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Technical Attachment

CONTRIBUTIONS OF HELICITY TO THE FORMATION OF A RELATIVELY LONG LIVED TORNADO IN CENTRAL FLORIDA

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1. INTRODUCTION

While Florida consistently ranks high in the number of tornadoes each year, the size, intensity and duration of the average Florida tornado is less than most other regions of the U.S. This is especially true in the central section of the Florida peninsula (Schmocker, et al., 1990). These statistics reflect a large number of F0-F1 tornadoes, including waterspout-tornadoes, which are typically less intense and shorter lived than supercell produced tornadoes.

The frequency of short lived tornadoes in Florida adds difficulty to the decision to issue warnings. Basing warnings on reports of sightings or damage, when the report is more than a few minutes old, often leads to false alarms when the tornado is of short duration. To avoid this, the forecaster must attempt to differentiate between days when convection could produce tornadoes of longer duration and those days when convection may produce the typical "Florida tornado." This paper will examine the use of helicity (Davies-Jones, et al., 1990) as a tool to aid this forecast problem.

In the following case, an F1 tornado struck the Orlando metropolitan area of Central Florida on November 9, 1990. The tornado was significant in that it was long lived and formed in an environment not conducive to strong convection. At least three additional damaging tornadoes occurred across central and south central Florida during the day and early evening.

2. DISCUSSION

At the surface at 1200 UTC, November 9, a well defined surface low was just west of New Orleans with a cold front extending south into the Gulf of Mexico (Fig. 1). By 0000 UTC, the low had moved to southern Alabama with the cold front extending to south of Pensacola. A warm front had also formed from the low across South Central Georgia to Charleston, SC (Fig. 2). During this period, a deep 500 mb trough and its associated vorticity maximum had moved from East Texas to Central Mississippi. Cold advection at 500 mb and strong PVA were well to the north and west of Central Florida (Fig. 3), as was any forcing with the cold front over the Gulf.

Ahead of this system, a southerly 40 kt jet at 850 mb was advecting + 17C dewpoint air across the Florida peninsula. Concurrently, a vigorous short wave was evident at 700 mb from West Tennessee to south of the Louisiana coast. Slight upper diffluence was occurring over the Florida panhandle and South Georgia (Fig. 4).

The morning soundings from Tampa and Cape Canaveral (Figs. 5 and 6) were characterized by a moist layer from the surface to approximately 700 mb. A capping inversion was -present .around 600 mb. Dry air from 700 mb and above with relatively warm 500 mb temperatures of 6 to -7C resulted in lifted indices (LI) of only + 1 to - 1 C. By 0000 UTC November 10, low level moisture had increased with + 15C dewpoints at 850 mb and surface dewpoints in the mid 70s(F). LIs had decreased to -3C at Tampa and -5C at the Cape, with a 500 mb temperature of -7C at Cape Canaveral. The 500 mb temperature at Tampa had actually increased to -5C. The 0000 UTC Cape sounding was contaminated by a rain shower during release.

By 1700 UTC, convection had begun across northern sections of Central Florida. Between 1900 and 1930 UTC, convection developed further south between Lake Okeechobee and Orlando. Maximum precipitation tops detected by the Tampa radar were only 19,000 ft. At 2015 UTC, a tornado (F1) struck near Sebring about 60 mi south of Orlando. WSO Tampa radar reported a maximum top to 28,000 ft. and VIP 3 reflectivity in this area of convection near the time of tornado occurrence.

Around 2100 UTC, a convective cell just south of downtown Orlando had increased to VIP 4 reflectivity with a top to 30,000 ft. by 2130 UTC. The cell at this time had a sharp reflectivity gradient on its southern low level inflow side with a small degree of concavity, but no pronounced hook.

No lightning was detected by the Atmospheric Research Systems, Inc. Lightning Position and Tracking System (LPATS) or reported by surface observations at Orlando International (MCO) or Orlando Executive (ORL) airports. At 2115 UTC, this cell produced a tornado which caused considerable damage and injured nine people a few miles north of downtown Orlando. The tornado diminished in size as it moved northward producing light damage during the next 32 minutes over a 16-mile distance (Fig. 7).

While convection was likely to occur across Central Florida during the day, temperature and moisture profiles did not suggest a strong possibility for severe weather. Vertical wind profiles throughout the day show a different story and may give a clue to why tornadoes developed.

3. STORM RELATIVE HELICITY

The lack of strong mid or upper level dynamics leads one to look at storm relative helicity as a possible reason for the Orlando tornado to form and last a long time, relative to other Florida tornadoes. The convective cell in question was fueled by good low level moisture and surface heating. The 1200 UTC hodograph from Tampa (Fig. 8) depicted very favorable directional shear from 0-3 km with a helicity value of 355 $(m/s)^2$. Hodographs early in the day were not as impressive at the Cape, however, where helicity values from 0-3 km were 102 at 1200 UTC (Fig. 9) and 165 at 1500 UTC. At 1700 UTC, little had changed, with the Cape sounding slightly more unstable, while the helicity value actually decreased to 140 (Figs. 10 and 11). At 0000 UTC November 10, the Cape sounding was contaminated by a rain shower during release (Fig. 12), but the helicity value had increased to 294 (Fig. 13).

The Orlando tornado occurred between 1700 UTC and 0000 UTC. Helicity values for 1700 UTC and 0000 UTC at the Cape were calculated using echo motion from the Daytona Beach radar observations after convection had initiated and during the time of the tornado.

Assuming that helicity was the critical parameter in this case, how do the computed helicity values compare with prior research? If we assume the 0000 UTC Cape Canaveral observation is a "proximity sounding," the storm relative helicity was 294. The prior (1200 UTC) Tampa sounding, which be considered "upstream," showed a helicity value of 355. Davies-Jones, et al. (1990) arrived at helicity ranges of 150-299, 300-449 and > 450 for development of weak, strong, and violent tornadoes, respectively. These ranges were based on supercell tornadoes in Oklahoma. Hagemeyer and Schmocker (1991) found an average helicity value of 273 for Central Florida tornado outbreaks of four more tornadoes.

4. SUMMARY

With no sea breeze interactions or readily apparent boundary collisions, the Orlando tornado was most likely not a "gustnado" or "landspout." Nor could the parent cell be categorized as a classic supercell, since no lightning, hail, or other strong winds occurred. Therefore, applying prior research values to this "hybrid" storm should be done only in the broadest sense. Even so, the November 9 1200 UTC helicity value at Tampa and the November 10 0000 UTC value at the Cape were in the general range which seems to support weak to strong tornado development, or as in this case, a weak tornado of long duration. Hence, we conclude the lack of strong upper dynamics or deep instability may not preclude relatively long duration tornadoes in Florida if sufficient storm-relative shear is present. Obviously, more study is needed.

The helicity values for this paper were calculated using the Sharp Workstation (Hart and Korotky, 1991). With the WSR-88D now operational in Melbourne, wind data from the radar, as well as accurate storm motion, can be used to modify soundings and recalculate helicity after convection has initiated. With these tools, diagnosis of helicity may become even more valuable in predicting times when tornadoes of greater intensity or longer duration may be possible in Florida.

REFERENCES

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Hart, J. A., and J. Korotky, 1991: The SHARP Workstation v1.50. Users manual, a SkewT/Hodogragh Analysis and Research Program for the IBM and compatible PC. NOAA/NWS WSFO Charleston, WV.

Hagemeyer, B. C., and G. K. Schmocker, 1991: Characteristics of east central Florida tornado environment. *Wea. Forecasting, 6*, 499-514.

Schmocker, G. K., D. W. Sharp, and B. C. Hagemeyer, 1990: Three initial climatological studies for WFO Melbourne, Florida. NOAA Tech. Memo. NWS SR-132.

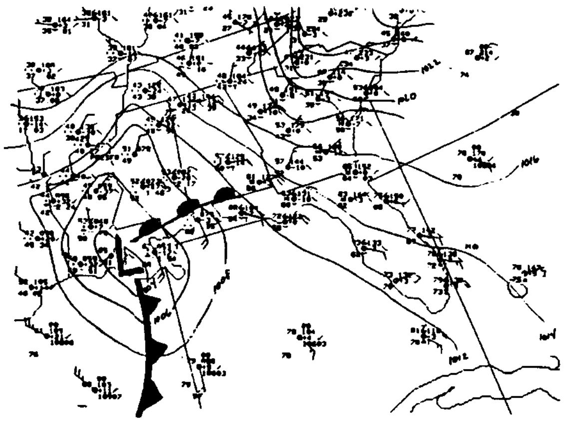

Fig 1
Surface 11/9/90 12z

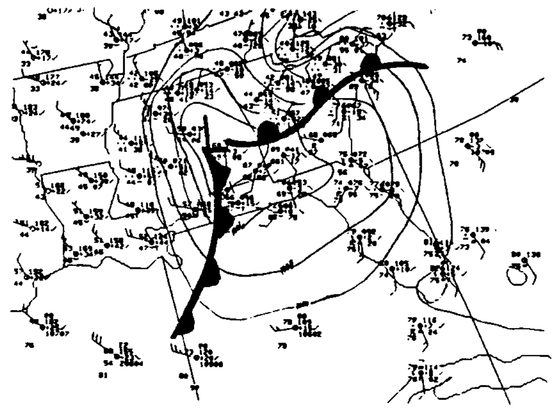

Fig 2
Surface 11/10/90 00z

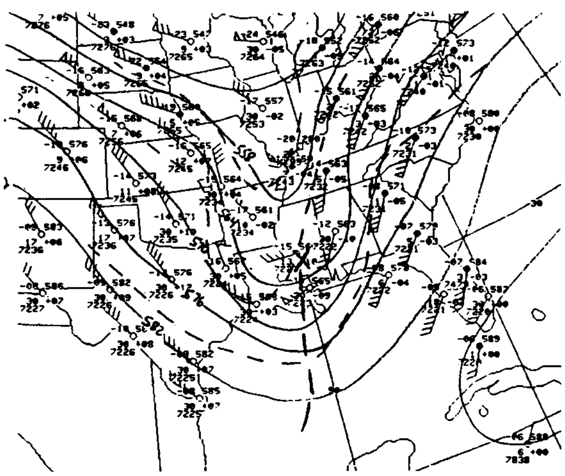

Fig 3
500 mb 11/10/90 00z

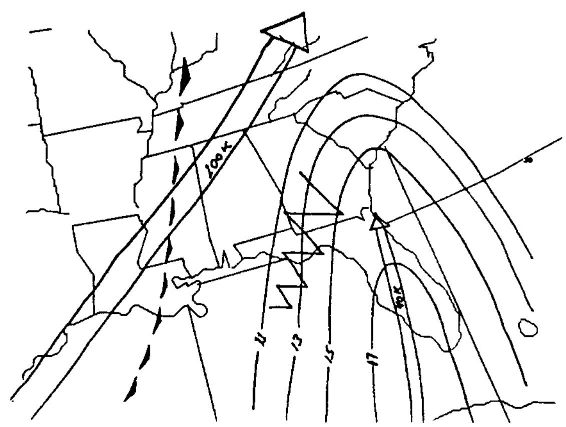

Fig 4
Composite 11/10/90 00z

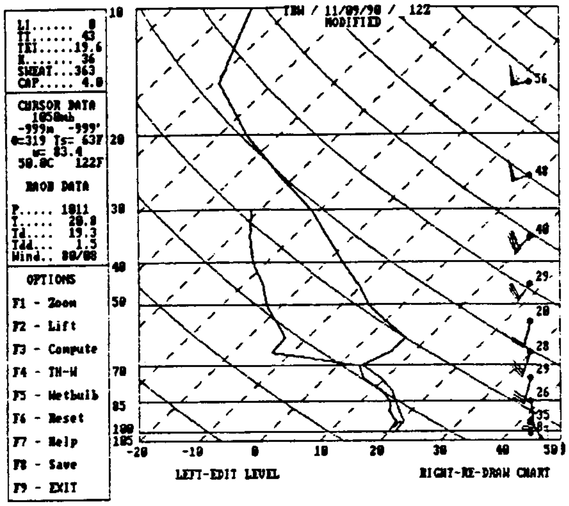

Fig 5
Tampa Sounding
11/9/90 12z

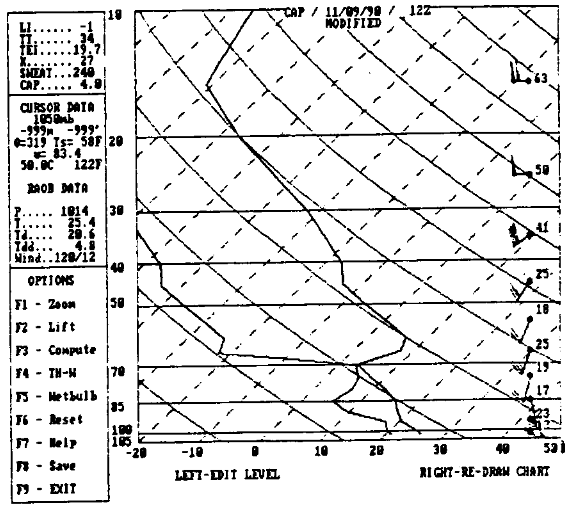

Fig 6
Cape Canaveral Sounding
11/9/90 12z

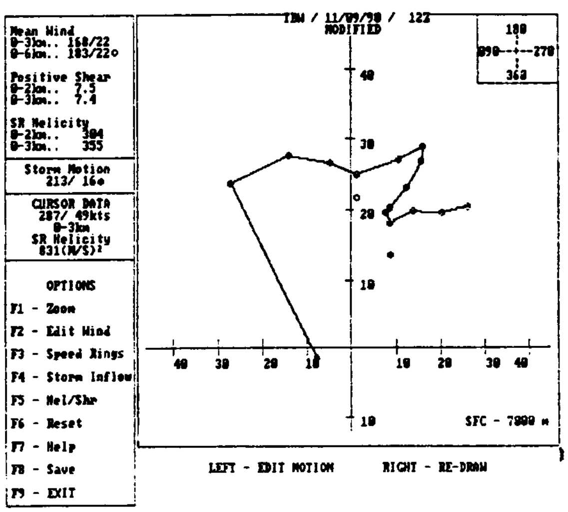

Fig 8
Tampa Hodograph
11/9/90 12z

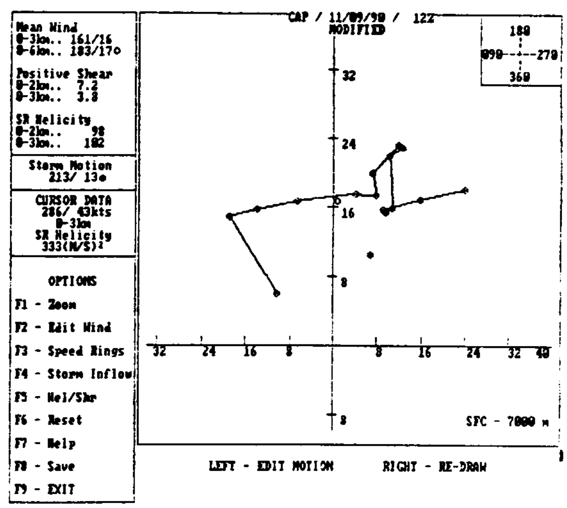

Fig 9
Cape Canaveral Hodograph
11/9/90 12z

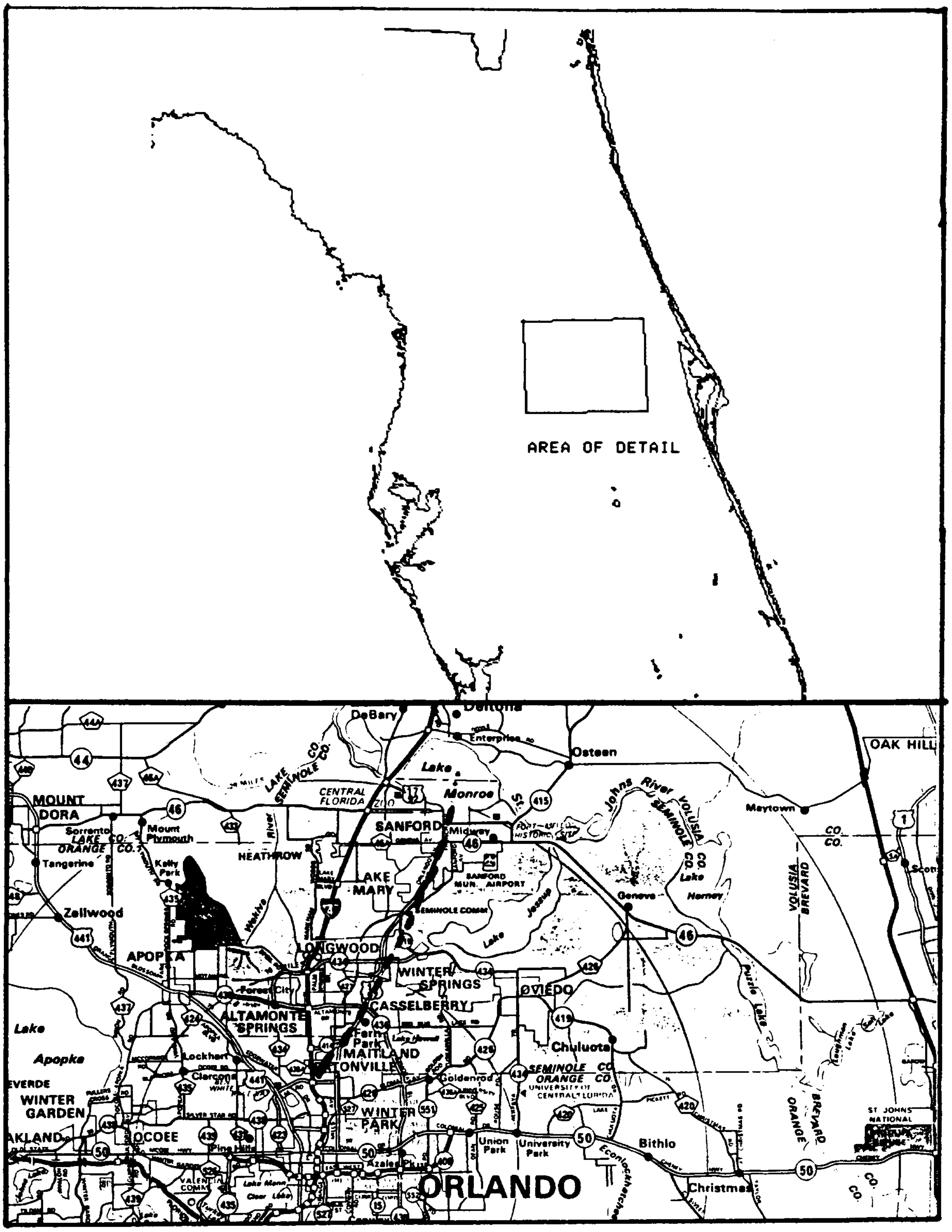

Figure 7
Approximate Path of Tornado of November 9th 1990

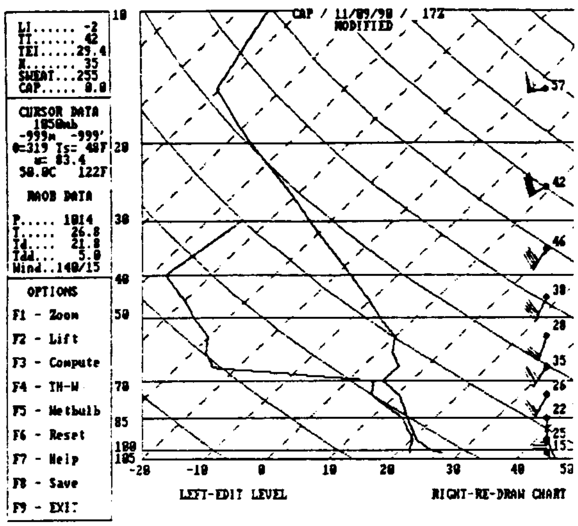

Fig 10
Cape Canaveral Sounding
11/9/90 17z

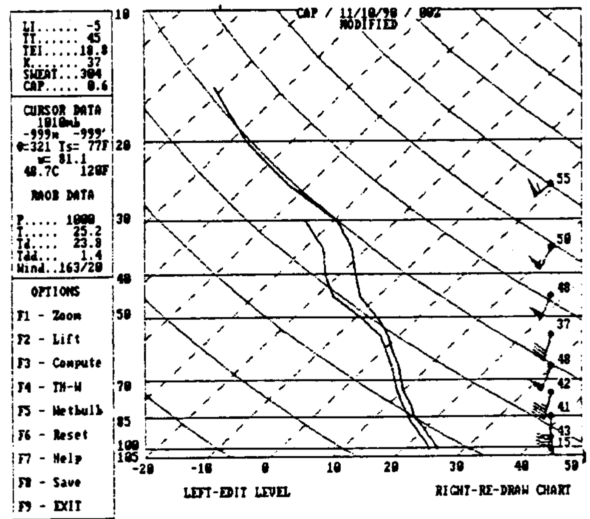

Fig 12
Cape Canaveral Sounding
11/10/90 00z

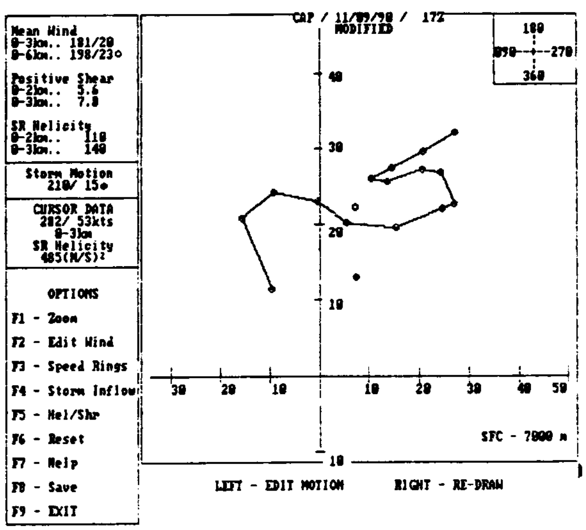

Fig 11
Cape Canaveral Hodograph
11/9/90 17z

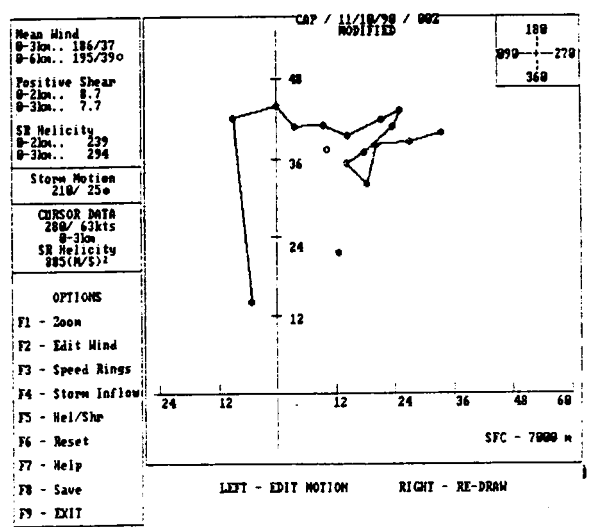

Fig 13
Cape Canaveral Hodograph
11/10/90 00z