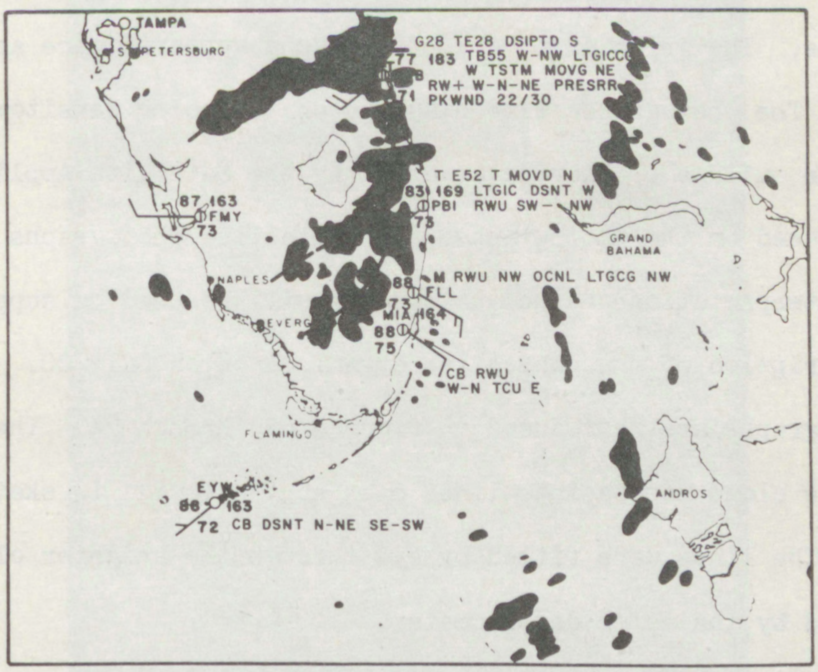


Figure 61. Miami WSR-57 radar echo coverage at 1657 EST and surface observations at 1700 EST on July 20, 1971.

the echoes. The echo activity was confined to eastern south Florida after 1657 EST in a region stretching from near Vero Beach southward to near Miami. The activity decreased rapidly after 1657 EST. By 2145 EST, there were no echoes over land.

In summary, the echoes on July 20 were organized into an arc. The vertex of the arc was well to the north of the southern tip of Florida. The western segment of the arc tended to move eastward during the day. The eastern segment remained fairly fixed with the northern section over and to the west of Palm Beach. The echoes appeared to move slowly northward early in the day. As seen in the synoptic analysis, the winds became more westerly with time.

The Satellite Applications Section of the National Hurricane Center made blowups of a portion of the ATS-3 photographs on July 20. The blowups were made to cover a larger area than the blowups of the June 29 photographs. The gridding of the photographs appeared more accurate on this day. The photographs were examined on the color densitometer. The approximate outline of Florida as drawn by the Satellite Applications Section is traced on the photographs. The satellite photographs and densitometer interpretation of the photographs will be used to supplement the radar description of the convective organization on July 20. The satellite photographs are reproduced in figures 62 through 74. The organization of the cloud masses into lines over south Florida is sketched on the figures. The lines were fitted by eye through the brighter cloud regions as revealed by the color densitometer.

At 0807 EST, a short line of clouds stretched northeastward from near the extreme southern tip of Florida. There were no noticeable clouds

Figure 62. ATS-3 photograph at 0807 EST on July 20, 1971.

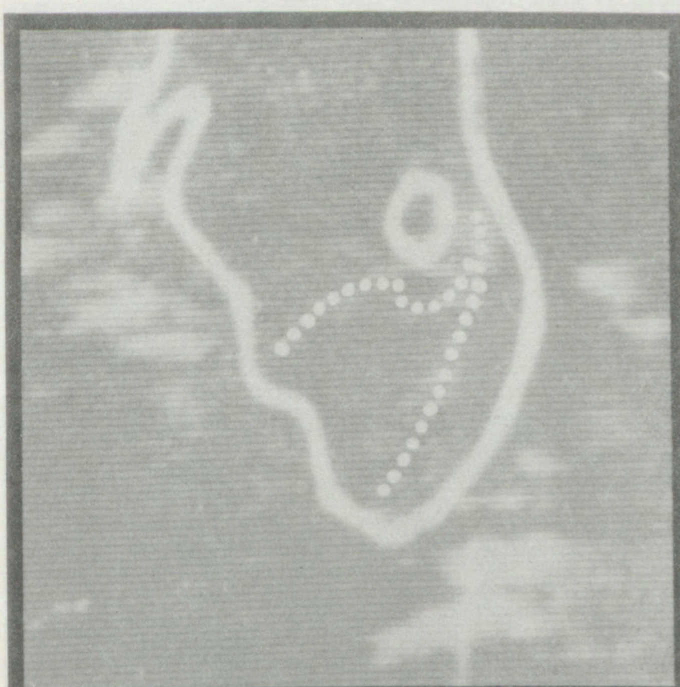


Figure 63. ATS-3 photograph at 0902 EST on July 20, 1971.

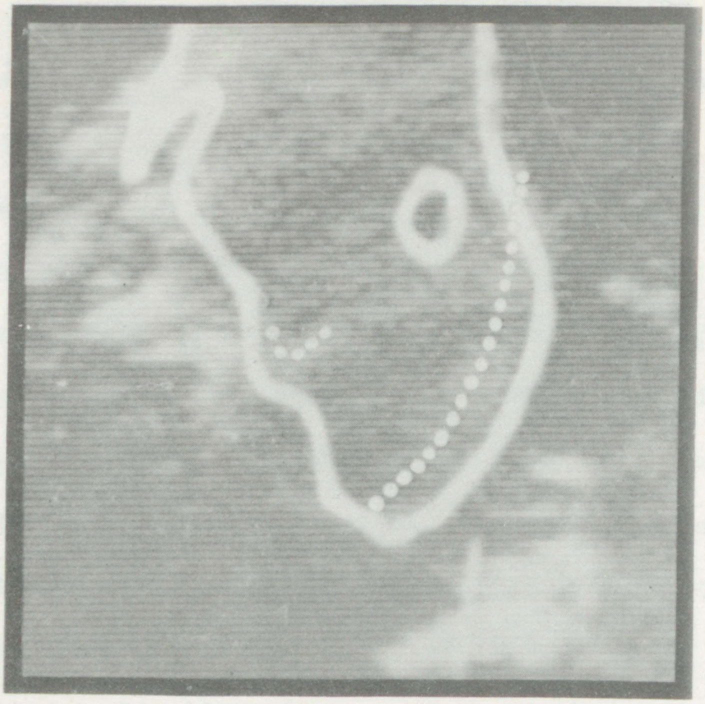


Figure 64. ATS-3 photograph at 0928 EST on July 20, 1971.

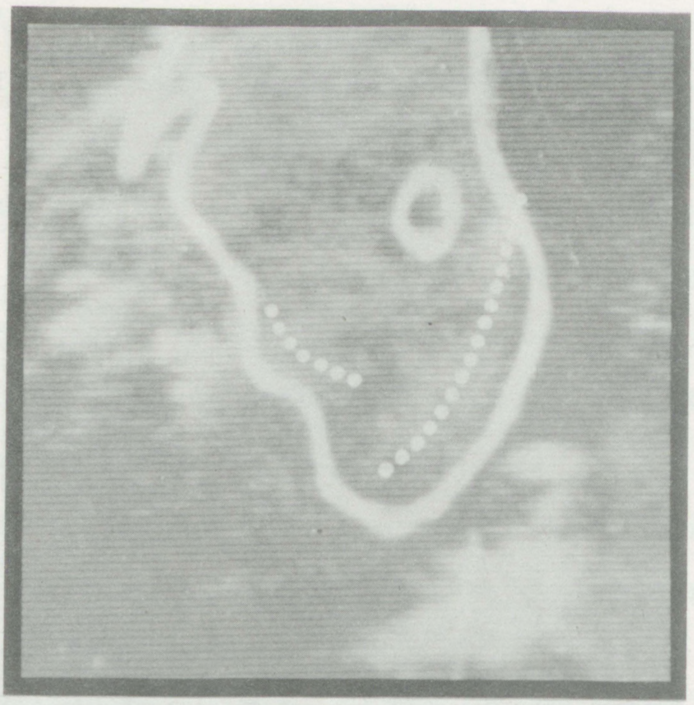


Figure 65. ATS-3 photograph at 0956 EST on July 20, 1971.

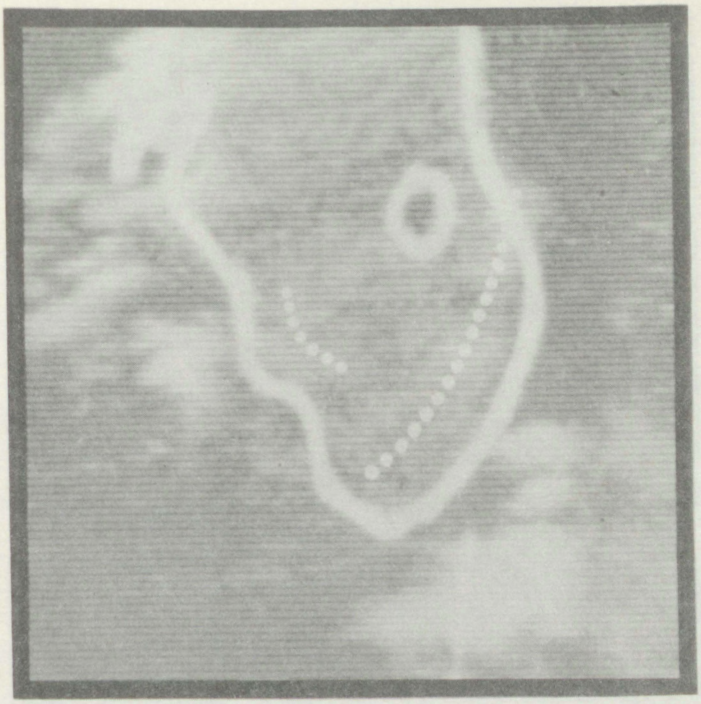


Figure 66. ATS-3 photograph at 1022 EST on July 20, 1971.

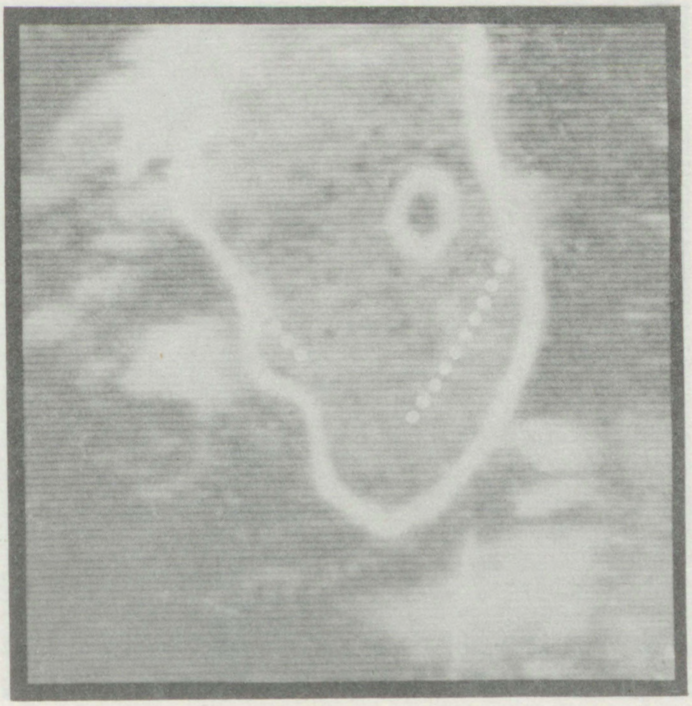


Figure 67. ATS-3 photograph at 1049 EST on July 20, 1971.

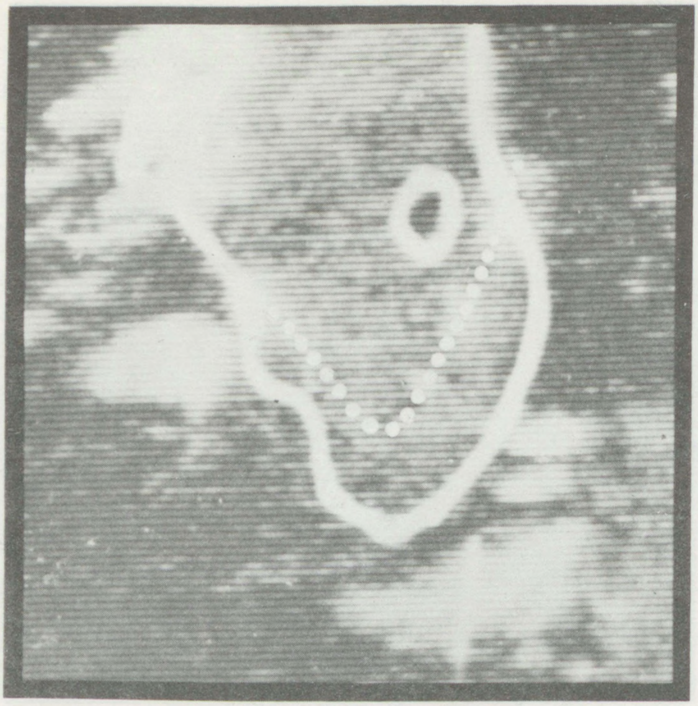


Figure 68. ATS-3 photograph at 1117 EST on July 20, 1971.

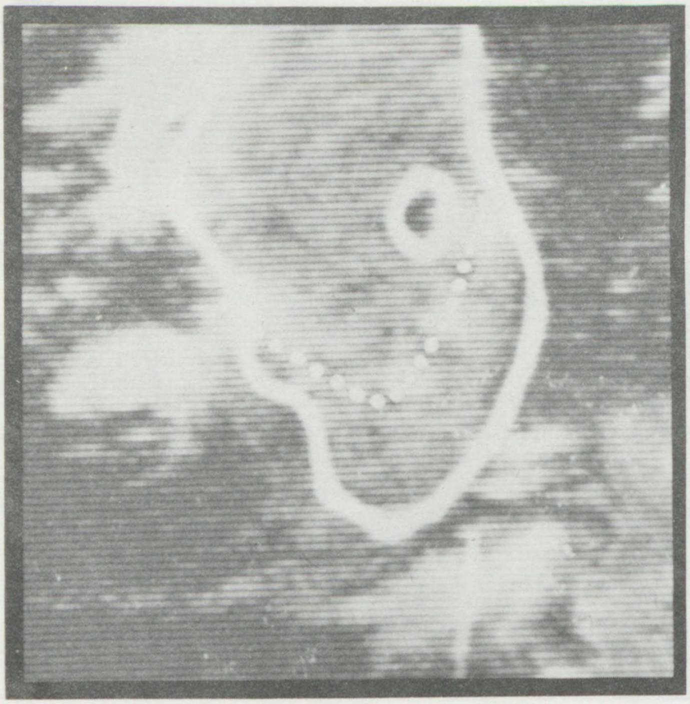


Figure 69. ATS-3 photograph at 1143 EST on July 20, 1971.

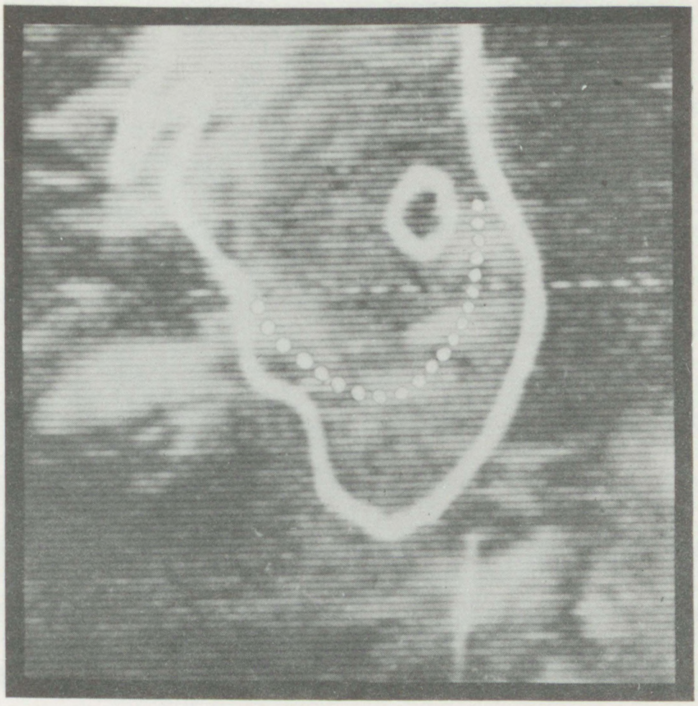


Figure 70. ATS-3 photograph at 1209 EST on July 20, 1971.

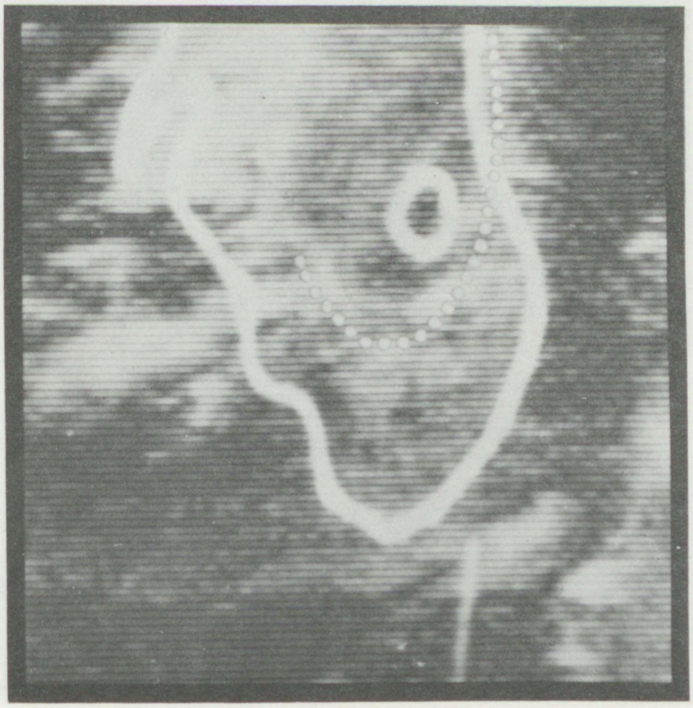


Figure 71. ATS-3 photograph at 1236 EST on July 20, 1971.

Figure 72. ATS-3 photograph at 1304 EST on July 20, 1971.

Figure 73. ATS-3 photograph at 1331 EST on July 20, 1971.

elsewhere over south Florida. By 0902 EST, the short line of clouds along the east coast had extended and stretched from east of Lake Okeechobee southwestward to north of the tip of Florida. The brightest area of cloudiness lay to the east of Lake Okeechobee. A second area of clouds extended eastward from the bulge on the west coast to just south of the lake.

The regions of cloudiness over Florida became more widespread after 0902 EST. A persistent relative bright area occurred to the east of Lake Okeechobee at least until 1209 EST. By 1209 EST, a definite arc of bright clouds stretched from east of Lake Okeechobee southwestward to near Everglades City, then northwestward along the coast. The arc was apparent at least until 1331 EST. The lake remained persistently free

Figure 74. ATS-3 photograph at 1358 EST on July 20, 1971.

of clouds during the day. By 1358 EST, the organization of the clouds into an arc was not obvious. The apex of the arc moved northward slowly during the day.

The satellite photographs were not as useful as radar in determining cloud organization. The inaccuracy of gridding and the lack of adequate photographic resolution for the scales of organization being examined hindered the usefulness of the satellite photographs.

The radar, satellite, and surface observations suggest a definite organized pattern to the convective activity on this day. The clouds formed in an arc which moved slowly northward early in the day. Later in the day, when the winds became more westerly, the western leg of the arc moved eastward. The geographical shape of Florida appeared instrumental in generating the organized pattern. The organization of convective activity on this day was not as well defined as for the previous two cases. The reason for this will be examined in section 4.

3.5 Southwest Wind Case (June 24, 1971)

The 1000-600 mb mean winds, 600-200 mb mean winds, mean vertical wind shears between these two levels, 1000-400 mb mean winds, and 1000-600 mb mean mixing ratios are tabulated in table 6 for Miami and Tampa.

The 1000-600 mb mean winds were southwesterly. The lower winds were more westerly and stronger at Tampa than at Miami.

The synoptic surface analysis for 0700, 1300, and 1900 EST on June 24 are given in figures 75, 76, and 77. The synoptic pressure gradient at 0700 and 1300 EST was very flat. A broad ridge of high pressure stretched from the Bermuda high westward across southern Florida into the Gulf of

Table 6. Mean Winds, Mean Vertical Wind Shear, and Mean Mixing Ratio at Miami and Tampa

	1900 EST June 23		0700 EST June 24		1900 EST June 24	
	Tampa	Miami	Tampa	Miami	Tampa	Miami
$\lvert\Delta\overline{V}\rvert$	06108	08208	05707	03107	03007	00306
1000-600 mb $\overline{V}$	25118	23209	24017	22408	25310	21603
600-200 mb $\overline{V}$	25811	17005	24111	27202	30207	34505
1000-400 mb $\overline{V}$	25017	22808	24018	23007	26609	24003
1000-600 mb $\bar{q}$	9.2	9.5	10.0	8.4	8.4	9.9

Mexico. At 1900 EST, the axis of the ridge lay across extreme southern Florida. A southwesterly flow over most of south Florida would be expected from the 1900 EST pressure pattern.

The lower troposphere mean circulation charts for 0700 and 1900 EST on the 24th are given in figures 78 and 79. The wind patterns were more enlightening than the surface pressure pattern. At both 0700 and 1900 EST, the flow was southwesterly across south Florida.

The thermodynamic soundings and wind profiles on the 24th at 0700 EST at Miami and Tampa are given in figure 80. The surface pressures and temperatures at that time were 1017 mb and 298°K at Miami and 1016 mb and 299°K at Tampa. The soundings were very similar. Tampa was slightly cooler and more moist below 500 mb. The winds at Tampa below 25,000 feet were generally southwesterly between 15 and 25 knots. The winds were relatively light and variable above 25,000 feet. The winds at Miami were southwesterly between 5,000 and 25,000 feet at about 10 knots. Below 5,000 feet, the winds were southerly. The winds above 30,000 feet were very light from the east.

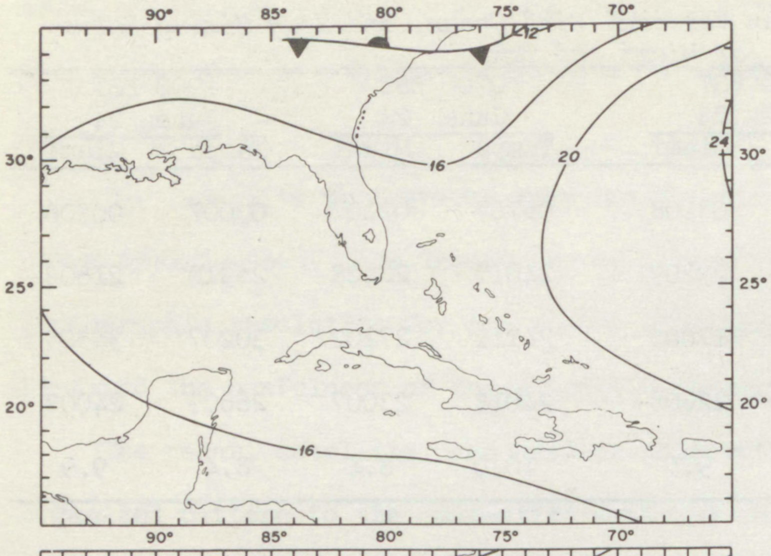


Figure 75. The surface analysis at 0700 EST on June 24, 1971.

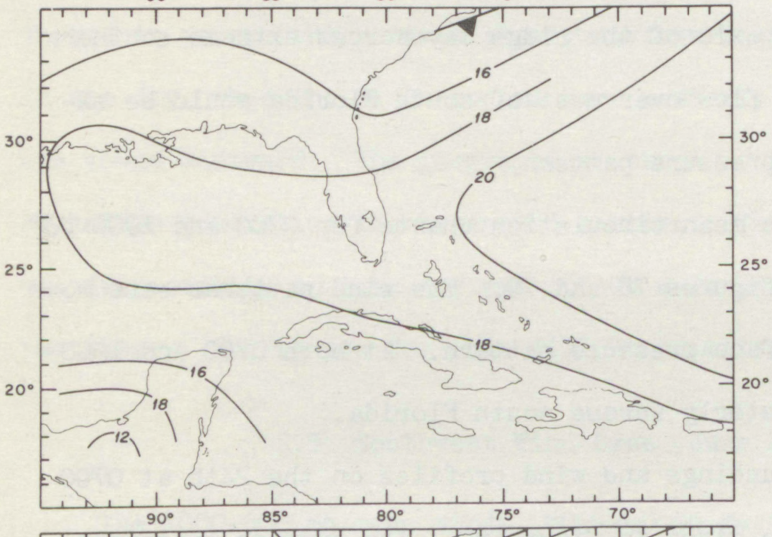


Figure 76. The surface analysis at 1300 EST on June 24, 1971.

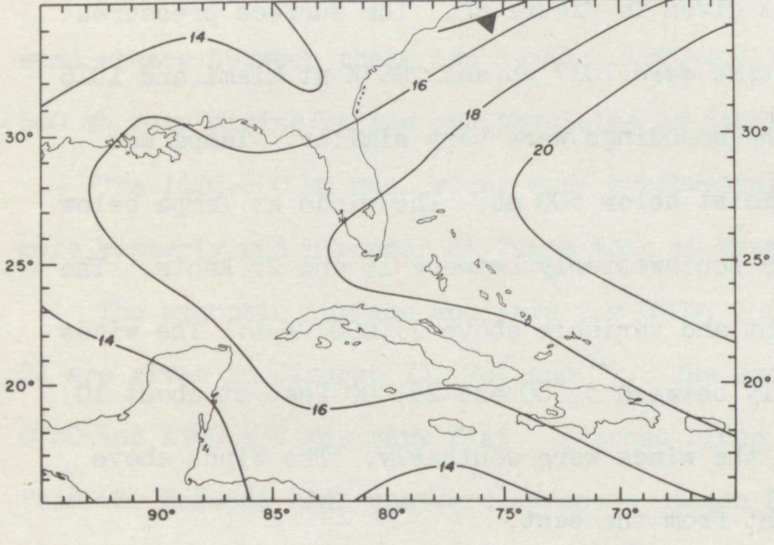
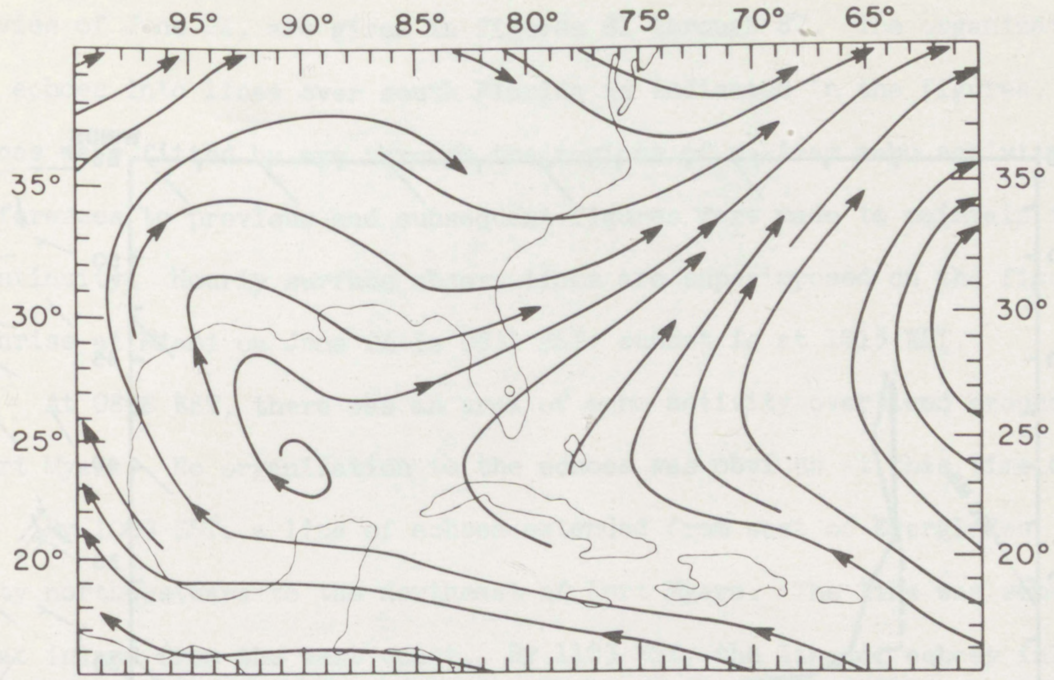


Figure 77. The surface analysis at 1900 EST on June 24, 1971.



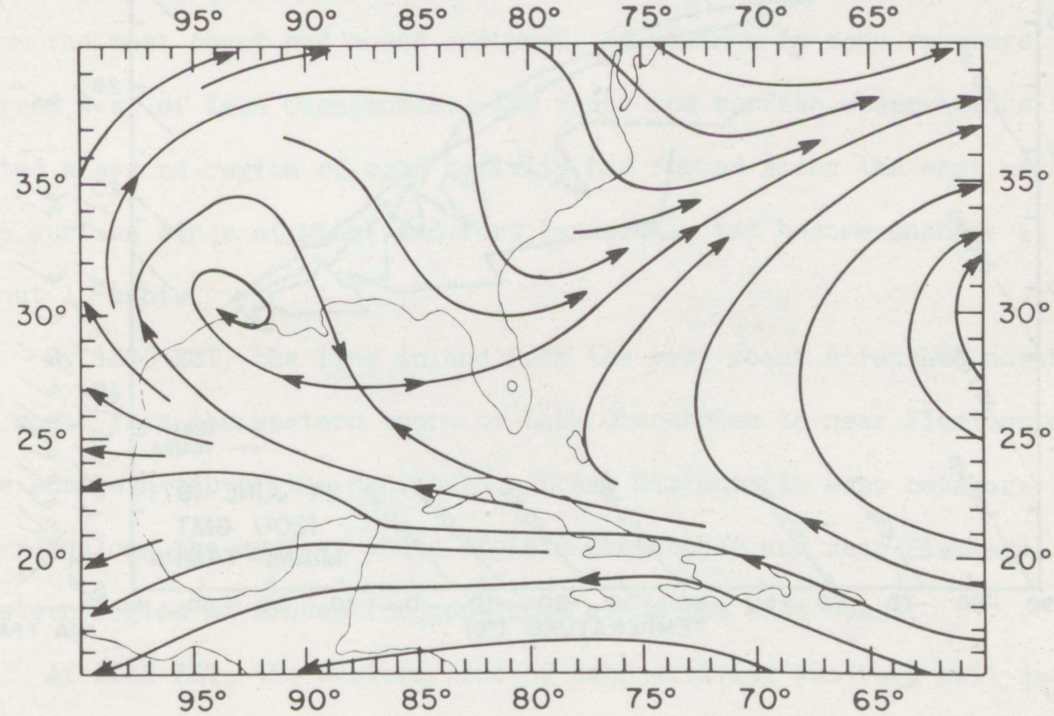


Figure 78. (top) Lower troposphere mean circulation 1000-600 mb layer at 0700 EST on June 24, 1971.

Figure 79. (bottom) Lower troposphere mean circulation 1000-600 mb layer at 1900 EST on June 24, 1971.

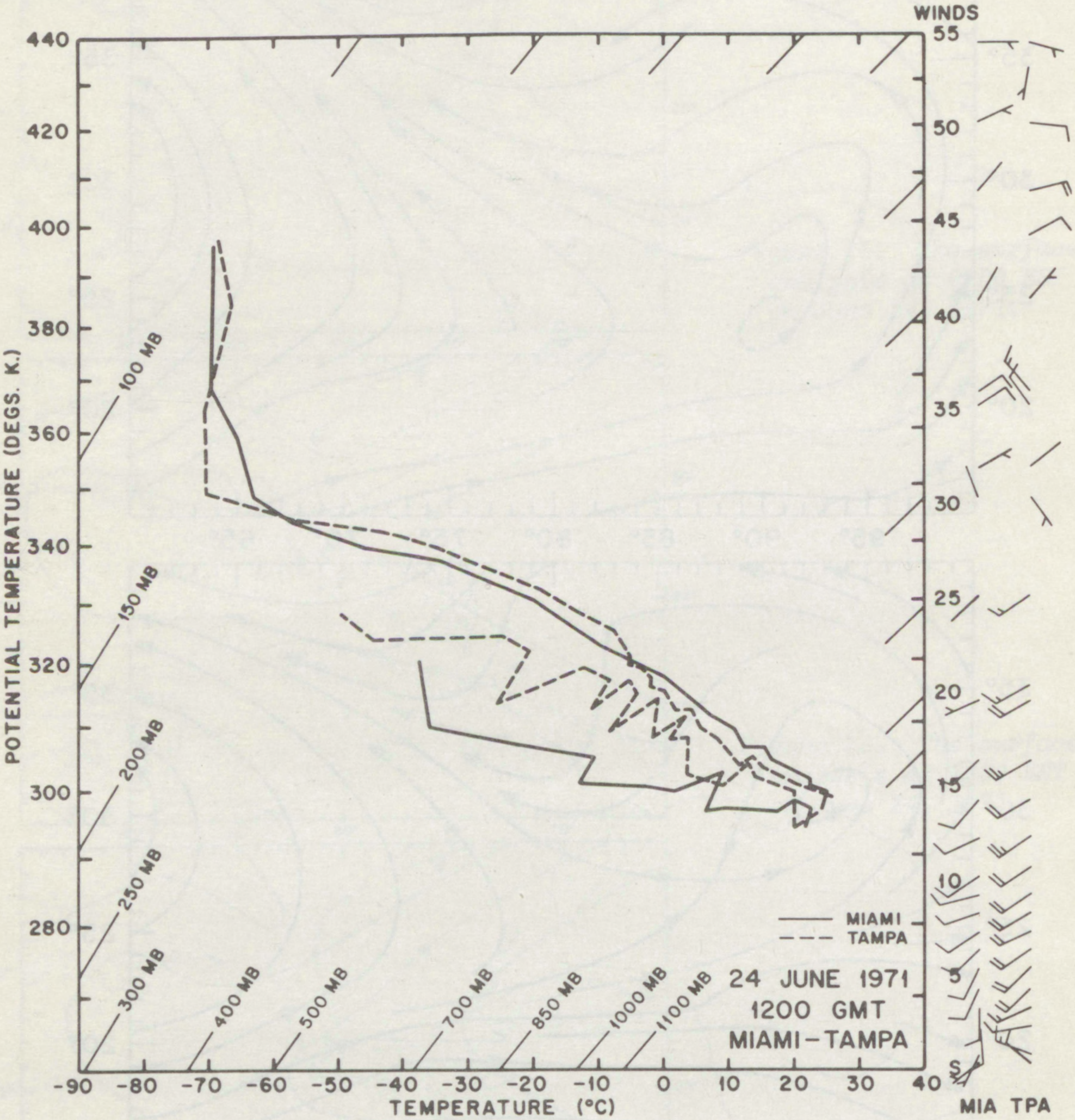


Figure 80. The radiosonde soundings at Miami and Tampa at 0700 EST on June 24, 1971.

The radar echo distributions, traced from the Miami WSR-57 radar movies of June 24, are given in figures 81 through 87. The organization of echoes into lines over south Florida is indicated in the figures. The lines were fitted by eye through the regions of maximum echo activity. References to previous and subsequent figures were made to maintain time continuity. Hourly surface observations are superimposed on the figures. Sunrise at Miami on June 24 is 0531 EST; sunset is at 1915 EST.

At 0858 EST, there was an area of echo activity over land around Fort Myers. No organization to the echoes was obvious at this time.

By 1003 EST, a line of echoes extended from east of Everglades City northwestward to the northeast of Fort Myers. The line was somewhat inland from the west coast. By 1103 EST, the line of echoes inland from the west coast had moved eastward. A maximum in echo coverage occurred west of Lake Okeechobee. The radar and surface observations indicated a second region of echo activity had formed along the east coast. The surface winds at Miami and Fort Lauderdale had become onshore at about 10 knots.

By 1203 EST, the line inland from the west coast stretched north to south from the western shore of Lake Okeechobee to near Flamingo on the southern tip of the peninsula. Local maximums in echo coverage occurred along the western shore of Lake Okeechobee and near Flamingo. The eastern region of convection continued along the east coast.

At 1248 EST, the western line of echo activity was very well defined. Considerable activity continued along the east coast. West Palm Beach was reporting a heavy thunderstorm with hail at the 1300 EST surface observation.

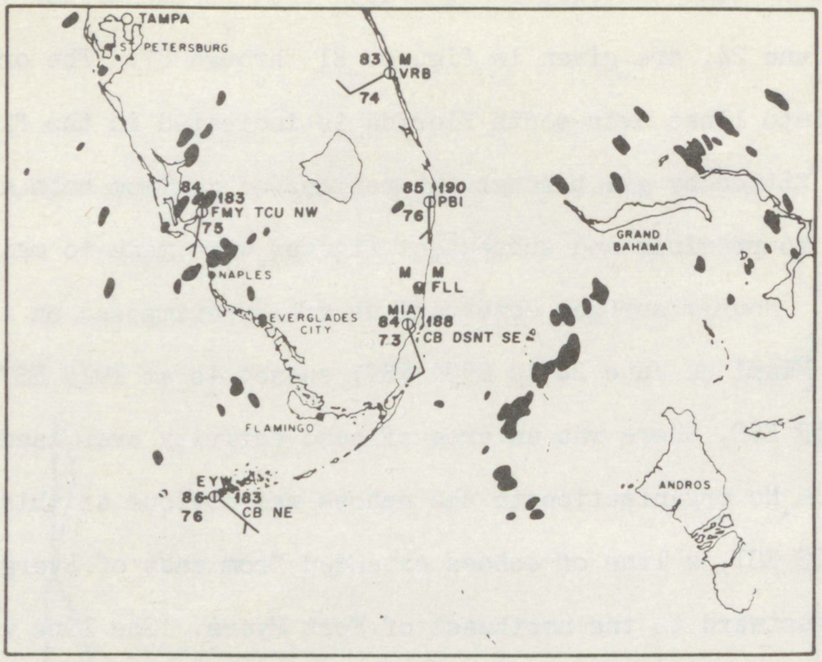


Figure 81. Miami WSR-57 radar echo coverage at 0858 EST and surface observations at 0900 EST on June 24, 1971.

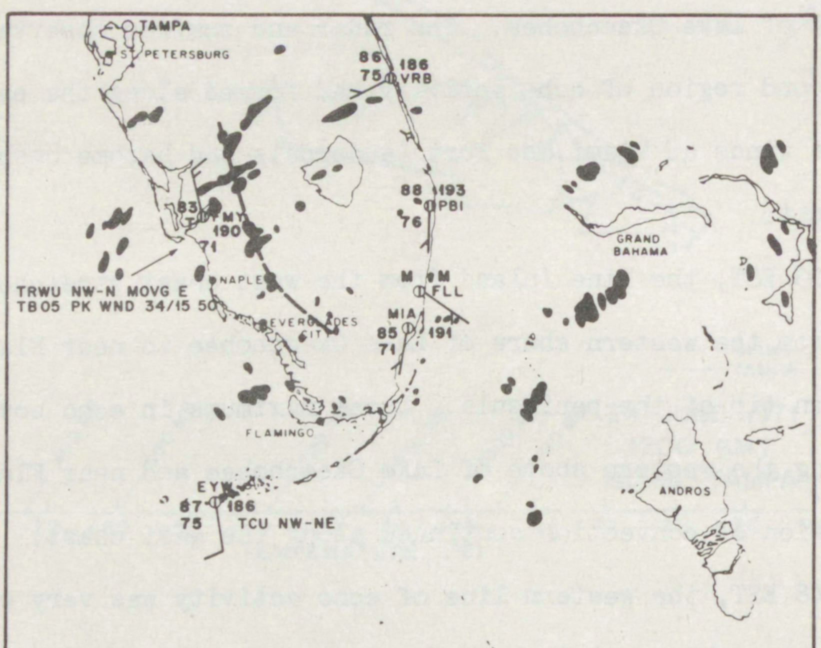


Figure 82. Miami WSR-57 radar echo coverage at 1003 EST and surface observations at 1000 EST on June 24, 1971.

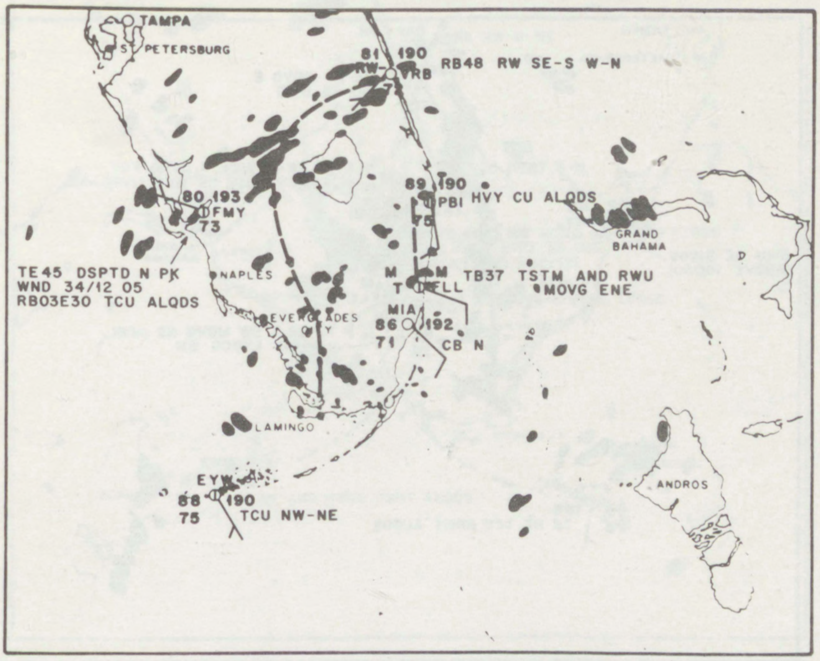


Figure 83. Miami WSR-57 radar echo coverage at 1103 EST and surface observations at 1100 EST on June 24, 1971.

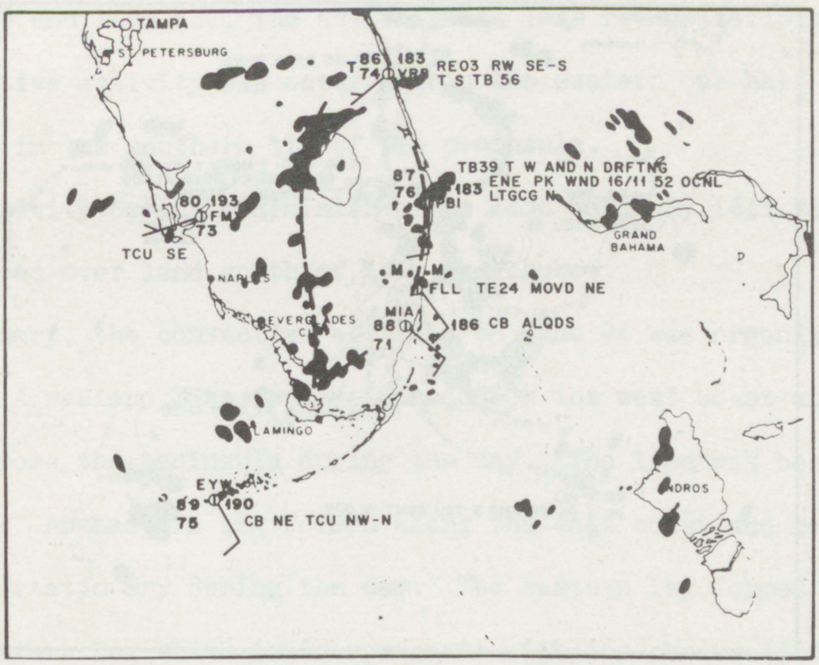


Figure 84. Miami WSR-57 radar echo coverage at 1203 EST and surface observations at 1200 EST on June 24, 1971.

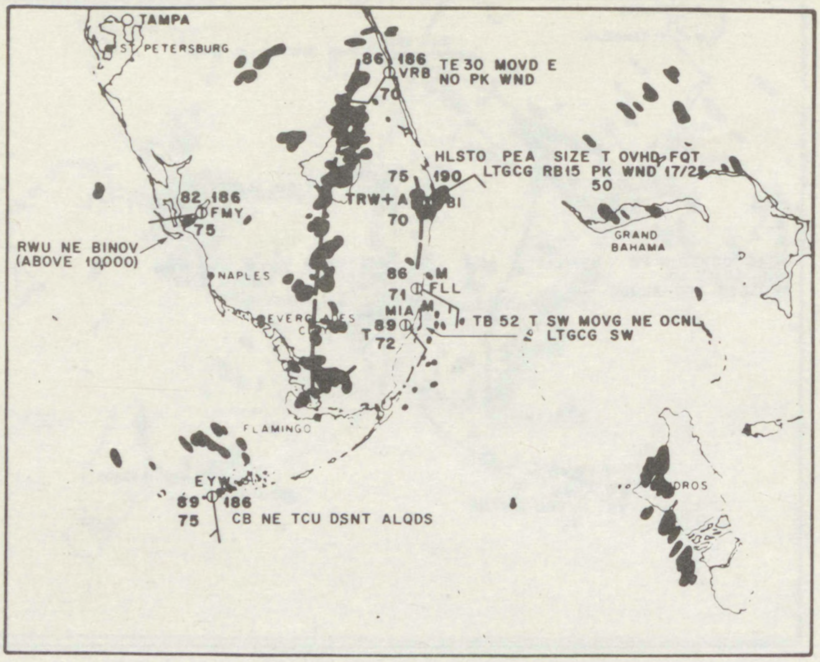


Figure 85. Miami WSR-57 radar echo coverage at 1248 EST and surface observations at 1300 EST on June 24, 1971.

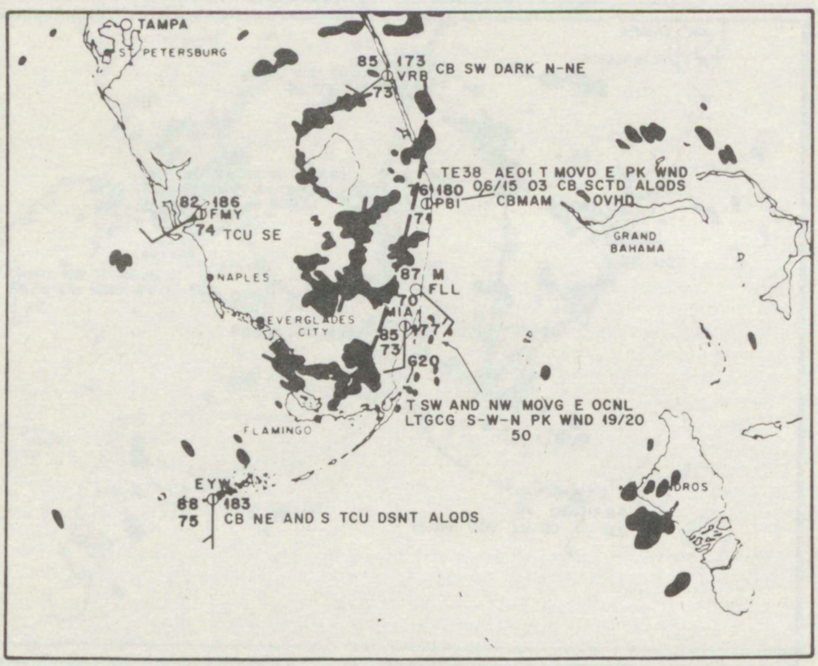


Figure 86. Miami WSR-57 radar echo coverage at 1359 EST and surface observations at 1400 EST on June 24, 1971.

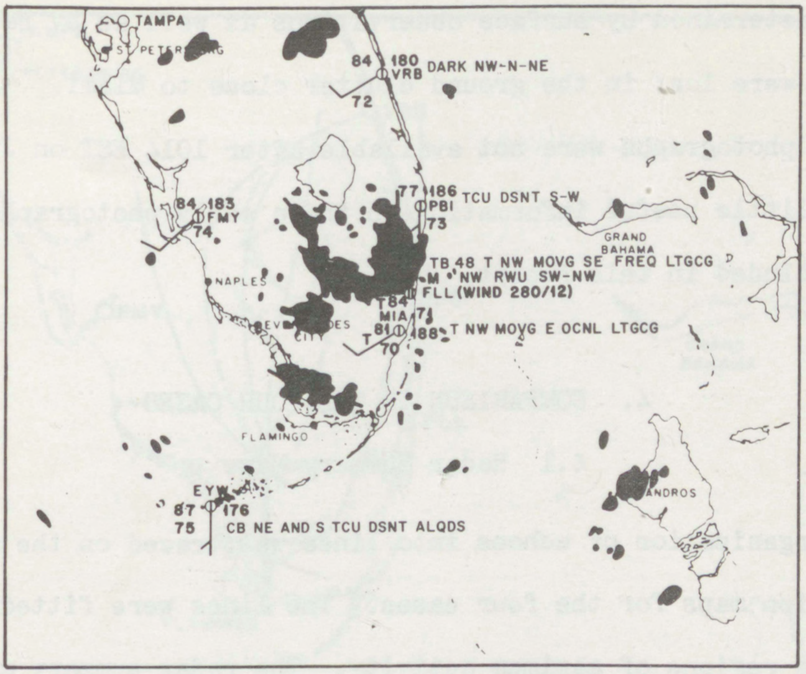


Figure 87. Miami WSR-57 radar echo coverage at 1458 EST and surface observations at 1500 EST on June 24, 1971.

At 1359 and 1458 EST, the activity had less recognizable patterns. Most convective activity was occurring in the eastern one-half of south Florida and in the southern tip of the peninsula.

The activity began to diminish after 1458 EST. By 1841 EST, there were no echoes over land south of Lake Okeechobee.

In summary, the convective activity on June 24 was organized into two lines. A western line formed inland from the west coast and moved eastward across the peninsula during the day. The line was best defined at 1248 EST. An eastern leg formed along the east coast and remained essentially stationary during the day. The eastern leg formed later than the western leg which is in agreement with the observational results of Frank, Moore, and Fisher that the echoes are most prominent first on the windward coast. The presence of convective activity along the east coast was determined by surface observations as well as by radar because the echoes were lost in the ground clutter close to Miami.

ATS-3 photographs were not available after 1014 EST on June 24. There was little useful information in these early photographs so they are not included in this report.

4. COMPARISON OF THE FOUR CASES

4.1 Radar Summary Maps

The organization of echoes into lines was traced on the radar coverage depiction maps for the four cases. The lines were fitted by eye through the regions of maximum activity. The radar summary maps for June 24, June 29, July 20, and August 19 are given in figures 88 through 91. The apparent organization of echoes on the 4 case-study days varied.

The light wind case of June 29, 1971, had the most obvious organization. Active lines of convection paralleled both coasts. The lines moved inland somewhat during the day.

The southeast wind case of August 19, 1971, was only slightly less organized than the case on June 29. A line of convection occurred along the west coast during the day. The line of convection along the east coast developed inland and somewhat earlier than on the west coast. The eastern zone moved westward early in the day. A wishbone pattern of convection developed during much of the afternoon. The apex of the wishbone was centered near Everglades City.

The southwest wind case of June 24, 1971, was somewhat less organized than that of the August 19 case. A line of convection occurred along

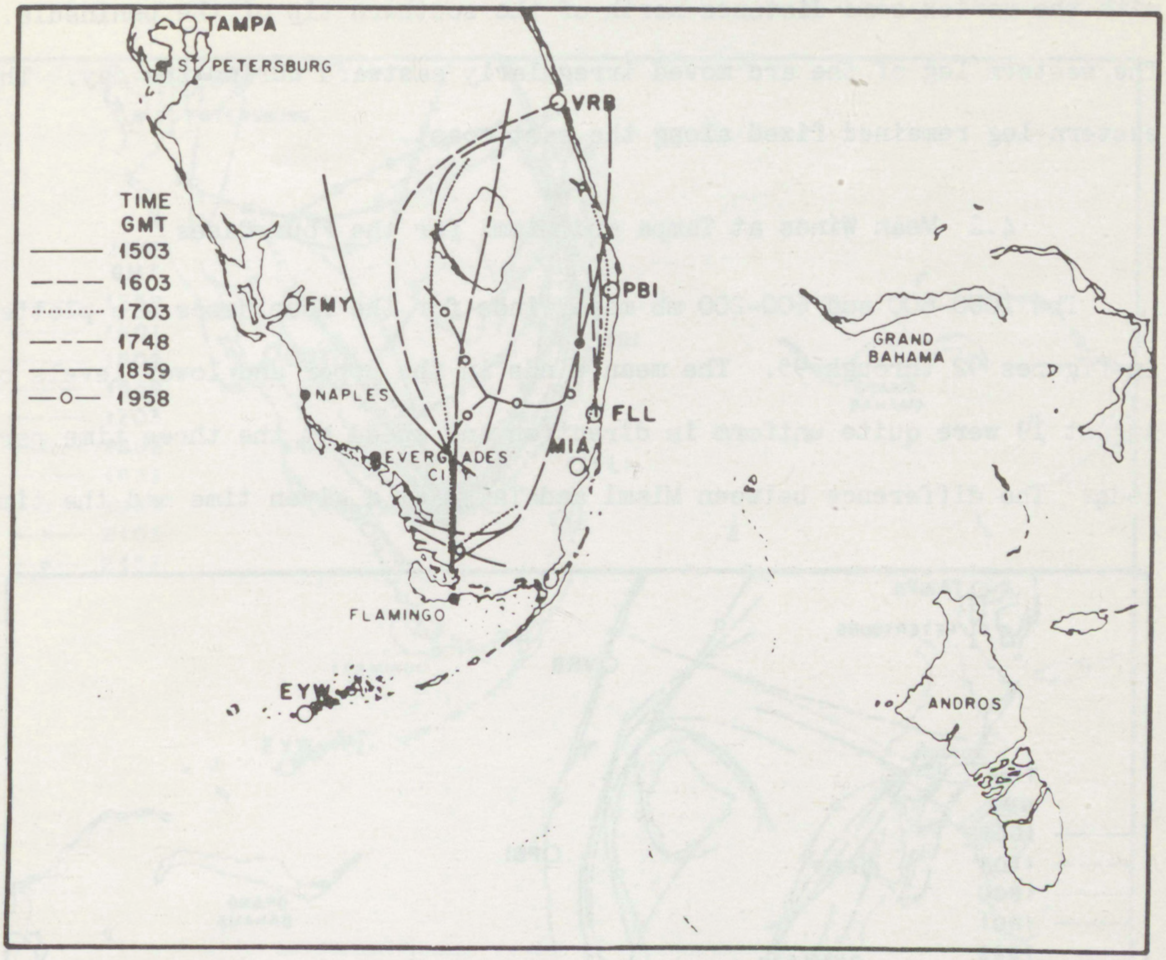


Figure 88. Radar summary map for June 24, 1971.

the east coast during the day. A second line of convection along the west coast developed inland and somewhat earlier than on the east coast. The western zone moved eastward during the day and appeared to merge with the eastern zone. The eastern and western lines intersected north of Flamingo. Radar observation of echo organization along the southeast coast was hindered by ground clutter.

The southerly wind case of July 20, 1971, was the least organized of the four cases. The convection formed in an arc across south Florida, with the vertex some distance north of the southern tip of the peninsula. The western leg of the arc moved irregularly eastward during the day. The eastern leg remained fixed along the east coast.

4.2 Mean Winds at Tampa and Miami for the Four Cases

The 1000-600 and 600-200 mb mean winds for the four cases are plotted in figures 92 through 95. The mean winds in the upper and lower levels on August 19 were quite uniform in direction and speed at the three time periods. The difference between Miami and Tampa at a given time and the time

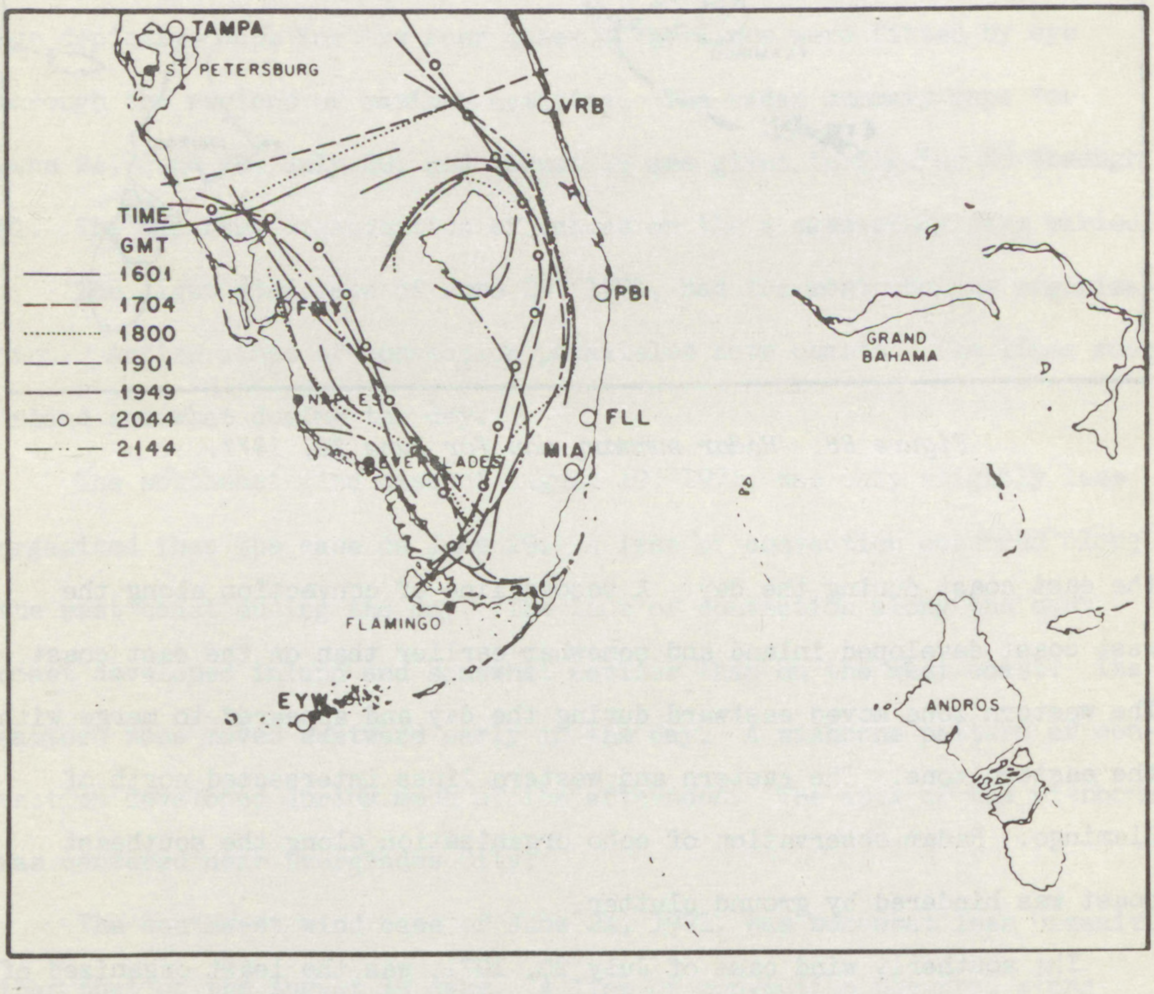


Figure 89. Radar summary map for June 29, 1971.

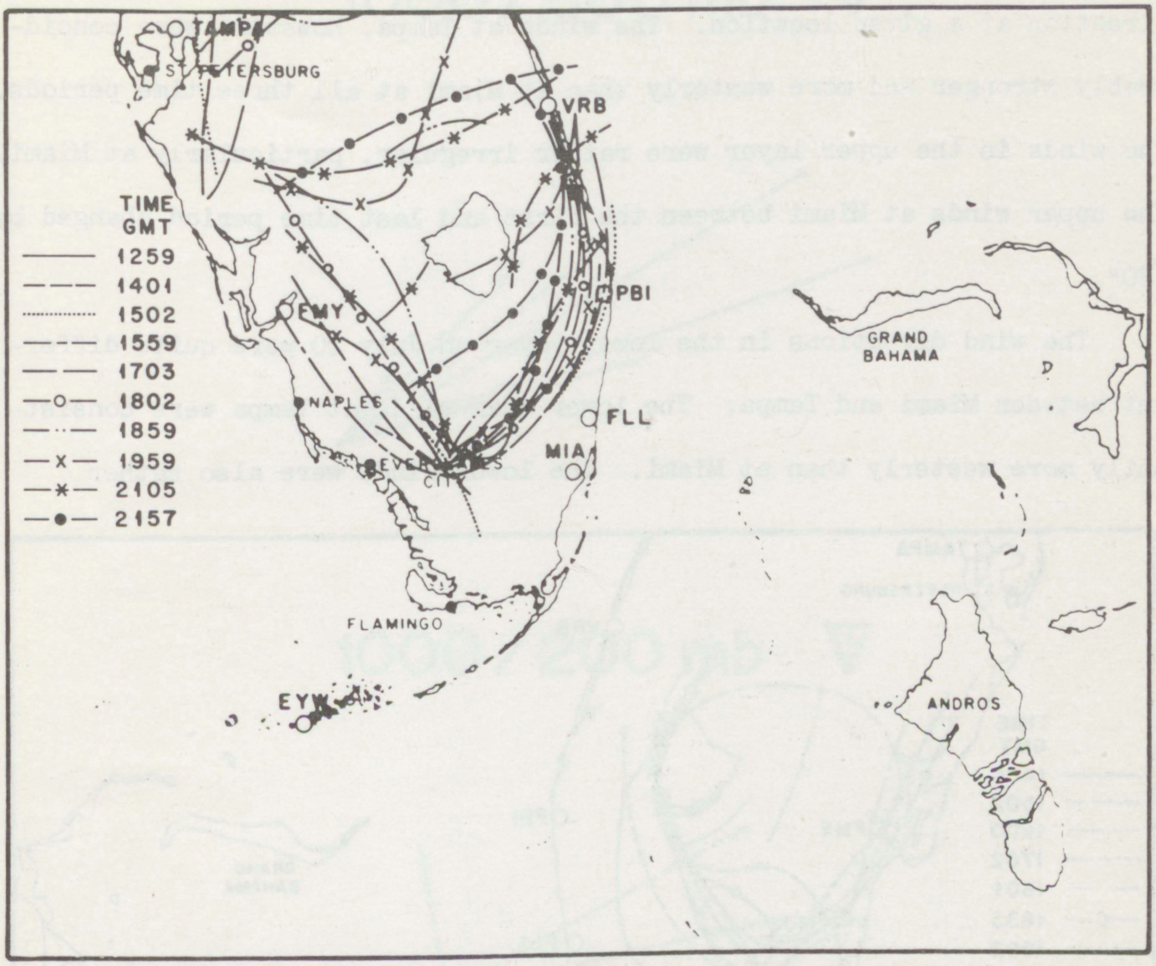


Figure 90. Radar summary map for July 20, 1971.

change at a given station were small. The difference between stations was greatest in the upper layer winds.

The mean winds in the lower level on June 29 were rather variable in direction between Miami and Tampa and change in time. The wind speeds were generally small, however, so that the wind field on June 29 was quite uniform. The wind speeds and directions in the upper layer in the last two time periods were very uniform. The winds in the lower layer were slowly becoming more easterly with time.

The mean winds in the lower layer on June 24 were very uniform in direction at a given location. The winds at Tampa, however, were considerably stronger and more westerly than at Miami at all three time periods. The winds in the upper layer were rather irregular, particularly at Miami. The upper winds at Miami between the first and last time period changed by 180°.

The wind directions in the lower layer on July 20 were quite different between Miami and Tampa. The lower mean winds at Tampa were consistently more westerly than at Miami. The lower winds were also rather

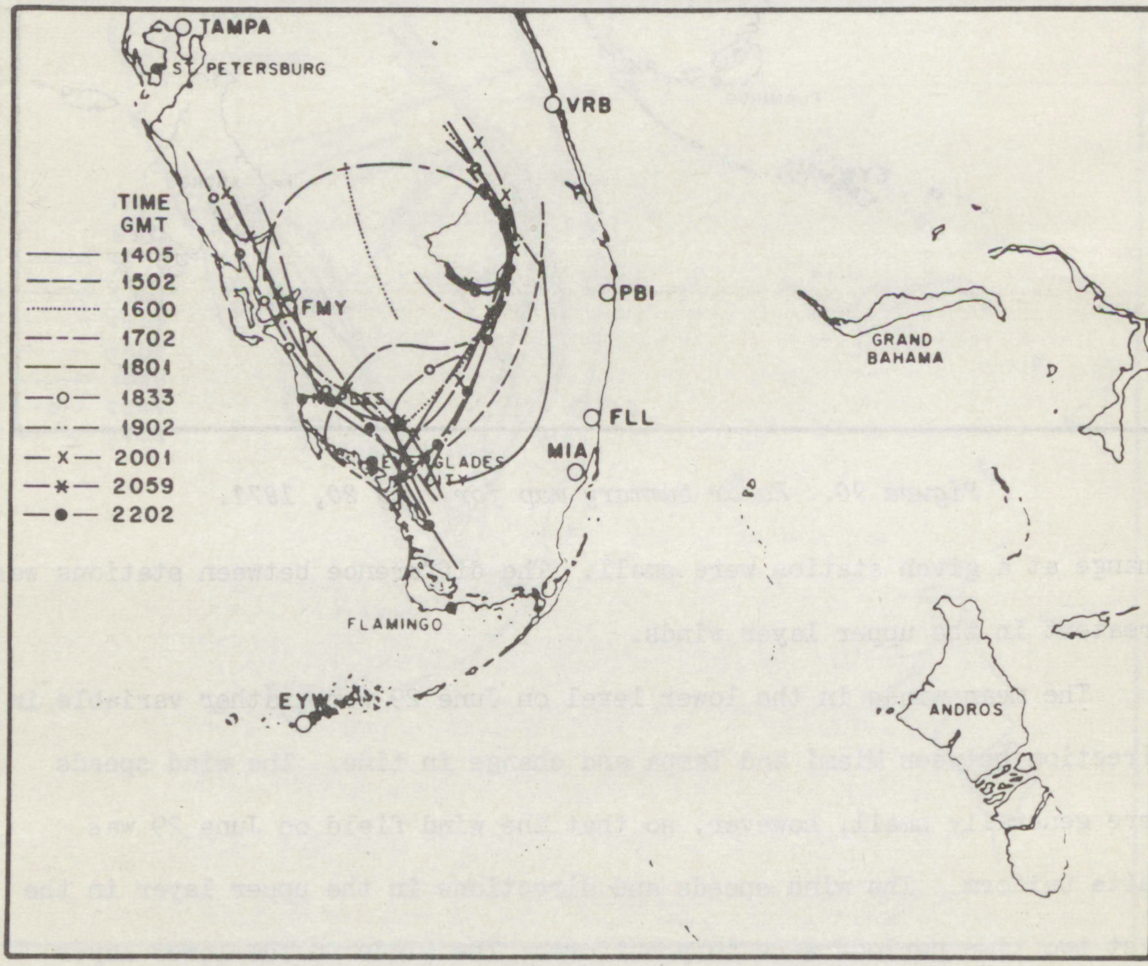


Figure 91. Radar summary map for August 19, 1971.

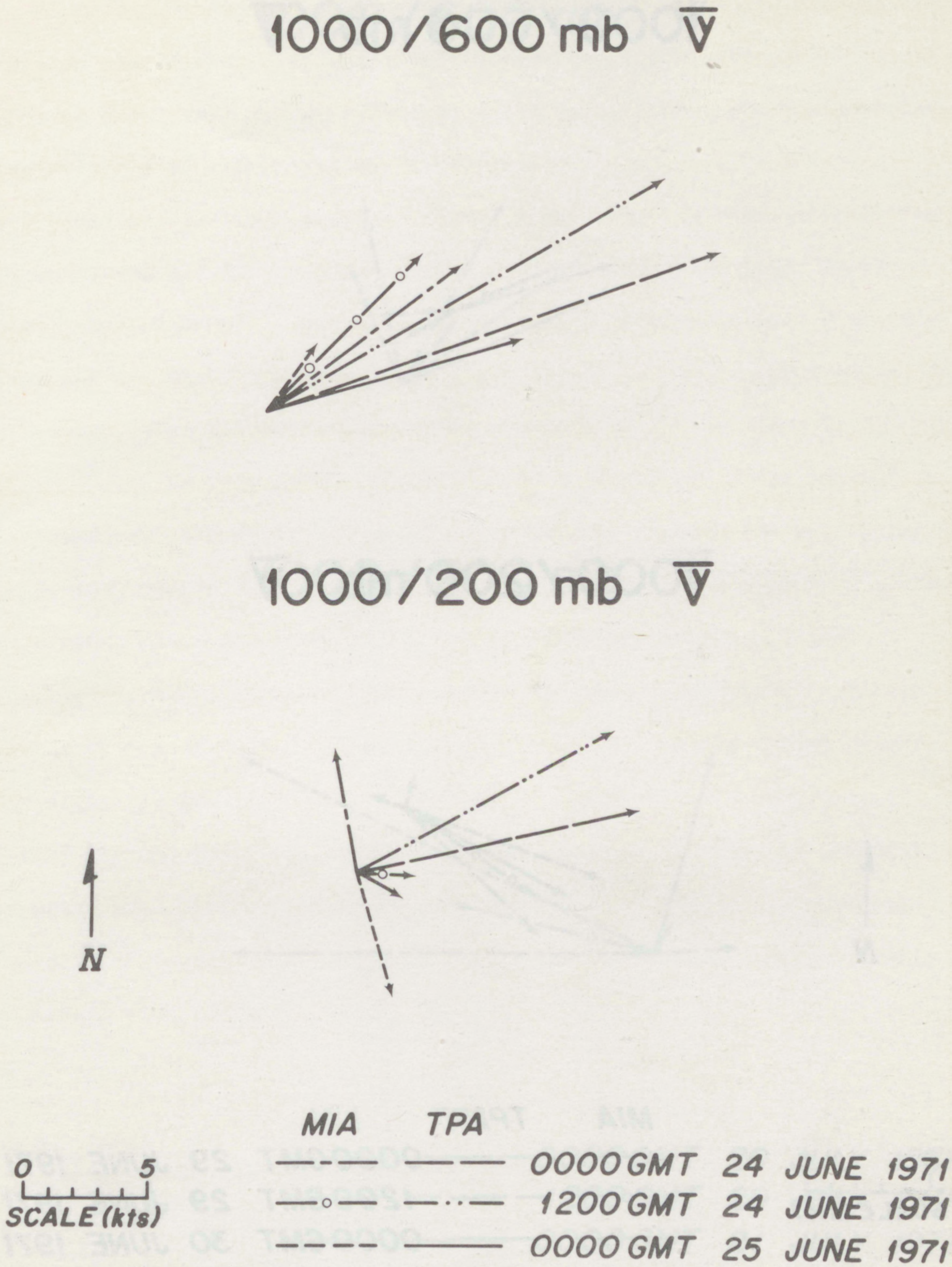


Figure 92. Wind rose at Miami and Tampa (1900 EST on June 23, 0700 EST on June 24, and 1900 EST on June 24).

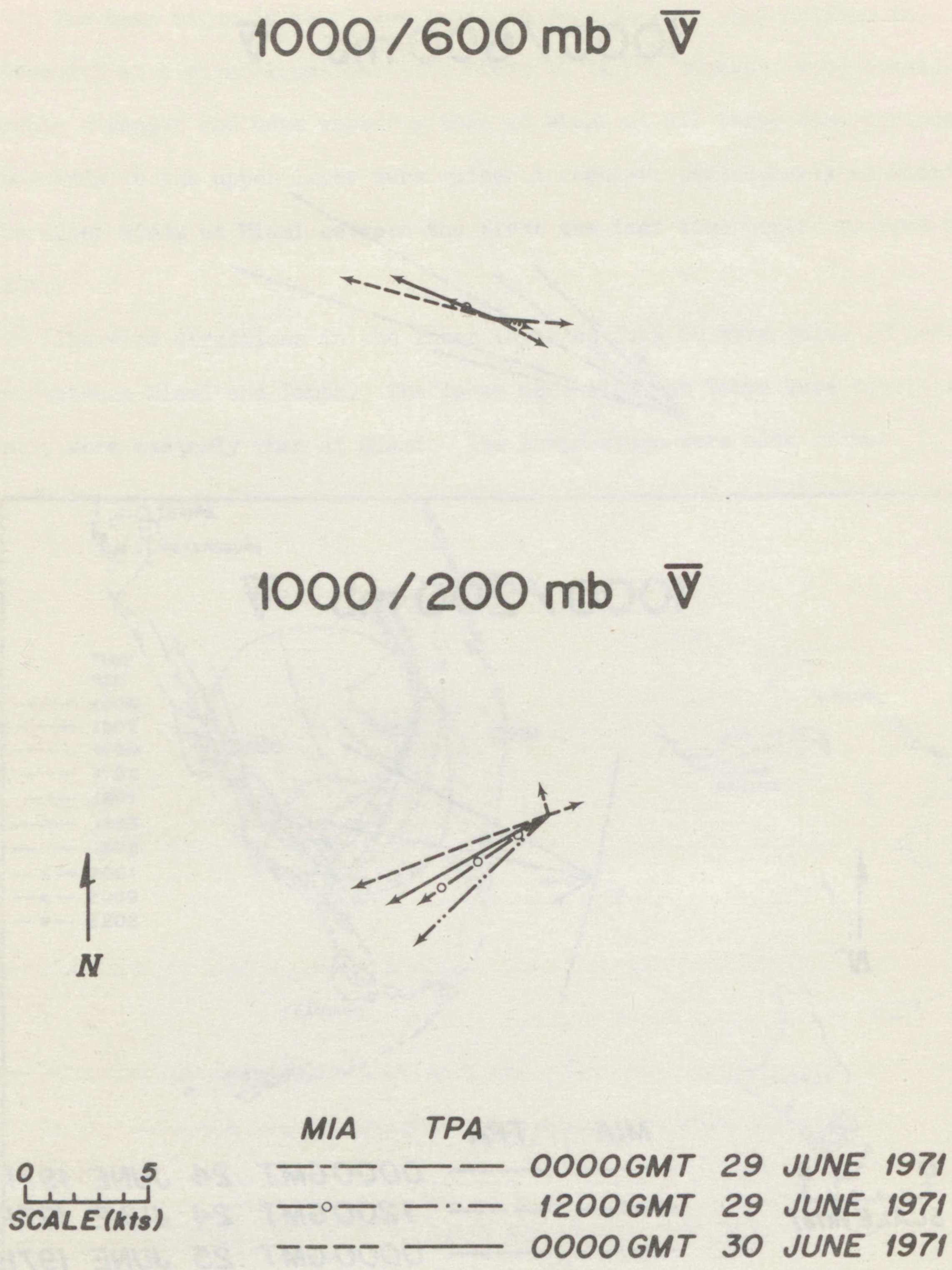


Figure 93. Wind rose at Miami and Tampa (1900 EST on June 28, 0700 EST on June 29, and 1900 EST on June 29).

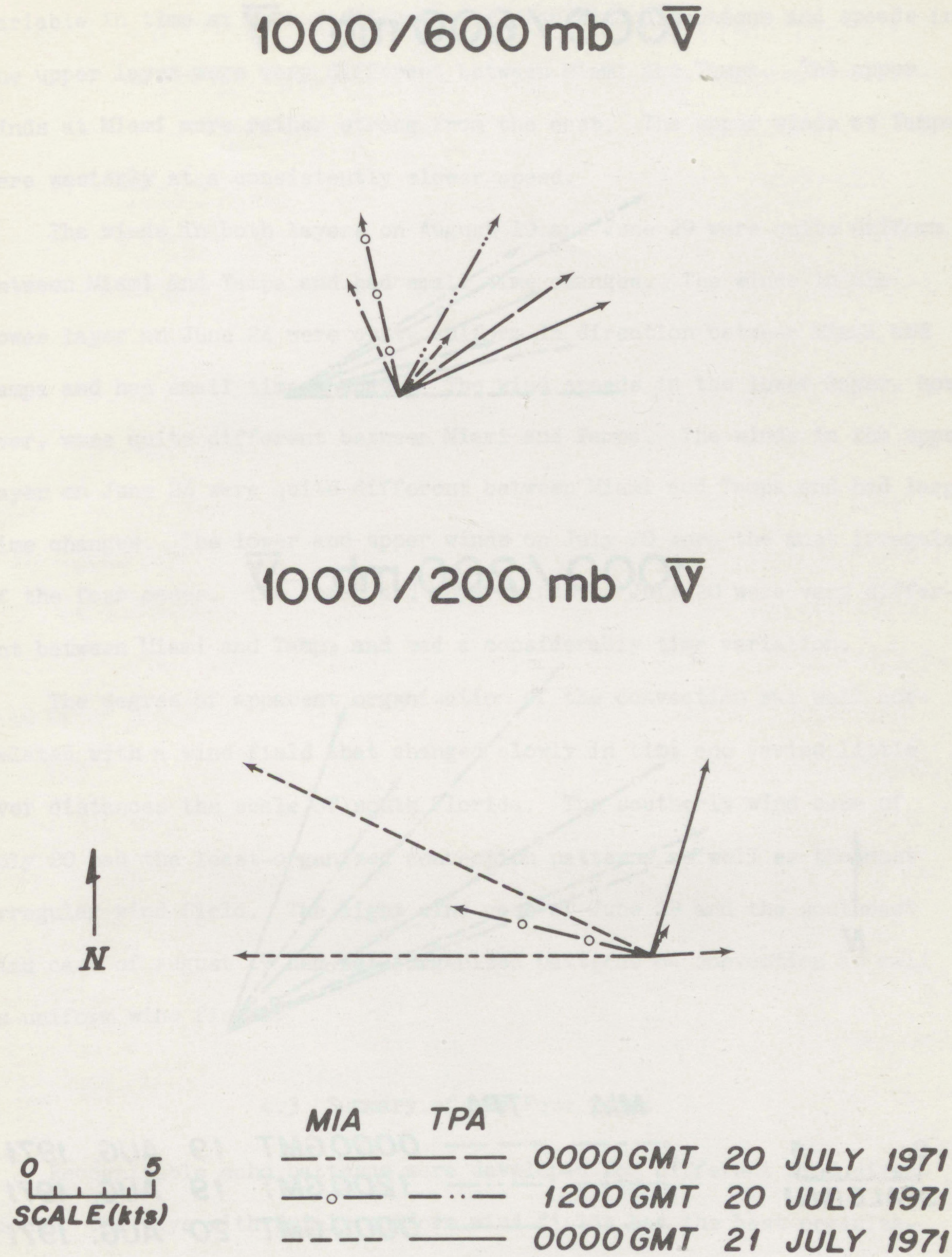


Figure 94. Wind rose at Miami and Tampa (1900 EST on July 19, 0700 EST on July 20, and 1900 EST on July 20).

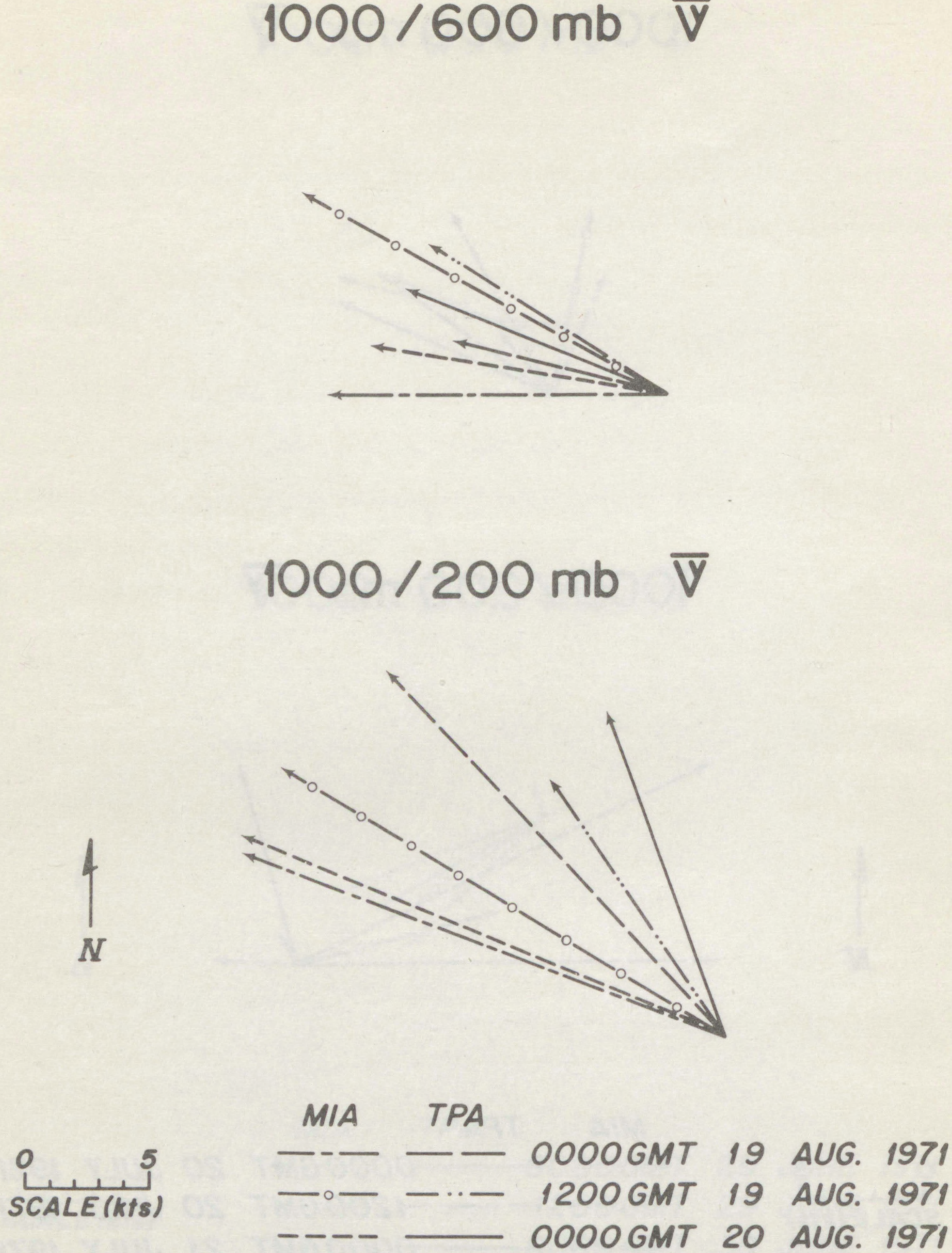


Figure 95. Wind rose at Miami and Tampa (1900 EST on August 18, 0700 EST on August 19, and 1900 EST on August 19).

variable in time at both stations. The mean wind directions and speeds in the upper layer were very different between Miami and Tampa. The upper winds at Miami were rather strong from the east. The upper winds at Tampa were westerly at a consistently slower speed.

The winds in both layers on August 19 and June 29 were quite uniform between Miami and Tampa and had small time changes. The winds in the lower layer on June 24 were quite uniform in direction between Miami and Tampa and had small time changes. The wind speeds in the lower layer, however, were quite different between Miami and Tampa. The winds in the upper layer on June 24 were quite different between Miami and Tampa and had large time changes. The lower and upper winds on July 20 were the most irregular of the four cases. The lower and upper winds on July 20 were very different between Miami and Tampa and had a considerable time variation.

The degree of apparent organization of the convection was well correlated with a wind field that changed slowly in time and varied little over distances the scale of south Florida. The southerly wind case of July 20 had the least-organized convection patterns as well as the most irregular wind field. The light wind case of June 29 and the southeast wind case of August 19 had well-organized patterns of convection as well as uniform wind fields.

4.3 Summary of the Four Cases

Recognizable echo patterns were developed for different wind directions. The days with fairly uniform wind fields had the best organization of echoes. The patterns found for the southeast, the southwest, and the light wind cases agreed qualitatively with the easterly, westerly, and light and variable cases discussed by Frank, Moore, and Fisher (1967).

The initial echo formation occurred in geographically favored regions. The area east of Lake Okeechobee, particularly, appeared to have a maximum of echo coverage for several different wind directions.

5. QUALITATIVE INTERPRETATION OF THE ECHO ORGANIZATION DURING JUNE, JULY, AND AUGUST 1971 AS SEEN FROM NATIONAL HURRICANE CENTER RADAR DEPICTION CHARTS

The National Hurricane Center prepares radar dipiction charts hourly directly from the radarscopes. The charts for June, July, and August 1971 were examined by the author to determine how many days showed patterns of organization similar to the patterns revealed in the 4 case-study days. The days were rated as to the degree of recognized organization. The days were given the following qualitative judgment:

0 no organization
1 fair organization
2 good organization
3 excellent organization.

Days with no echoes were given zeros. Days in which the peninsula was saturated with echoes were also given zeros. This type of qualitative interpretation is admittedly highly subjective, but it will give some idea as to how often recognizable organized patterns of convection occur over south Florida during the summer. The author attempted to be conservative, and a lower class was chosen when there was a question between two classes.

The results suggest that there is obvious organization to the echo distribution over south Florida on many summer days. The effect of the large-scale wind direction on the movement of echoes is very important. The results for June, July, and August 1971 are given below.

Month	Organization Rating			
	0	1	2	3
June	10	8	11	1
July	5	11	12	3
August	10	8	10	3

There was no evidence of organization on less than 28 percent of the days. There was good or excellent echo organization, as seen by radar, on over 43 percent of the days. The estimate of the number of days with organization is probably conservative because:

(a) Days with no radar return may have well-defined nonprecipitating cloud patterns or even organized motion fields without clouds.

(b) The radar depiction charts are made in real time. Of necessity, a meticulous tracing of radar echo coverage is not possible. Moreover, a parallax error is possible because the plate glass that covers the scope is about 6 inches from the actual radarscope.

(c) The degree of organization was determined based on the results of the four case studies. Other flow regimes may have similar well-organized patterns, but they were not recognized by the author.

The degree of recognized organization of echoes as seen by radar was compared against the mean mixing ratio in the 1000-600 mb layer and against the days with the mean vertical shear between the upper and lower mean charts of less than 10 knots at both Miami and Tampa. The mean mixing ratio was plotted against the degree of recognized echo organization. Also, the degree of recognized echo organization for the days where the mean shear at Tampa and Miami was less than 10 knots was tabulated and examined. There was no obvious correlation in either case. A number of days with low vertical wind shear had no recognizable organization as seen from the radar depiction charts. The highly subjective interpretation of organization of echoes probably precluded a quantitative comparison. A more desirable approach would be to examine every day during a summer period in the same detail as the four case studies presented in this report. Then the author feels definitive correlations with certain meteorological parameters will be established.

6. CONCLUSION

The organization of convection over south Florida under different large-scale flow regimes was examined in detail using radar and surface observations for 4 days during the summer of 1971. On 2 of the days, ATS-3 photographs were also available. The detailed examination of the 4 case-study days revealed organized patterns to the convection that were generated by the geographical shape of south Florida and by the prevailing large-scale wind.

On the light wind case-study day, convection initially occurred in regions favored by a convex shape of the coastline. Lines of convection formed parallel to the coasts and moved inland very slowly during the day.

On the southeast wind case-study day, a line of convection formed along the west coast and remained stationary during the day. A separate line formed inland from the east coast somewhat earlier and moved westward. A wishbone pattern to the convection developed during the afternoon. The wishbone remained essentially stationary during the afternoon.

On the southwest wind case-study day, the convection organized into two lines along the two coasts. The western line formed inland from the west coast and moved eastward across the peninsula during the day. The eastern leg formed later and remained essentially stationary during the day.

On the south wind case-study day, the convection was organized into the arc with the vertex well north of the southern tip of the peninsula. The western segment of the arc moved irregularly eastward during the day apparently because the synoptic winds became more westerly with time. The eastern segment remained approximately stationary with the northern section fixed over and to the west of Palm Beach. The echoes moved northward early in the day.

The general patterns on the case study days agreed with the results of Frank, Moore, and Fisher (1967) who used statistics derived from digitized radar data to determine mean radar echo movement and development as a function of the prevailing winds. The convection on the case study days was more organized into well-defined lines on the days with a small time variation in the mean winds and a small difference in mean winds between Miami and Tampa.

Radar depiction charts for June, July, and August 1971, prepared hourly by the National Hurricane Center, were examined subjectively by the author for the degree of organization as revealed by the case studies.

Over 43 percent of the days during that period had good or excellent organization! Less than 28 percent of the days had no evidence of organization. There was no obvious correlation between the degree of organization and the low vertical wind shear or mean mixing ratio in the lower troposphere. Results of the case studies suggest that uniform winds in time and space are a necessary prerequisite for easily recognizable echo organization.

The analysis of the echo organization during 4 case-study days suggests that the development and movement of convection over south Florida are to a large extent controlled by the geographical shape of the peninsula and by the large-scale prevailing winds. The subjective examination of the echo organization during June, July, and August 1971 suggests that such organization exists on many days during the summer.

7. ACKNOWLEDGMENTS

The synoptic analyses and radar movies prepared by the National Hurricane Center under the directorship of Robert Simpson, who made the information very accessible for research use, were essential to the successful completion of this study. Don Gaby and staff of the Satellite Applications Section of the National Hurricane Center are especially thanked for the processing of the satellite photographs.

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