

AD-A070 266

ROSENSTIEL SCHOOL OF MARINE AND ATMOSPHERIC SCIENCE --ETC F/6 4/2
SATELLITE AND RADAR ANALYSIS OF MESOSCALE WEATHER SYSTEMS. (U)

JUL 76 H P GERRISH

DAAD07-75-C-0058

UNCLASSIFIED

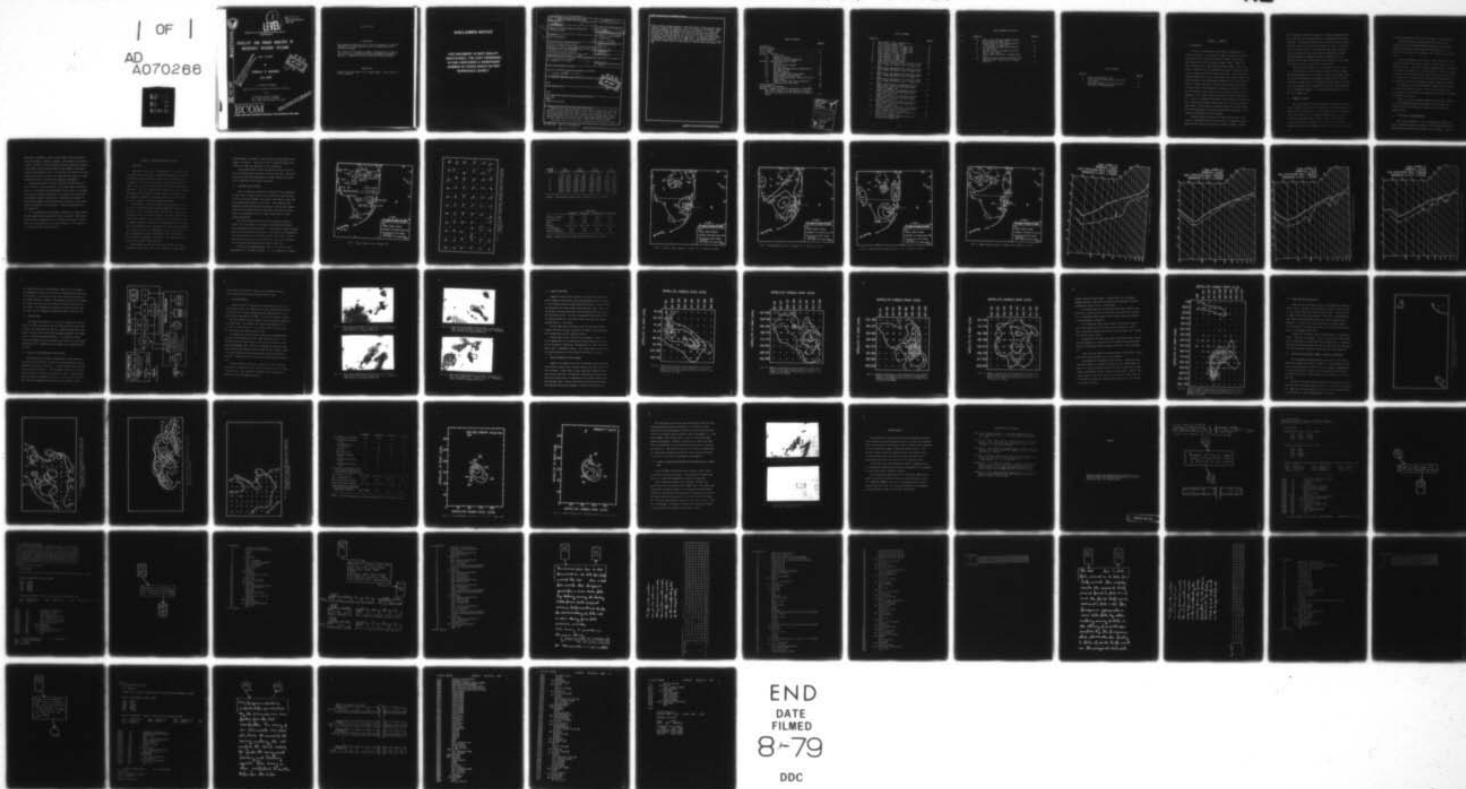
UM-RSMAS-76008

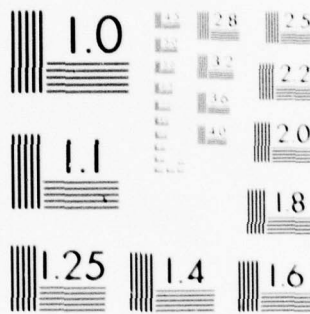
ECOM-0058F

NL

| OF |

AD
A070266





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



**1
LEVEL**

AD

Reports Control Symbol
OSD-1366

RESEARCH AND DEVELOPMENT TECHNICAL REPORT
ECOM-0058-F

AD A070266

SATELLITE AND RADAR ANALYSIS OF MESOSCALE WEATHER SYSTEMS

FINAL REPORT

By

HAROLD P. GERRISH

July 1976

DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

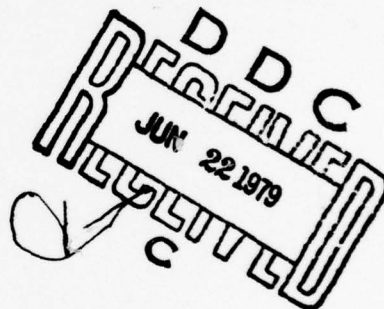
FOR

Atmospheric Sciences Laboratory
U.S. Army Electronics Command
White Sands Missile Range, N.M. 88002

ECOM

UNITED STATES ARMY ELECTRONICS COMMAND - FORT MONMOUTH, NEW JERSEY

THIS DOCUMENT IS BEST QUALITY PRACTICE.
THE COPY FURNISHED TO DDC CONTAINED A
SIGNIFICANT NUMBER OF PAGES WHICH DO NOT
REPRODUCE LEGIBLY.



ORIGINAL CONTAINS COLOR PLATES: ALL DDC
REPRODUCTIONS WILL BE IN BLACK AND WHITE.

DDC FILE COPY

79 06 18 158

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

DISCLAIMER NOTICE

**THIS DOCUMENT IS BEST QUALITY
PRACTICABLE. THE COPY FURNISHED
TO DDC CONTAINED A SIGNIFICANT
NUMBER OF PAGES WHICH DO NOT
REPRODUCE LEGIBLY.**

18 (19) REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ECOM 0058-F	2. GOVT ACCESSION NO.	RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Satellite and Radar Analysis of Mesoscale Weather Systems.	5. TYPE OF REPORT & PERIOD COVERED Final Report, 16 December 1974 - 14 June 76	6. PERFORMING ORG. REPORT NUMBER 6626 -1 UM-RSMAS 76008
7. AUTHOR(s) Harold P. Gerrish	8. CONTRACT OR GRANT NUMBER(s) Contract No. DAAD07-75-C-0058	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Project No. IT162111 AH 71
9. PERFORMING ORGANIZATION NAME AND ADDRESS Division of Atmospheric Science Rosenstiel School of Marine and Atmospheric Science University of Miami, Coral Gables, Fl. 33124	11. CONTROLLING OFFICE NAME AND ADDRESS Atmospheric Sciences Laboratory U.S. Army Electronics Command, DRSEL-BL-MS White Sands Missile Range, N.M. 88002	12. REPORT DATE July 1976
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) U.S. Army Electronics Command Ft. Monmouth, N.J. 07703	13. NUMBER OF PAGES 67	15. SECURITY CLASS. (of this report) Unclassified
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited. 14 UM-RSMAS-76048, 6626-1		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) Same		
18. SUPPLEMENTARY NOTES None		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Satellite Radar Tropical Convection		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Relationships between satellite visible and I.R. gray levels, and such parameters as the existence of radar echoes, ceiling height and surface visibility are studied using SMS-1/GOES satellite data, digital radar data, surface observations from first order stations, and the Kennedy Space Center Image 100 Multispectral Image Analyzer. Radar echo/rainfall relationships are also studied using rain gauge data from the 1975 FACE mesonet network. The results from four case studies during August 1975 show that radar		

DDC
REFILED
JUN 22 1979
RECEIVED
C

405 515

LB

echoes occurred, without exception, when both types of satellite gray levels exceeded a value of 183 based on a scale of 0 (black) to 255 (white). Other joint relationships are described for lower gray levels. It is shown that the lowest ceilings and surface visibilities occurred with the satellite visible levels near 100 and the I.R. levels near 130 and 110 respectively. An example is presented showing the simulation of a radar echo pattern from themed satellite visible data on 14 August 1975. And computer programs are appended for converting 7-track NHEML KART digital radar tapes to 9-track tapes with suitable block size and format for the KSC PDP 11/35 computer system.

TABLE OF CONTENTS

	<u>Page No.</u>
DD FORM 1473	
Table of Contents	i
List of Figures	ii
List of Tables	iv
Section 1 - Overview	1
1.1 Introduction	1
1.2 Summary of Results	2
1.3 Conclusions and Recommendations	3
Section 2 - Detailed Description of Work	5
2.1 Input Data	5
2.2 Selection of Case Studies	6
2.3 Analysis Area	18
2.4 The Image 100 Multispectral Image Analyzer	18
2.5 Data Registration	20
2.6 Analysis Procedure	23
2.7 Satellite/Radar Echo Relationships	23
2.8 Radar Echo/Rain Relationships	30
2.9 Satellite/Ceiling Height, Surface Visibility Relationships	30
2.10 Example of Radar Echo Pattern Depiction from Satellite Visible Data	38
Acknowledgements	40
Bibliography and References	41
Appendix - Computer programs for converting 7-track NHEML KART digital tapes to 9-track tapes with suitable block size and format for the KSC PDP 11/35 Computer System	43

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DDC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	<input type="checkbox"/>
By _____	
Distribution/ _____	
Availability Codes _____	
Dist	Avail and/or special
A	23 074

LIST OF FIGURES

<u>Figure No.</u>		<u>Page No.</u>
1	Map of digital radar coverage area	7
2	1975 FACE rain gauge network	8
3	Daily rainfall pattern, 13 August 1975	10
4	Daily rainfall pattern, 14 August 1975	11
5	Daily rainfall pattern, 18 August 1975	12
6	Daily rainfall pattern, 21 August 1975	13
7	2100Z sounding, 13 August 1975	14
8	2100Z sounding, 14 August 1975	15
9	2100Z sounding, 18 August 1975	16
10	2100Z sounding, 21 August 1975	17
11	Image 100 System block diagram	19
12	Radar echoes superimposed over satellite visible data in Image 100 analysis area, 13 August 1975 case	21 21
13	Radar echoes superimposed over satellite visible data in Image 100 analysis area, 14 August 1975 case	21 21
14	Radar echoes superimposed over satellite visible data in Image 100 analysis area, 18 August 1975 case	21 22
15	Radar echoes superimposed over satellite visible data in Image 100 analysis area, 21 August 1975 case	22 22
16	Number of grid points in mesonetwork with no radar echoes (solid) and with radar echoes (dashed) 13 August 1975	24 24
17	Number of grid points in mesonetwork with no radar echoes (solid) and with radar echoes (dashed) 14 August 1975	25 25
18	Number of grid points in mesonetwork with no radar echoes (solid) and with radar echoes (dashed) 18 August 1975	26 26
19	Number of grid points in mesonetwork with no radar echoes (solid) and with radar echoes (dashed) 21 August 1975	27 27
20	Composite number of grid points in mesonetwork with no radar echoes (solid) and with radar echoes (dashed) from all four cases	29 29
21	Radar (solid) and rain (dashed) patterns in mesonetwork 13 August 1975	31 31
22	Radar (solid) and rain (dashed) patterns in mesonetwork 14 August 1975	32 32

LIST OF FIGURES (continued)

<u>Figure No.</u>		<u>Page No.</u>
23	Radar (solid) and rain (dashed) patterns in mesonetwork 18 August 1975	33
24	Radar (solid) and rain (dashed) patterns in mesonetwork 21 August 1975	34
25	Ceiling height <u>vs</u> satellite visible and I.R. gray level	36
26	Surface visibility <u>vs</u> satellite visible and I.R. gray level	37
27	Actual radar echo pattern, 14 August 1975 case	39
28	Simulated radar echo pattern produced from themed satellite visible data, 14 August 1975 case	39

LIST OF TABLES

<u>Table No.</u>		<u>Page No.</u>
1	Digital radar printout code	9
2	Times (Z) of the various data used in the case studies	9
3	Grid point comparison of rain and radar echo data in FACE mesonetwork	35

SECTION 1 - OVERVIEW

1.1. INTRODUCTION

In tropical latitudes where the clouds are predominantly of convective origin, it is reasonable to expect that generally the more intense radar echoes and thus the greater rainfall rates would be associated with the taller, brighter (colder) clouds. Indeed, the work of Griffith et al. (1973 and 1976) heavily supports such a contention. Moreover, the ceiling heights and surface visibilities would tend to be lower with the more intense convection. These generalities strongly suggest that specific relationships can be found to permit the identification of such meteorological parameters direct from satellite imagery. Further, the ability to depict radar patterns and intensities from satellite data would make it possible to determine the location of turbulence, gusty winds, hail and tornado activity, and other parameters. This overall capability would be of obvious importance to the U.S. Army. Accordingly, the purpose of this work was to investigate basic relationships between satellite gray levels and the existence of radar echoes, ceiling height, and surface visibility in South Florida with the ultimate goal of developing identification techniques. Radar echo/rain relationships were also examined.

A rather impressive collection of input data were used in the analysis. SMS-1/GOES satellite visible and I.R. transparencies were provided by the Satellite Field Services Station in Miami. Digital

WSR-57 radar data together with special rain gauge and radiosonde data were provided by the National Hurricane and Experimental Meteorology Laboratory. The National Climatic Center provided the surface weather observations which contained ceiling heights and surface visibilities for first order stations. The analysis was performed on the highly sophisticated Kennedy Space Center Image 100 Multispectral Image Analyzer through an arrangement between the Atmospheric Science Laboratory, White Sands Missile Range, the Kennedy Space Center (KSC) Data Analysis Facility, and the University of Miami.

The analytical procedure was to contour the satellite visible, I.R., and radar data into various gray or intensity levels (themes) and then make comparisons of the specific values at grid points within the special mesonetwork of rain gauges installed for the 1975 FACE experiment in South Florida. The satellite/ceiling height and surface visibility comparisons were made for the Fort Myers, West Palm Beach, and Ft. Lauderdale airports. Case studies were analyzed for 13, 14, 18, and 21 August 1975.

1.2 SUMMARY OF RESULTS

This brief study has shown that specific relationships do exist between satellite visible and I.R. gray levels, and such parameters as the existence of radar echoes, ceiling height, and surface visibility. Echoes were found to occur, without exception, when the satellite visible and I.R. gray levels exceeded a value of 183, based on a scale of 0 (black) to 255 (white). Most of the echoes occurred, however, with satellite visible gray levels of 131-216 and I.R. levels

of 163-192; and visible levels of 131-147 and I.R. levels of 193-222.

A good correlation was shown between radar echo and rain patterns over the rain gauge mesonetwork but the linear correlation coefficients between the intensities were surprisingly low. The reason for that was not clear; perhaps it was related to registration errors.

It was interesting to note that this study revealed clear relationships between satellite gray level and ceiling height as well as surface visibility. The lowest ceilings occurred when the visible gray level was near 100 and the I.R. level was near 130. The lowest surface visibilities occurred with the same visible gray levels but with the I.R. level near 110 instead of 130. Those observations appeared to be consistent with our understanding of tropical cumulus development.

An example was presented showing how a radar echo pattern could be simulated from themed satellite visible data on 14 August 1975. The reproduction was quite good and suggestive that further work should be performed in this area.

Finally, a series of computer programs was developed to convert the 7-track NHEML KART digital radar tapes to 9-track tapes with suitable block size and format for input into the KSC PDP 11/35 computer system.

1.3 CONCLUSIONS AND RECOMMENDATIONS

This study has produced a series of findings that support our initial contentions and thus the stage is set for additional work in meteorological parameter depiction from satellite imagery. From the

operational standpoint it would be quite handy to be able to push a button and produce a complete, simulated, radar display from satellite imagery. Therefore, not only should more work be performed on pattern relationships, but the effort should be large enough to investigate intensity relationships as well. The findings with respect to ceiling heights and surface visibilities are suggestive that satellite imagery potentially contains a wealth of meteorological information.

The Image 100 system is ideally suited for the sophistication that is needed in this type of work. Of the many sources of possible errors, it is essential that registration errors be held to a minimum. The electronic stacking capabilities of the Image 100 system provide unparalleled accuracy in registration. Moreover, the system has a multispectral capability that received only cursory use in this study because of analytical time restraints. Future work should utilize that capability.

It is recommended that film gamma be normalized in future studies and that taped satellite products be used as available. Other procedures should be standardized such as using the same aperture setting of the lens, the same gray level range of themes, etc. For this initial study such rigor was not required.

SECTION 2 - DETAILED DESCRIPTION OF WORK

2.1 INPUT DATA

SMS-1/GOES visible and I.R. transparencies served as the satellite input data for this study. Operational products were used and no effort was made to normalize the densities for differences in film gamma. The visible resolution was $\frac{1}{2}$ mile for the 13 and 14 August cases, 2 miles for the 18 August case, and 1 mile for the 21 August case. The I.R. resolution was 4 miles for all cases. Efforts were made to try to use SMS-1 and SMS-2 data as stereo pairs but the attempt was abandoned as being beyond the scope of this study which was limited to only 4 meteorologist man months.

Digital WSR-57 radar data which had been rectified into 1 n. mile by 1 n. mile grid squares using the NHEML KART program, were provided to us on 7-track tape and in printout form. One printout covered the entire area shown in Figure 1. In order to analyze the digital data at the KSC, it was necessary for us to develop a series of computer programs to convert the 7-track KART tapes into 9-track tapes with suitable block size and format for input into the KSC PDP 11/35 computer system. This turned out to be a sizable task and thus it represented a major contribution to the research effort. Those programs are appended to this report. The radar data on the printouts were coded as shown in Table 1.

Fifteen-minute rainfall data from the 1975 FACE rain gauge network were used in this study. This network was located south of

Lake Okeechobee, see Figure 1, and contained 66 tipping bucket rain gauges, see Figure 2. The rainfall rates in inches/15 minutes were converted to mm/hr for comparison with the radar data.

Official NWS surface weather observations served as the basis for the ceiling height and surface visibility input data. The record observations were taken approximately 5 minutes before the hour but special observations were taken as necessary.

2.2 SELECTION OF CASE STUDIES

After reviewing the availability and quality of the input data, the four cases as shown in Table 2 were selected for specific study. It was felt that the rainfall data slightly later than the radar data would produce more realistic correlations. Even though the time departures of the ceiling height and surface visibility data ranged between 5 and 25 minutes from the other data, the values were considered to be reasonably reliable in light of the earlier or later surface observations.

The daily rainfall patterns for the case dates are shown in Figures 3-6. The rainfall on 13 August occurred mostly near Miami and just southwest of Lake Okeechobee. On the 14th the rainfall occurred mostly over the center of the peninsula. The rainfall was predominately just inland from the east and southwest coasts on the 18th. And the rainfall was near the west coast on the 21st. These were considered to be representative patterns for the South Florida area.

The 2100Z radiosonde soundings taken at the 1975 FACE Field Observation Site are shown in Figures 7-10. The sounding on 13 August

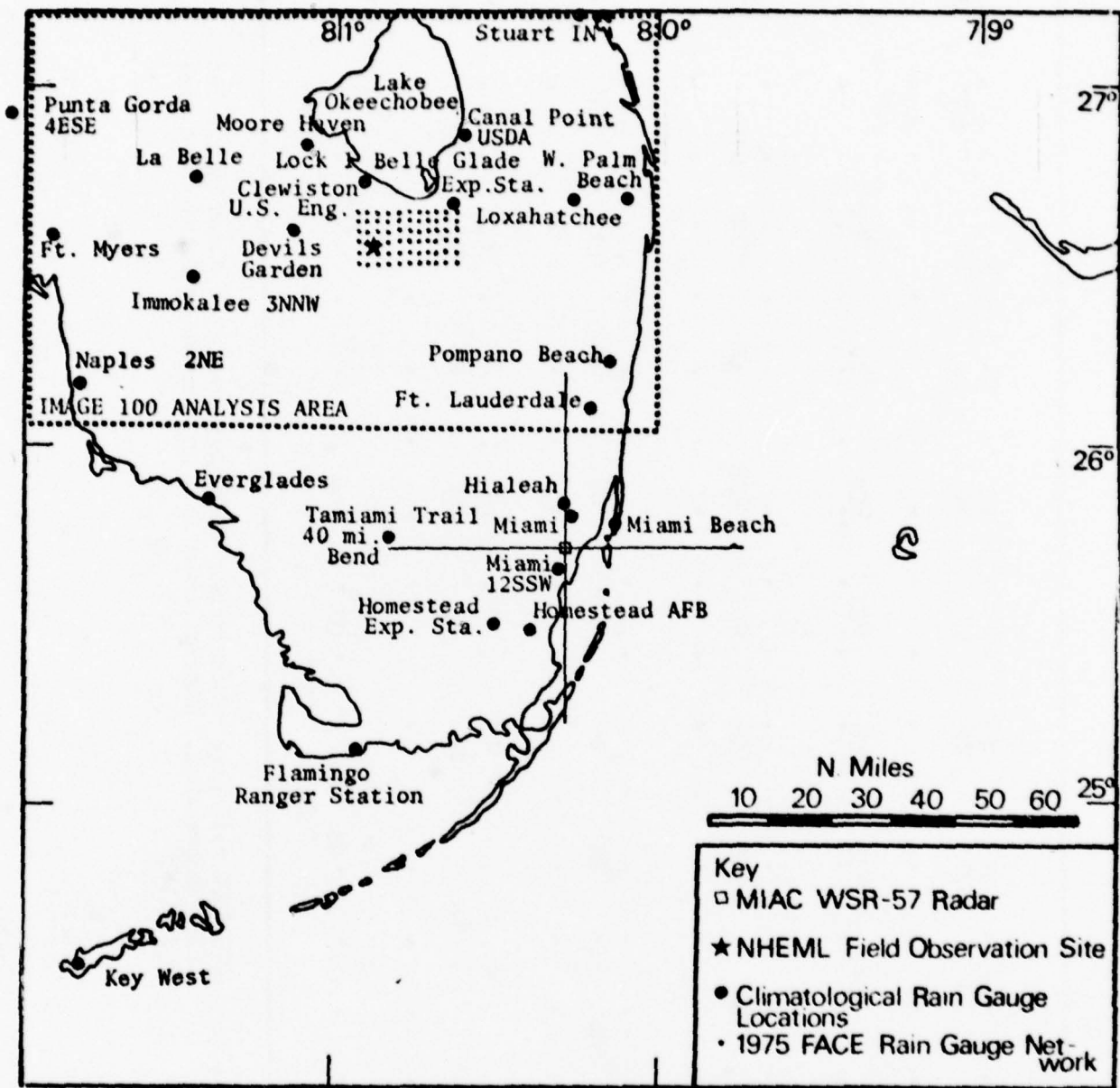


FIG. 1 - Map of digital radar coverage area.

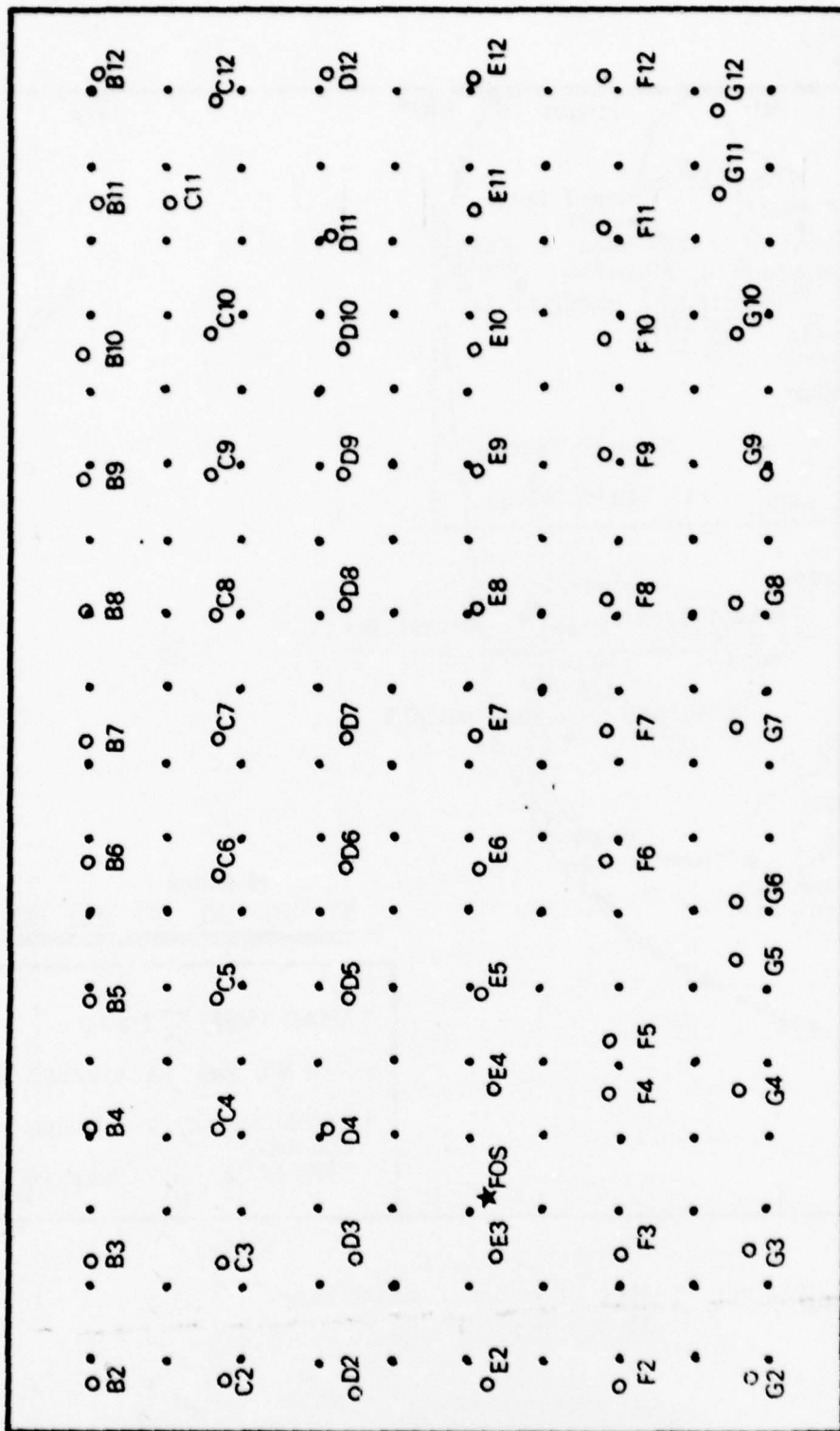


FIG. 2 - 1975 FACE rain gage mesonet. Rain gage locations shown by circles labeled B through G. Digital radar data grid shown by dots---mesh size 1 n. mile.

PRINTOUT CODE	2130Z 13 AUG 75	1930Z 14 AUG 75	1915Z 18 AUG 75	2110Z 21 AUG 75
.	3.08 - 6.16	1.63 - 3.27	1.66 - 3.33	2.37 - 4.75
1	6.16 - 12.31	3.27 - 6.53	3.33 - 6.66	4.76 - 9.50
2	12.31 - 18.47	6.53 - 9.80	6.66 - 9.98	9.50 - 14.24
3	18.47 - 24.62	9.80 - 13.07	9.98 - 13.31	14.24 - 18.99
4	24.62 - 30.78	13.07 - 16.34	13.31 - 16.64	18.99 - 23.74
5	30.78 - 36.93	16.34 - 19.60	16.64 - 19.97	23.74 - 28.49
6	36.93 - 43.09	19.60 - 22.87	19.97 - 23.30	28.49 - 33.24
7	43.09 - 49.24	22.87 - 26.14	23.30 - 26.62	33.24 - 37.98
8	49.24 - 55.40	26.14 - 29.40	26.62 - 29.95	37.98 - 42.73
9	55.40 - 61.55	29.40 - 32.67	29.95 - 33.28	42.73 - 47.48

TABLE 1 - Digital radar printout code. Rainfall rates are in mm/hr.

	CASE DATES			
	13 AUG 75	14 AUG 75	18 AUG 75	21 AUG 75
Satellite Visible	2130	1930	1930	2100
Satellite I.R.	2130	1930	1900	2100
Radar	2130	1930	1915	2110
Rainfall	2130 - 2145	1930 - 1945	1915 - 1930	2115 - 2130
Ceiling Height	2155	1955	1855	2055
Surface Visibility	2155	1955	1855	2055

TABLE 2 - Times (Z) of the various data used in the case studies.

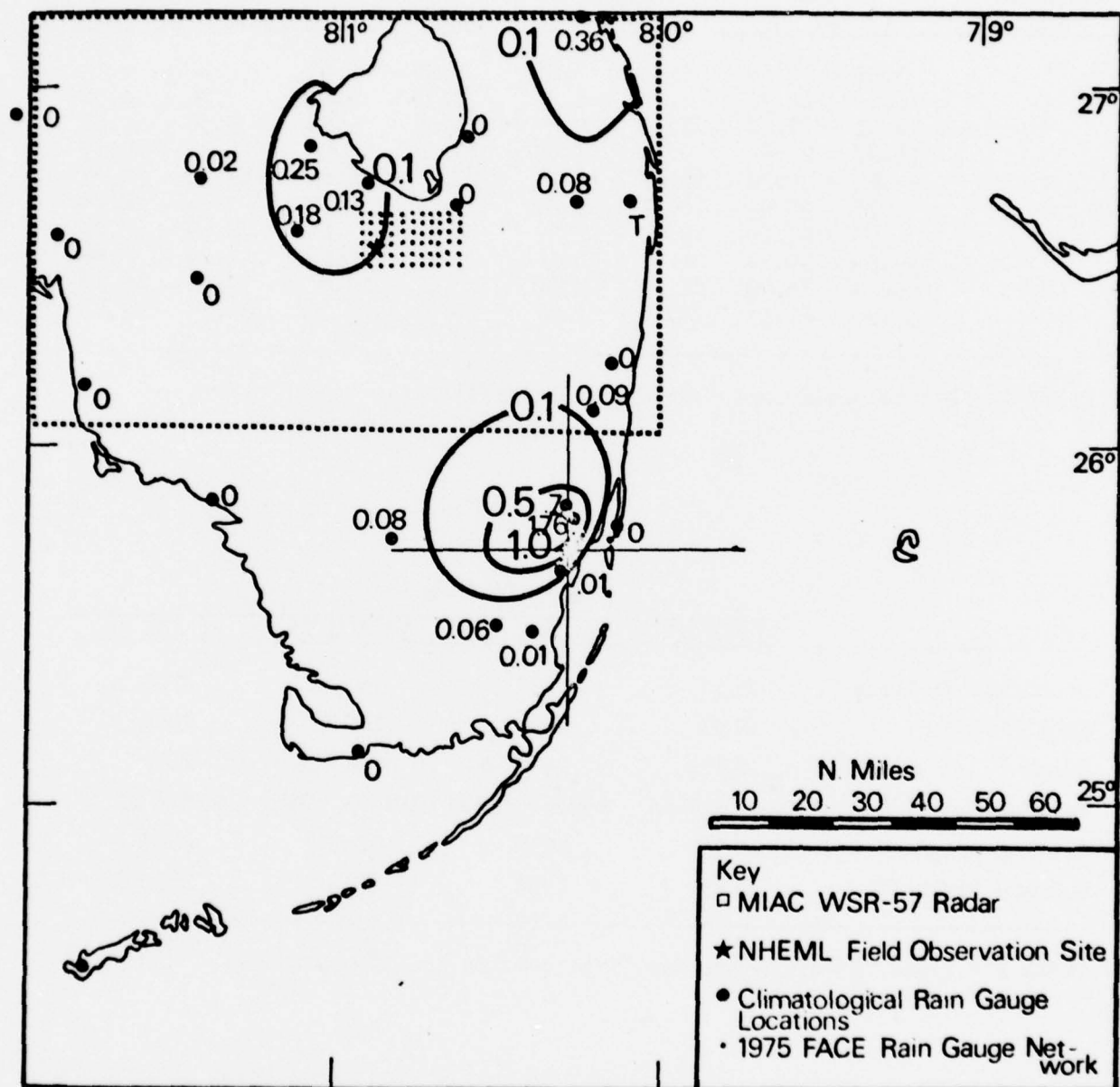


FIG. 3 - Daily rainfall pattern, 13 August 1975. Isohyets in inches.

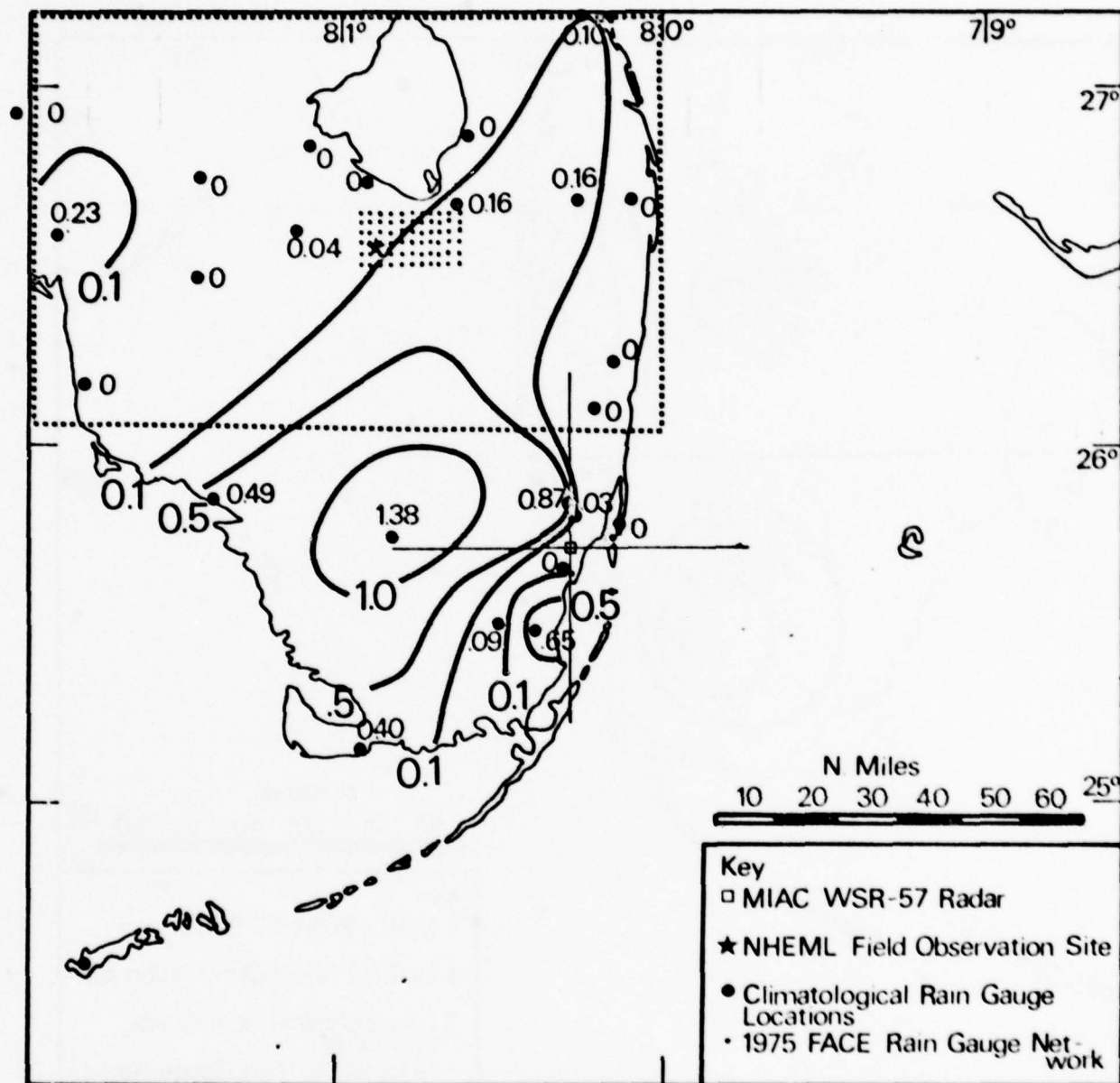


FIG. 4 - Daily rainfall pattern, 14 August 1975. Isohyets in inches.

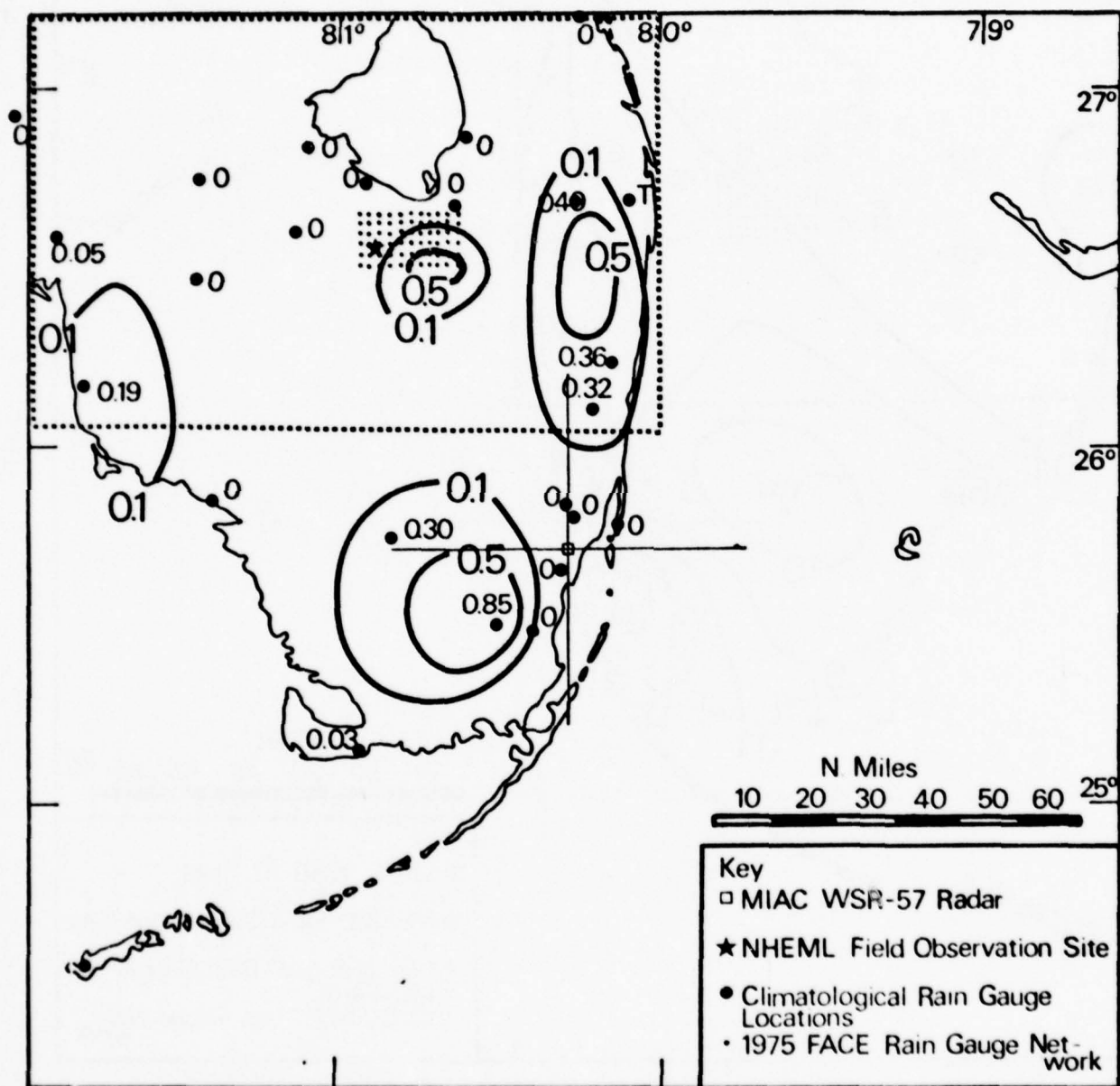


FIG. 5 - Daily rainfall pattern, 18 August 1975. Isohyets in inches.

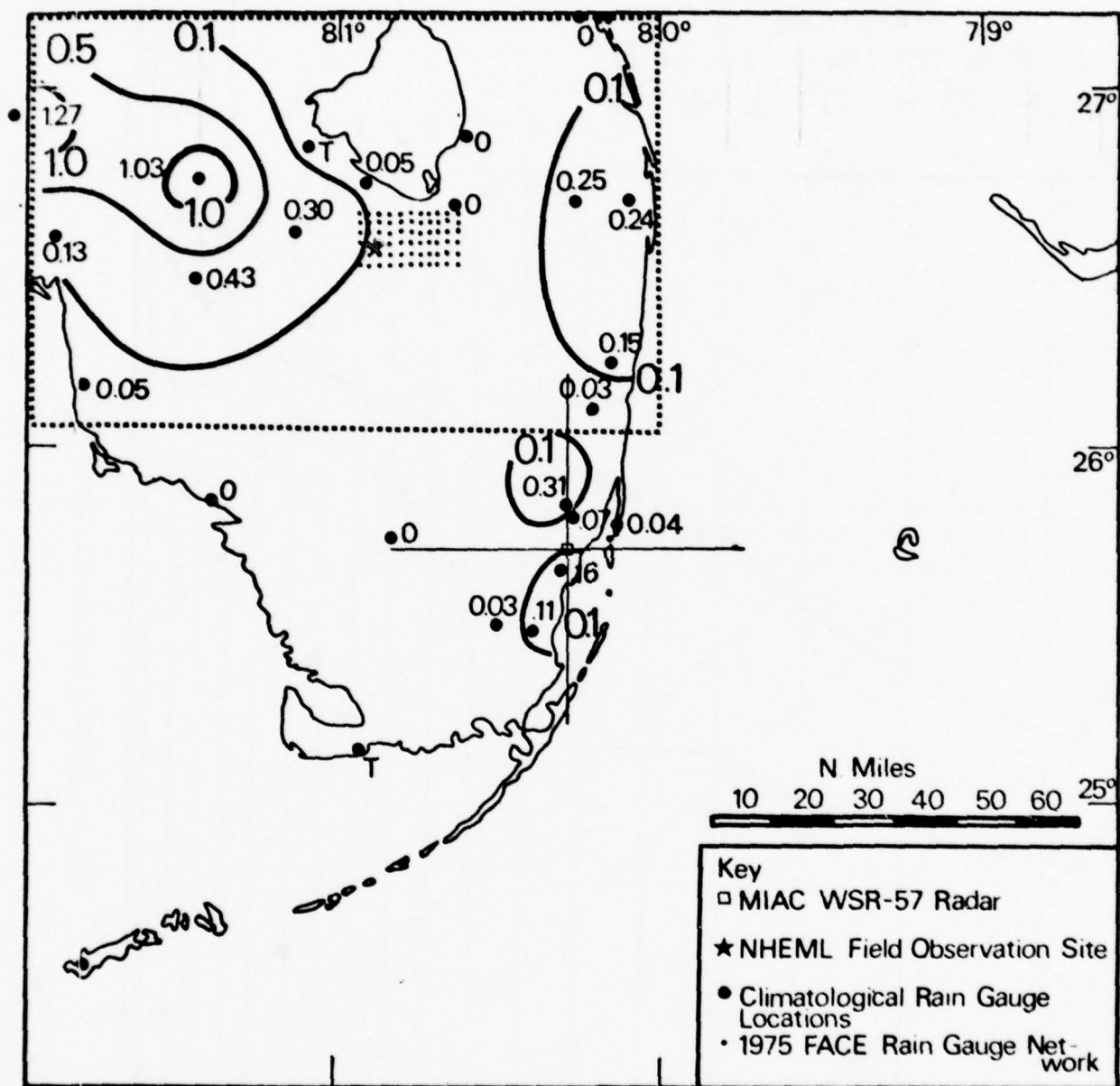


FIG. 6 - Daily rainfall pattern, 21 August 1975. Isohyets in inches.

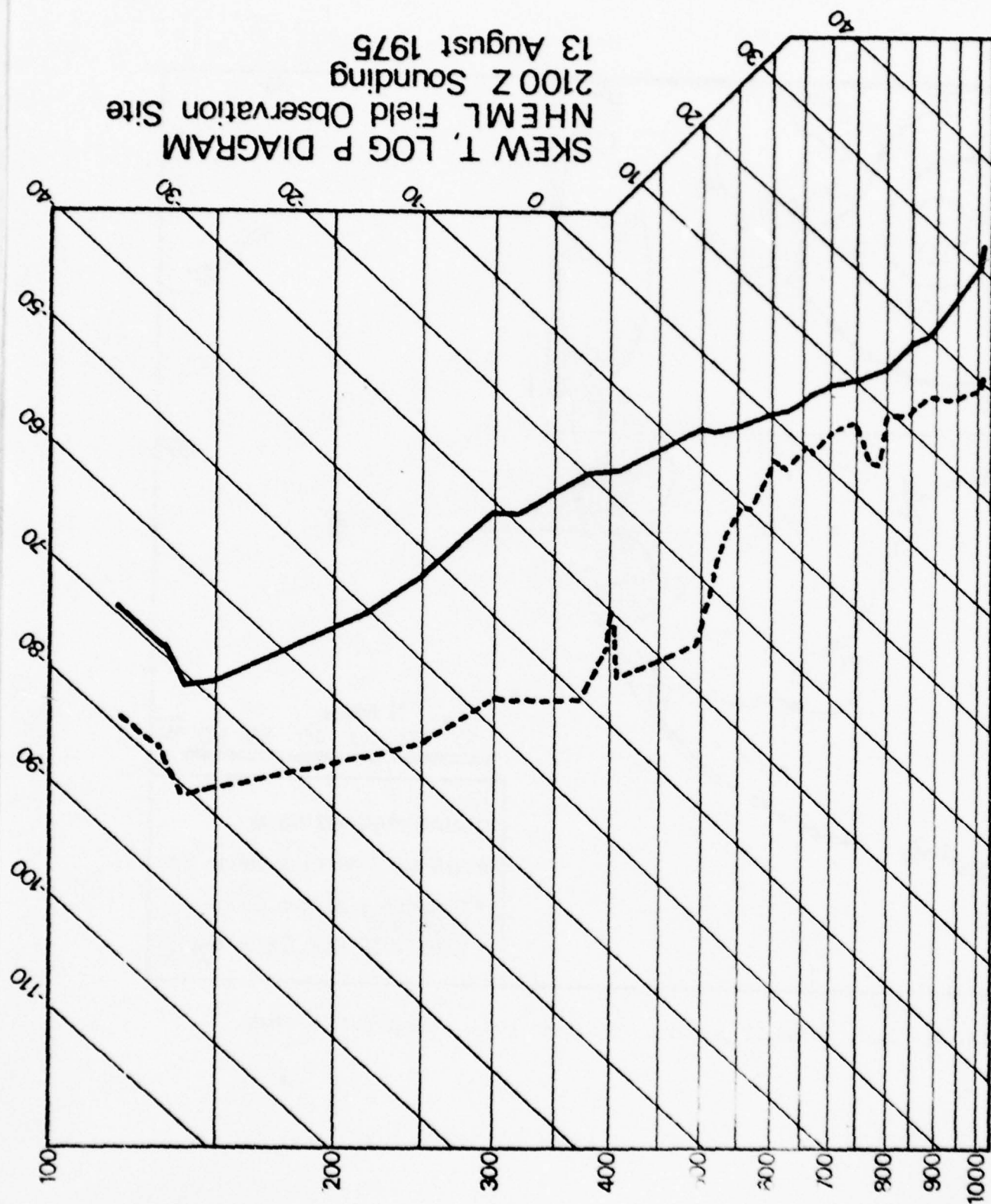


FIG. 7 - 2100Z sounding, 13 August 1975.

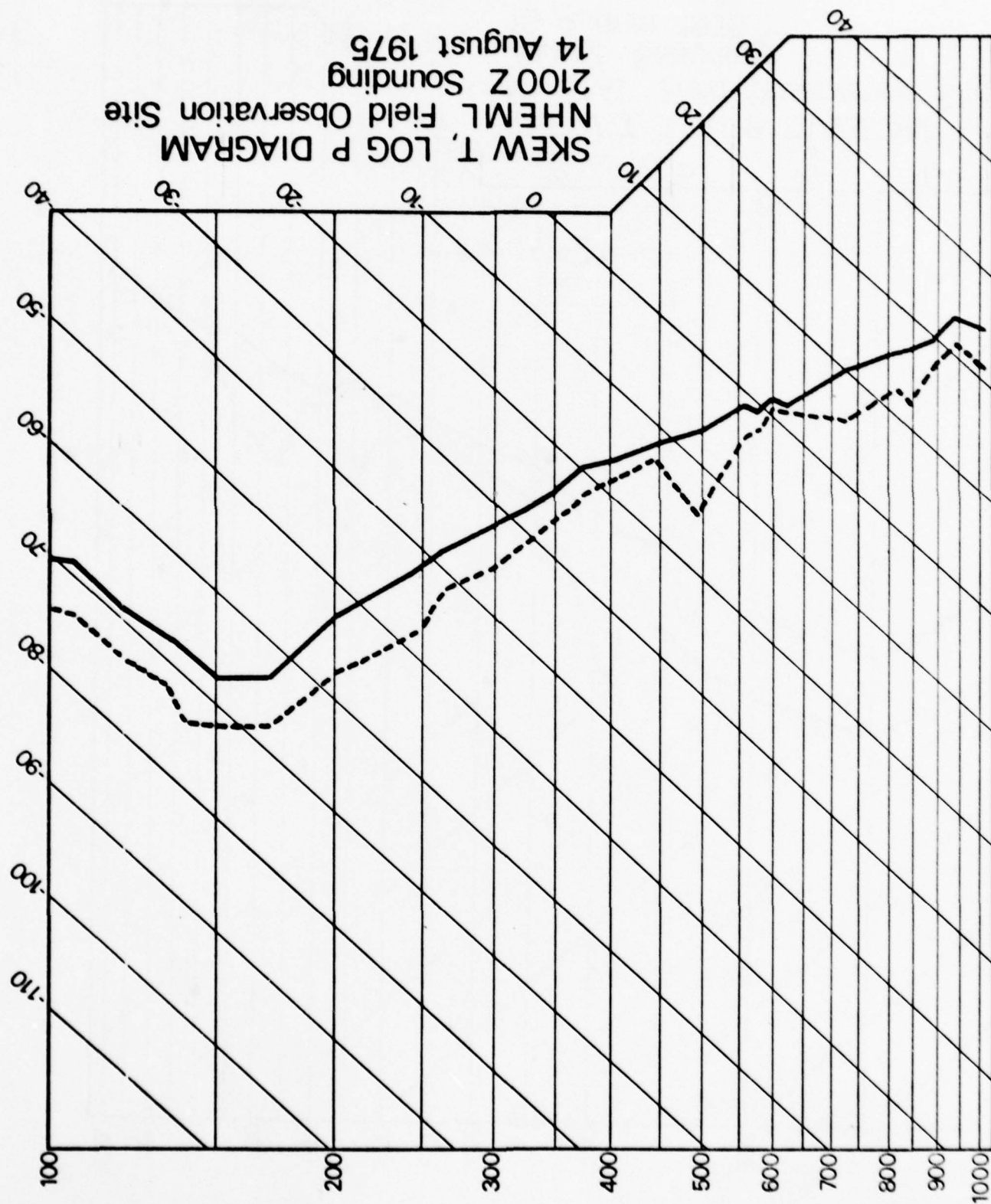


FIG. 8 - 2100Z sounding, 14 August 1975.

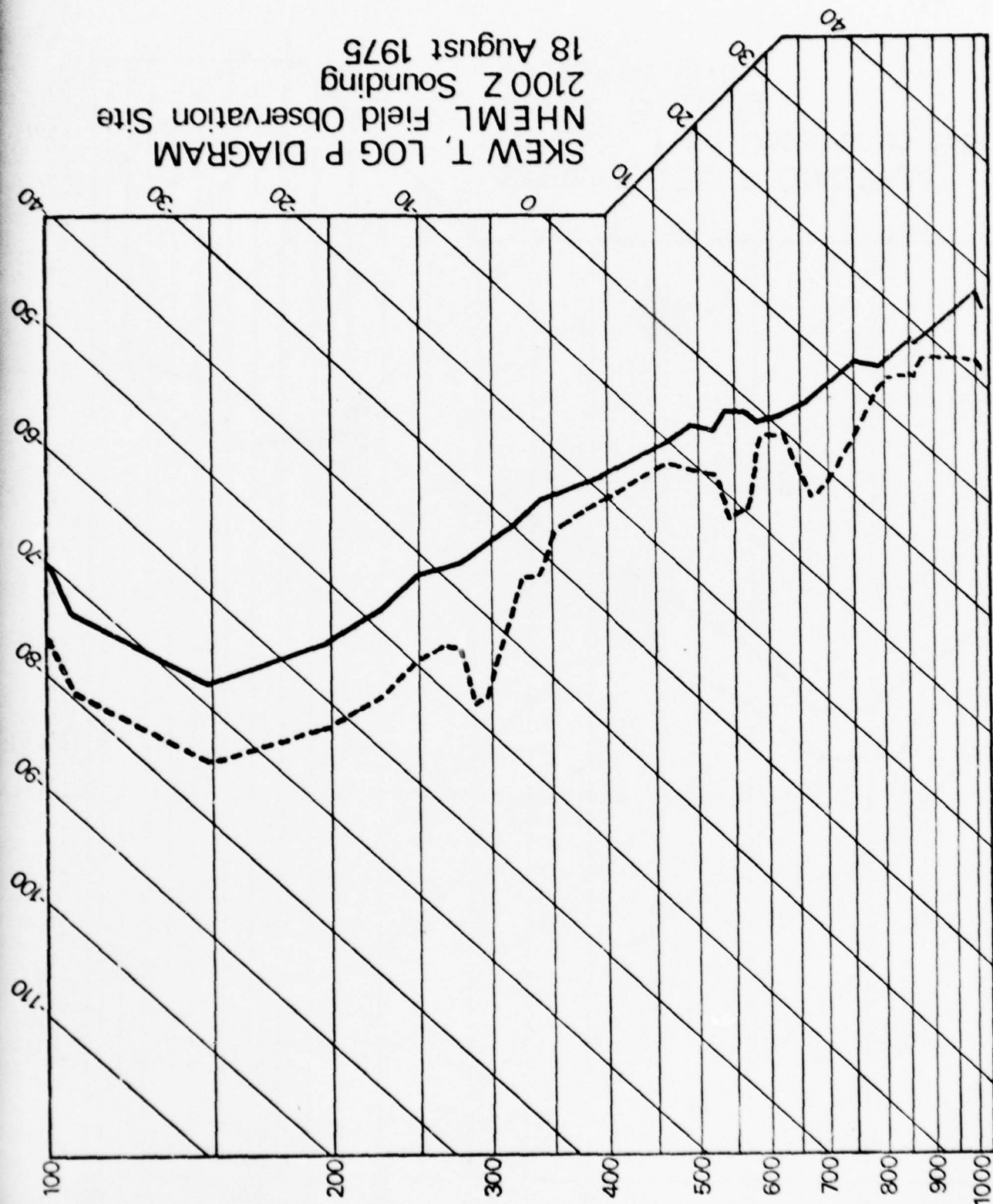


FIG. 9 - 2100Z sounding, 18 August 1975.

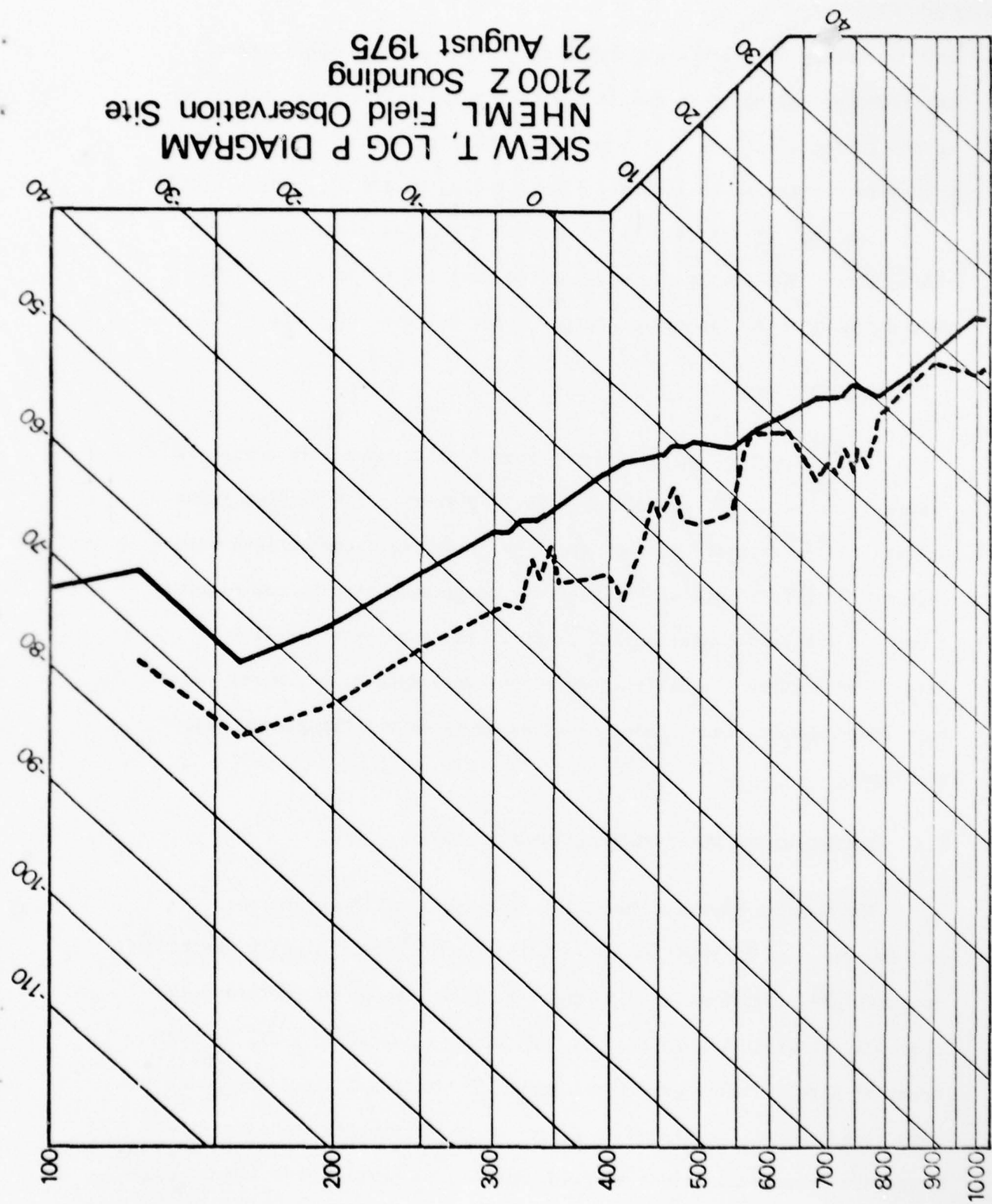


FIG. 10 - 2100Z sounding, 21 August 1975.

was relatively dry with a superadiabatic lapse rate at the surface. The sounding was moist on the 14th with a relatively deep stable layer at the surface. It was not as moist on the 18th and an inversion at the surface extended to 1000 mb. The sounding on the 21st was slightly drier than that on the 18th and contained a shallow stable layer at the surface. The tropopause was located near 150 mb on each of the case dates with the tropopause temperatures between -65°C and -71°C .

2.3 ANALYSIS AREA

The "Image 100 Analysis Area" shown in the upper left corner of Figure 1 served as the general area for registering the various forms of data. Once registered, the satellite, radar/rain comparisons were made at the grid points within the rain gauge mesonetwork, see Figures 1 and 2. The grid contained 180 points. The satellite, ceiling height and surface visibility comparisons were made at Ft. Myers, West Palm Beach and Ft. Lauderdale, near the edges of the "Image 100 Analysis Area".

2.4 THE IMAGE 100 MULTISPECTRAL IMAGE ANALYZER

The General Electric Image 100 Multispectral Image Analyzer at the KSC was used to register the satellite data electronically and to document gray levels at grid points. A block diagram of the Image 100 system is shown in Figure 11. The CRT display contained a 512 by 512 array of pixels with a gray level range of 0 to 255. Since the radar data were contrast stretched to assist with registering the satellite data, the radar comparisons at grid points were performed by hand

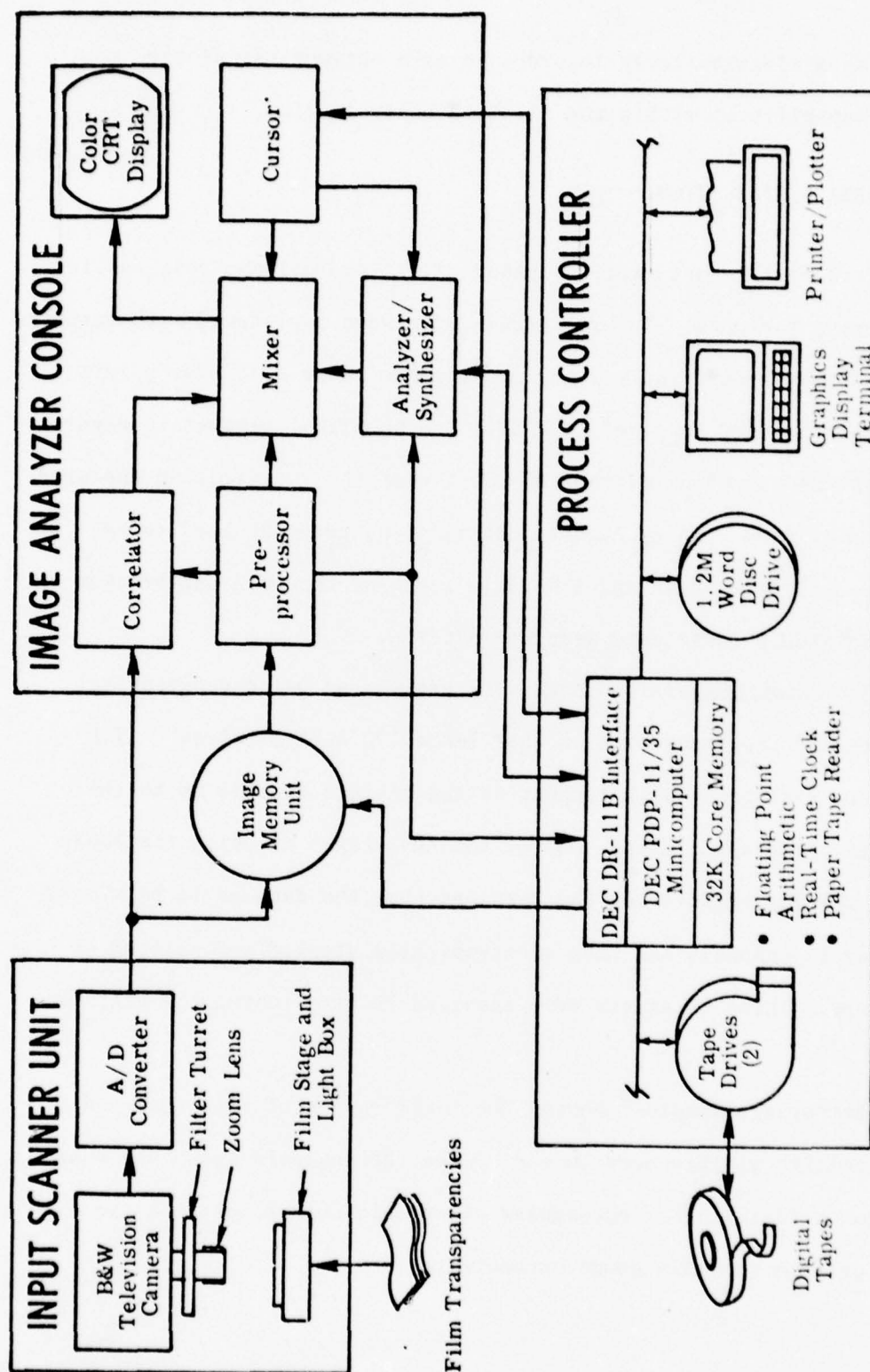


FIG. 11 - Image 100 system block diagram.

rather than electronically in order to make optimum use of the system capabilities within the allotted analysis time.

2.5 DATA REGISTRATION

Perhaps the most critical phase of the overall analysis was in registering the data. The radar/rain data were registered with respect to each other by carefully superimposing the radar grid over a rain gauge location map supplied by NHEML, see the final product in Figure 2. With the exception of the 18 August case, the registration appeared to be quite good. On 18 August, the radar pattern appeared to be shifted 3 n. miles west and 1 n. mile south of the rain pattern but for consistency those data were not altered.

The satellite visible data were registered using geographical features and the radar data in the "Image 100 Analysis Area". I.R. data were registered with respect to the visible as well as to the radar and geographic data. One of the advantages of using the Image 100 system for registering the data was that the data could be stored in separate channels and then electronically stacked and shifted as necessary. Three observers were involved in fine tuning the registration.

Pictorial examples showing the registration of the radar and the satellite visible data in the "Image 100 Analysis Area" are shown in Figures 12-15. The rectangular electronic cursor outlines the radar grid in the rain gauge mesonetwork.



FIG. 12 - Radar echoes superimposed over satellite visible data in Image 100 analysis area, 13 August 1975 case. Rectangular cursor outlines rain gauge mesonetwork.

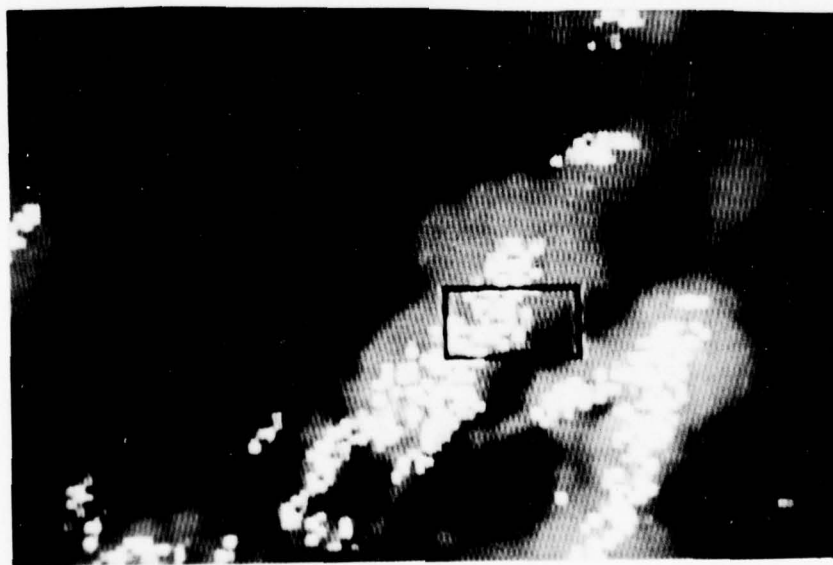


FIG. 13 - Radar echoes superimposed over satellite visible data in Image 100 analysis area, 14 August 1975 case. Rectangular cursor outlines rain gauge mesonetwork.



FIG. 14 - Radar echoes superimposed over satellite visible data in Image 100 analysis area, 18 August 1975 case. Rectangular cursor outlines rain gauge mesonetwork.

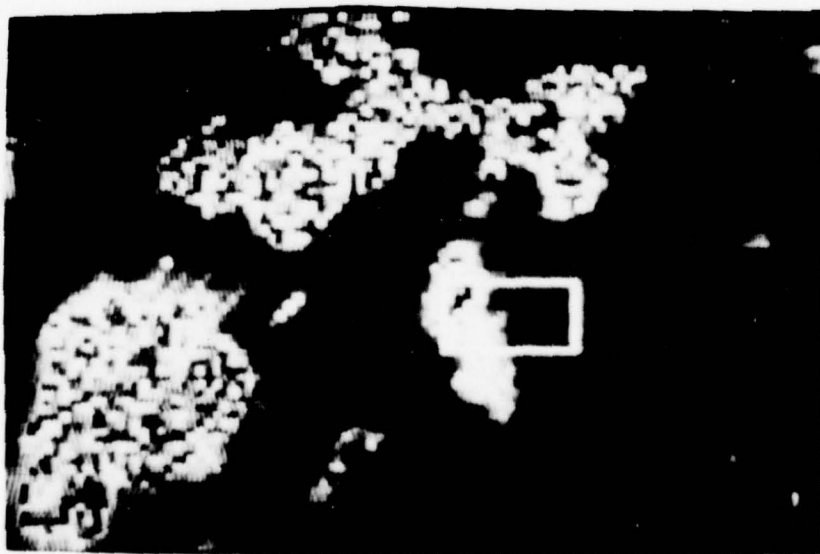


FIG. 15 - Radar echoes superimposed over satellite visible data in Image 100 analysis area, 21 August 1975 case. Rectangular cursor outlines rain gauge mesonetwork.

2.6 ANALYSIS PROCEDURE

Numerical values of the satellite visible and I.R. gray level density themes for each pixel within the mesonetwork grid, see Figure 2, were tabulated using the Image 100 Printer/Plotter. Values for the 180 grid points were then manually taken from that array. Values of the contrast stretched radar data were also tabulated but not used in the grid point analysis. Instead, the unmodified data from the digital radar printouts were used (recall that those data were already gridded into a 1 n. mile mesh).

For the radar/rain correlations, the rain data were plotted on maps like that in Figure 2 and then the values at the grid points were extrapolated from the isohyetal analysis.

The procedure for the satellite/ceiling height, surface visibility comparisons was to tabulate the average satellite gray level for the four pixels immediately surrounding the Ft. Myers, West Palm Beach, and Ft. Lauderdale airports. The average values were then compared with the observed ceiling heights and surface visibilities.

2.7 SATELLITE/RADAR ECHO RELATIONSHIPS

Figures 16-19 summarize the joint relationship between satellite visible and I.R. gray levels, and the existence of radar echoes at the 180 grid points. Eight themes or class intervals of density ranges were used for each case. The numerical values for each theme varied from case to case because of differences in the dynamic range of the observed gray levels. Unique relationships would be indicated when the contoured echo pattern (dashed) is displaced from the no echo

SATELLITE VISIBLE GRAY LEVEL

SATELLITE I.R. GRAY LEVEL

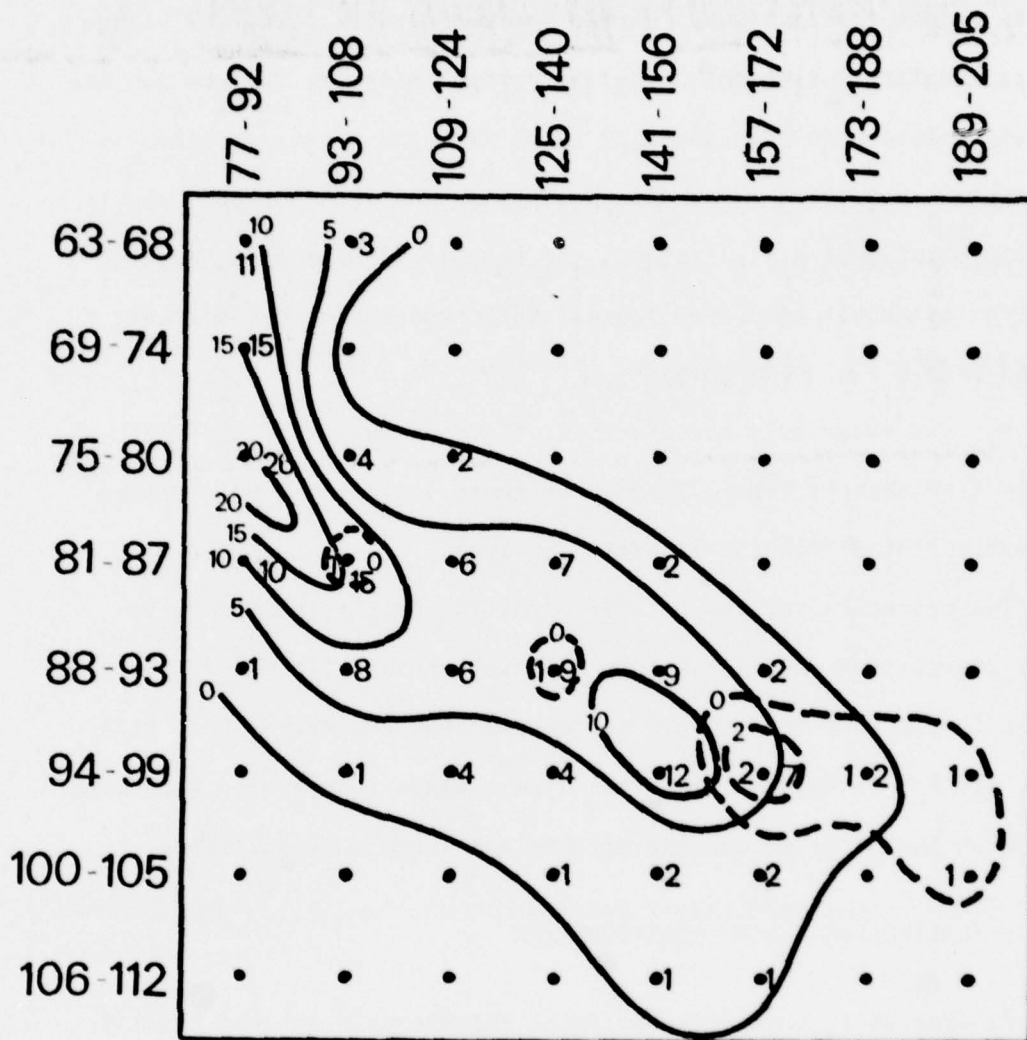


FIG. 16 - Number of grid points in mesonetwork with no radar echoes (solid) and with radar echoes (dashed) 13 August 1975. Numbers to the right of the dots are for no echoes, those to the left for echoes.

SATELLITE I.R. GRAY LEVEL

SATELLITE VISIBLE GRAY LEVEL

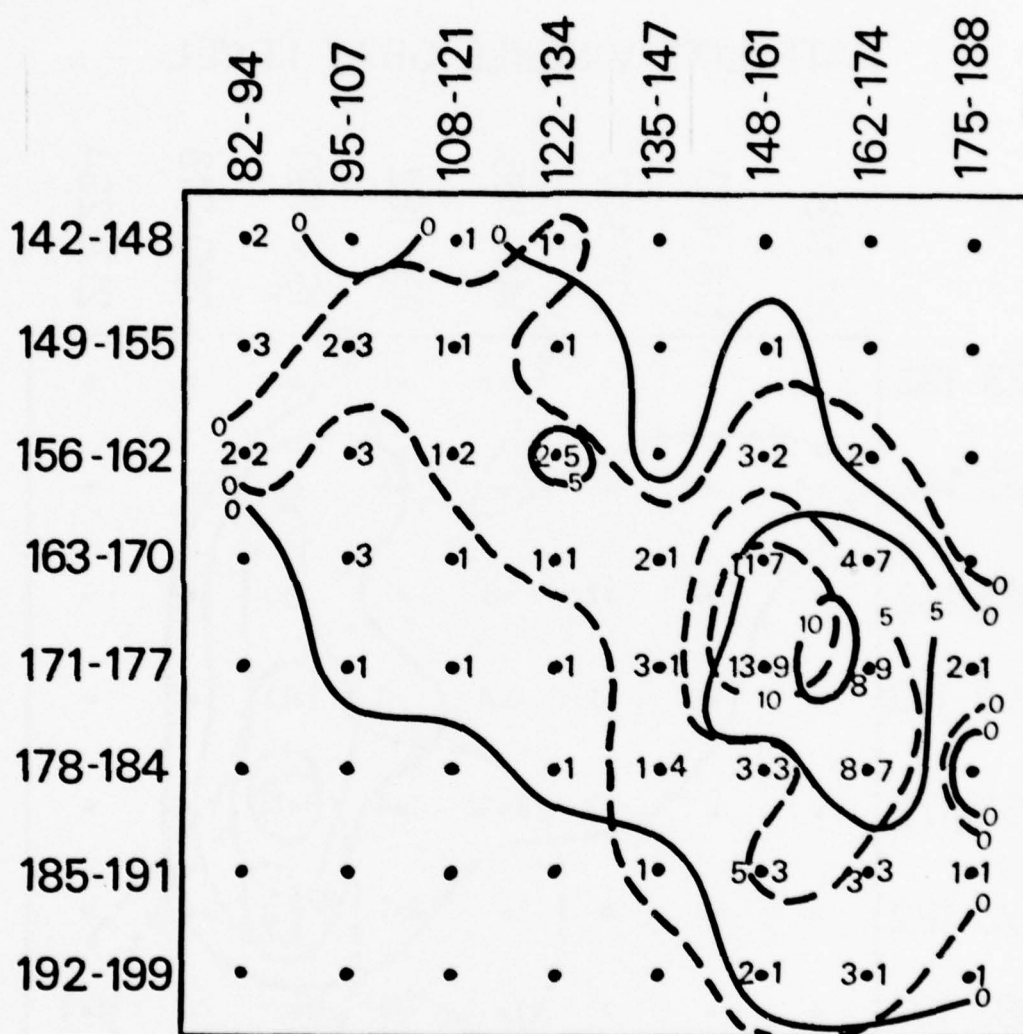


FIG. 17 - Number of grid points in mesonetwork with no radar echoes (solid) and with radar echoes (dashed) 14 August 1975. Numbers to the right of the dots are for no echoes, those to the left for echoes.

SATELLITE VISIBLE GRAY LEVEL

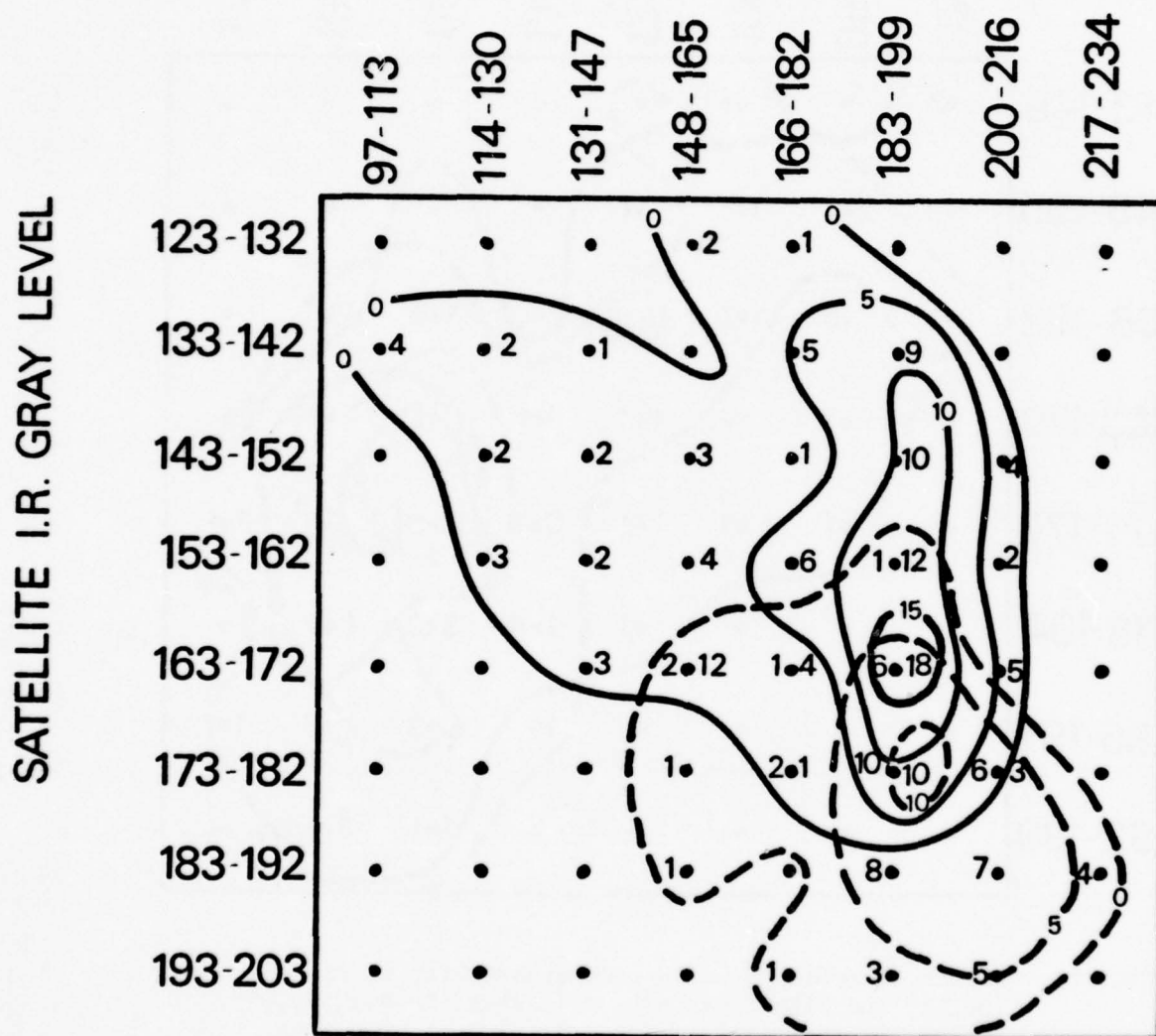


FIG. 18 - Number of grid points in mesonetwork with no radar echoes (solid) and with radar echoes (dashed) 18 August 1975. Numbers to the right of the dots are for no echoes, those to the left for echoes.

SATELLITE I.R. GRAY LEVEL

SATELLITE VISIBLE GRAY LEVEL

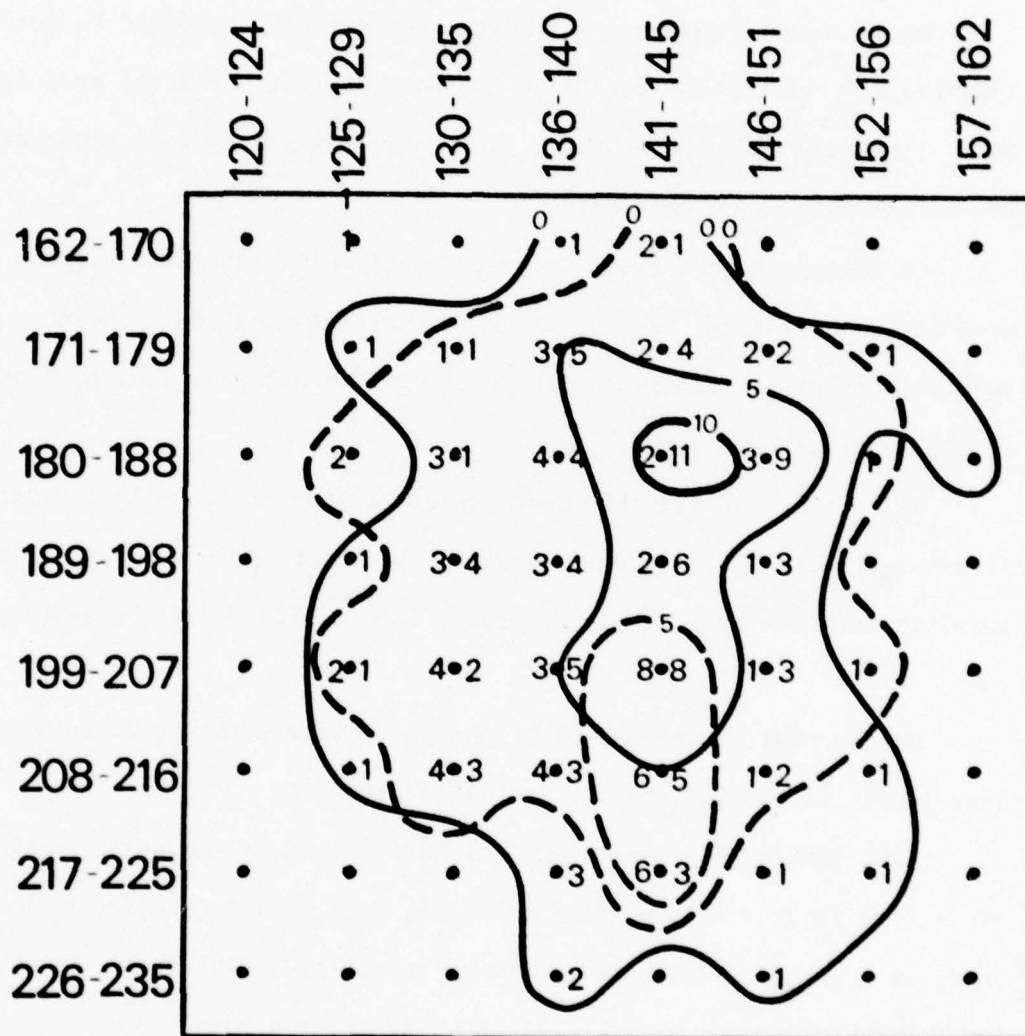


FIG. 19 - Number of grid points in mesonetwork with no radar echoes (solid) and with radar echoes (dashed) 21 August 1975. Numbers to the right of the dots are for no echoes, those to the left for echoes.

pattern (solid) in these figures. Relationships with overlapping patterns would be a function of the position and strength of the echo maximum with respect to the no echo maximum.

On 13 August there was an indication that echoes tended to occur when the I.R. gray level was 94-99 and when the visible level exceeded 157. It should be noted, however, that not many echoes were observed in the mesonet network on that date.

On 14 August the echoes occurred mostly with satellite visible gray levels of 148-161 and I.R. gray levels exceeding 163. There were a substantial number of grid points with those gray levels, though, that did not contain echoes.

The pattern on the 18th shows unique relationships with I.R. gray levels exceeding 183. Actually most of the echoes were observed with satellite visible gray levels exceeding 183 and I.R. levels exceeding 173.

On the 21st the echoes were observed mostly with satellite visible gray levels of 141-145 and I.R. levels of 199-225.

Even though the film gammas may have varied, a composite of the above four figures is presented in Figure 20. This figure shows that there is a unique relationship between satellite visible and I.R. gray levels exceeding 183, and the existence of radar echoes. However, most of the echoes in these cases existed with satellite visible levels of 131-216 and I.R. levels of 163-192; and visible levels of 131-147 and I.R. levels of 193-222.

SATELLITE VISIBLE GRAY LEVEL

29

SATELLITE I.R. GRAY LEVEL

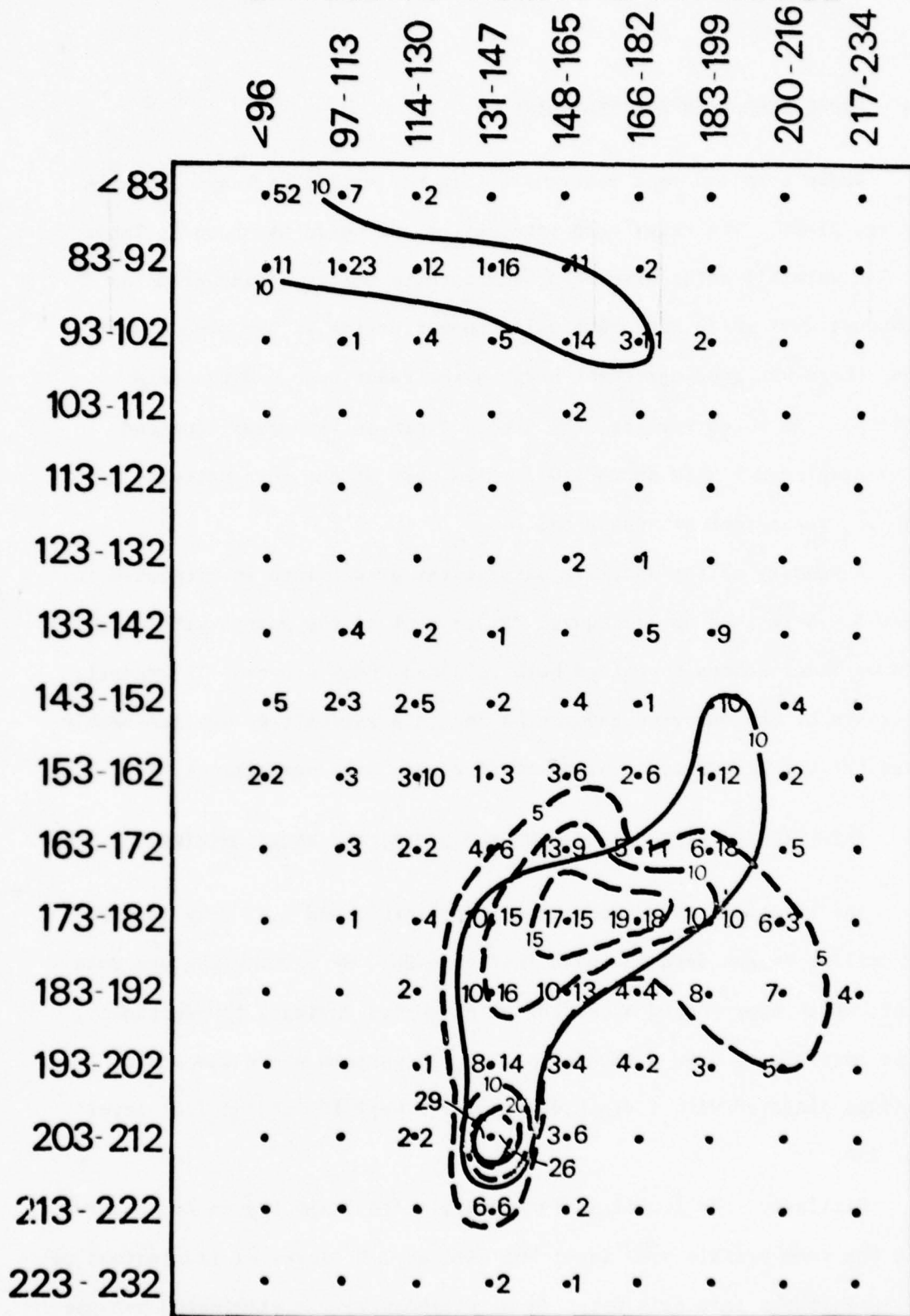


FIG. 20 - Composite number of grid points in mesonet with no radar echoes (solid) and with radar echoes (dashed) from all 4 cases. Numbers to the right of the dots are for no echoes, those to the left for echoes.

2.8 RADAR ECHO/RAIN RELATIONSHIPS

Radar echo and rain patterns within the mesonetwork are shown in Figures 21-24. The radar echo intensities are coded as shown in Table 1. The rainfall rates have been converted to mm/hr. Aside from the 13 August case which had practically no convection in the mesonetwork area, there was good agreement between the radar echo and the rain patterns. As noted earlier, the echo pattern on 18 August appeared to be displaced 1 mile south and 3 miles west of the rain pattern, but even so, the agreement wasn't bad.

A summary of the specific data at the grid points is presented in Table 3. Note that on 14 August, 72 per cent of the points with either rain or radar echoes contained both rain and radar echoes. In general, the range of the observed radar echo and rain intensities was reasonably close but the linear correlation coefficients were surprisingly low.

2.9 SATELLITE/CEILING HEIGHT, SURFACE VISIBILITY RELATIONSHIPS

The relationship between satellite visible and I.R. gray levels, and ceiling height data is shown in Figure 25. By eliminating one data point, which represented a ceiling at Ft. Myers during a thundershower, it is possible to draw a smooth, bull's eye pattern where the lowest ceilings occurred with a visible gray level near 100 and an I.R. level near 130.

Similarly, the lowest surface visibilities, see Figure 26, occurred with the same visible gray level but with an I.R. level of 110 instead of 130. Again the same data point (4 mi visibility) was eliminated because it was related to an active thundershower at Ft. Myers.

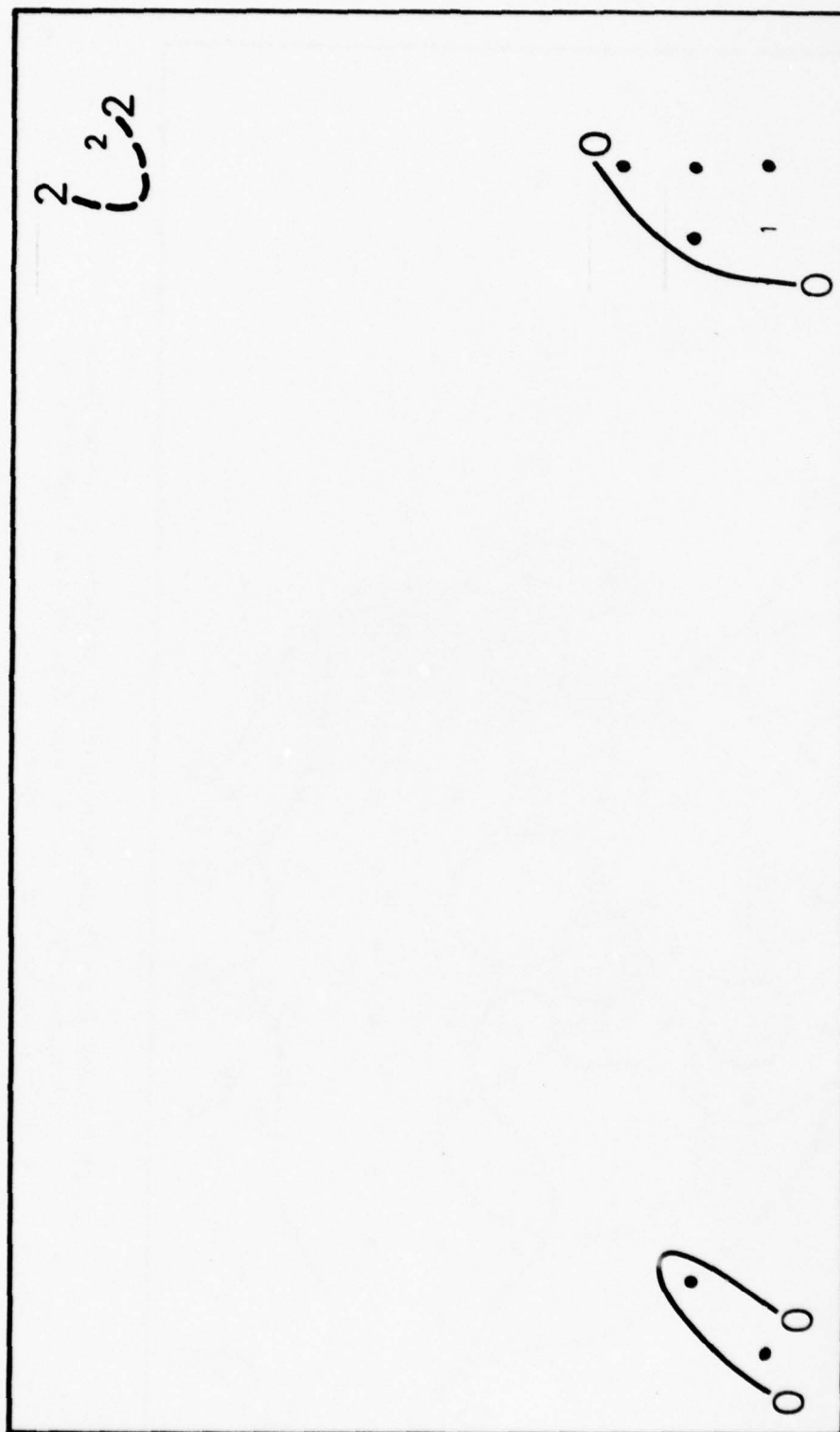


FIG. 21 - Radar (solid) and rain (dashed) patterns in mesonet network 13 August 1975. Coded radar data in small numbers; rain data, mm/hr, large numbers.

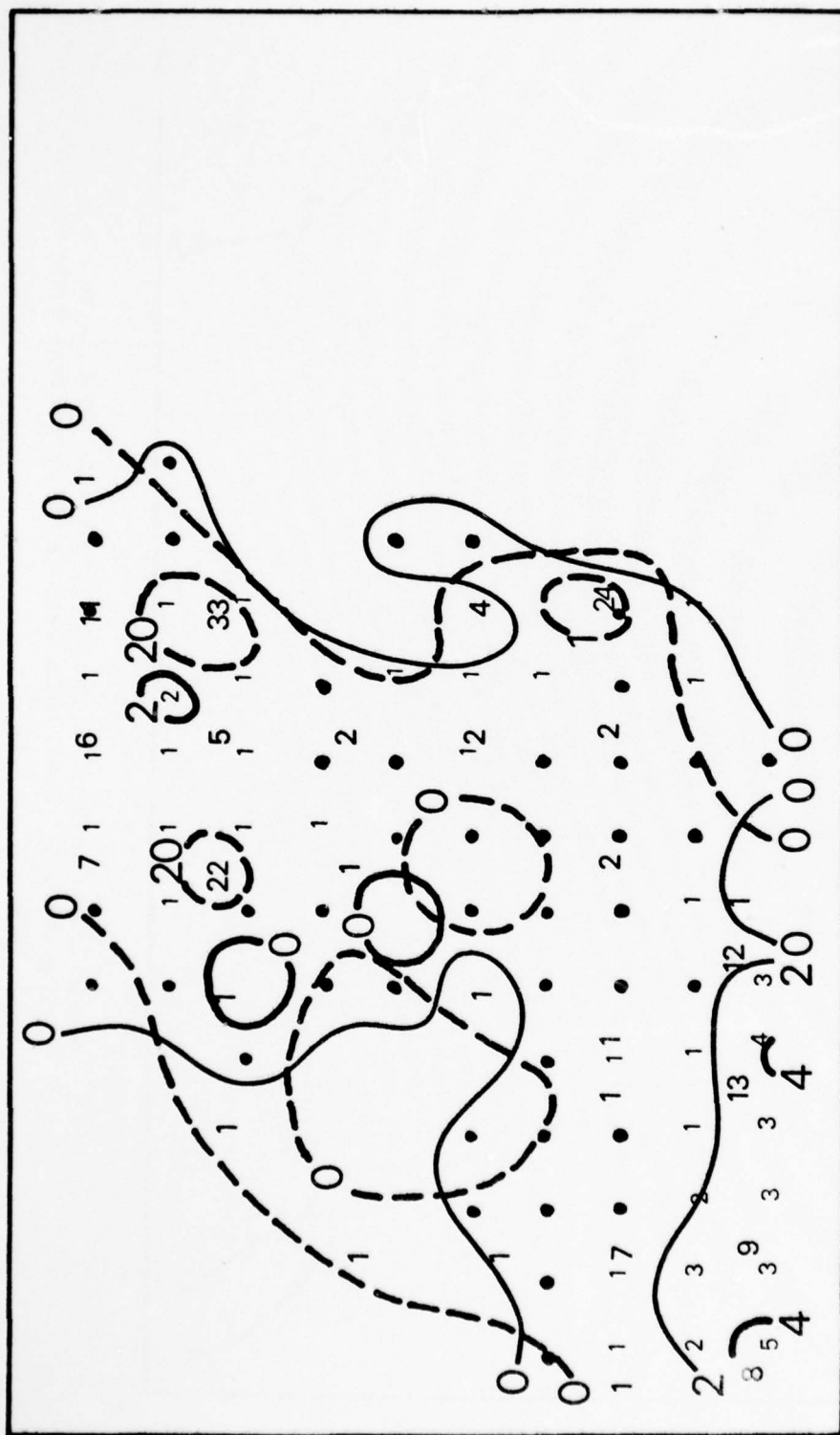


FIG. 22 - Radar (solid) and rain (dashed) patterns in mesonet network 14 August 1975. Coded radar data in small numbers; rain data, mm/hr, large numbers.

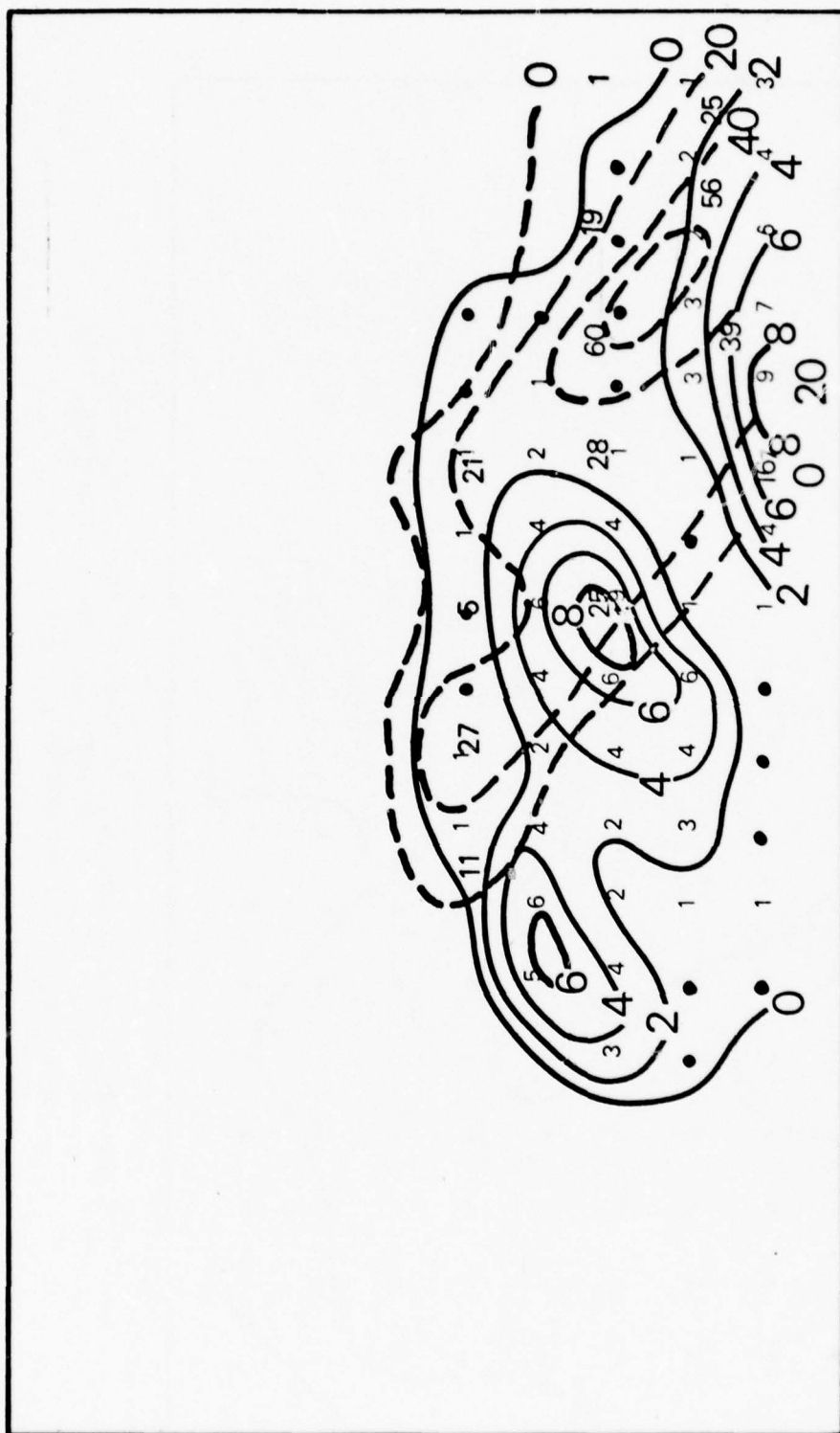


FIG. 23 - Radar (solid) and rain (dashed) patterns in mesonet network 18 August 1975. Coded radar data in small numbers; rain data, mm/hr, large numbers.

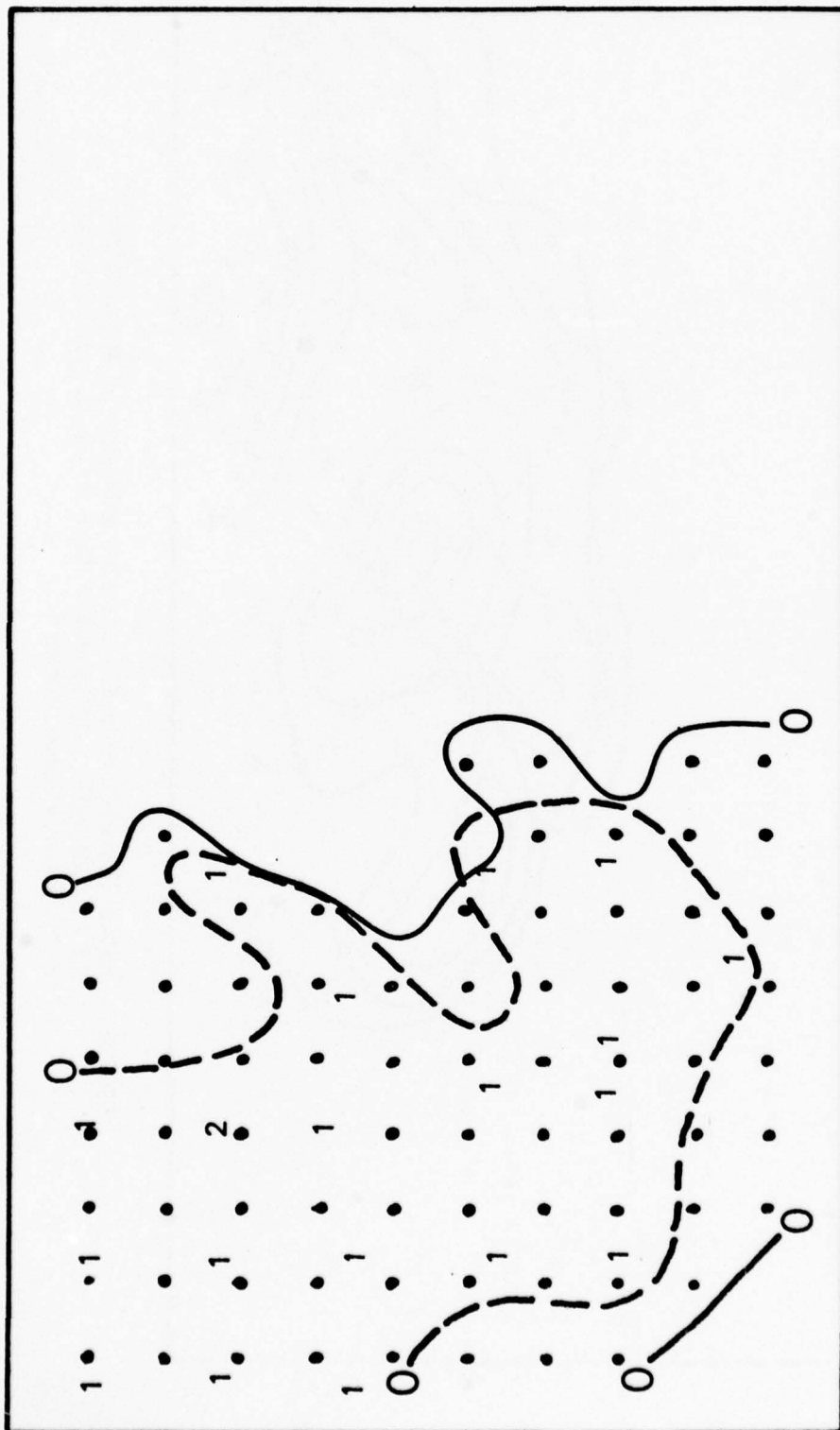


FIG. 24 - Radar (solid) and rain (dashed) patterns in mesonetwork 21 August 1975. Coded radar data in small numbers; rain data, mm/hr, large numbers.

	<u>13 AUG 75</u>	<u>14 AUG 75</u>	<u>18 AUG 75</u>	<u>21 AUG 75</u>
Total Number of Grid Points	180	180	180	180
With No Rain Nor Radar Echo	172	91	118	104
With Either Rain or Radar Echo	8	89	62	76
With Rain	1	75	37	48
With Radar Echo	7	78	58	75
With Rain and Radar Echo	0	64	33	47
With Rain But No Radar Echo	1	11	4	1
With Radar Echo But No Rain	7	14	25	28
Percentage of Points With Either Rain or Radar Echo That Include Both Rain <u>and</u> Radar Echo -		72	53	62
Time of Rain Data (Z)	2130 - 2145	1930 - 1945	1915 - 1930	2115 - 2130
Time of Radar Data (Z)	2130	1930	1915	2110
Range of Rain Data (mm/hr)	0 - 2	0 - 22	0 - 60	0 - 2
Range of Radar Data (mm/hr)	3.1 - 12.3	1.6 - 19.6	1.7 - 33.3	2.4 - 4.8
Linear Correlation Coefficient Between Rain Intensity and Radar Echo Intensity	Small Sample	0.19	0.02	0.01

TABLE 3 - Grid Point Comparison of Rain and Radar Echo Data in FACE Mesonetwork.

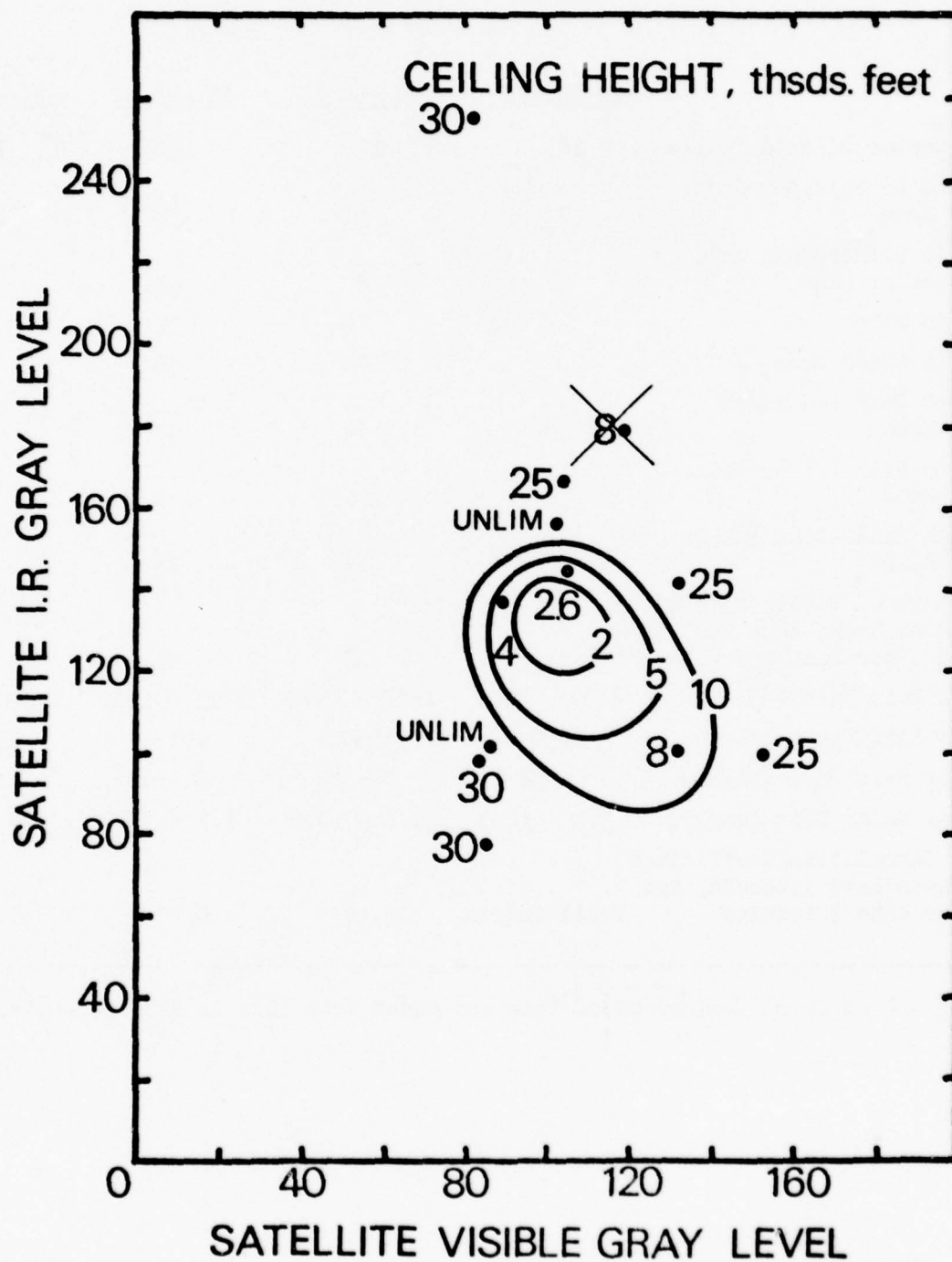


FIG. 25 - Ceiling height vs. satellite visible and I.R. gray level.

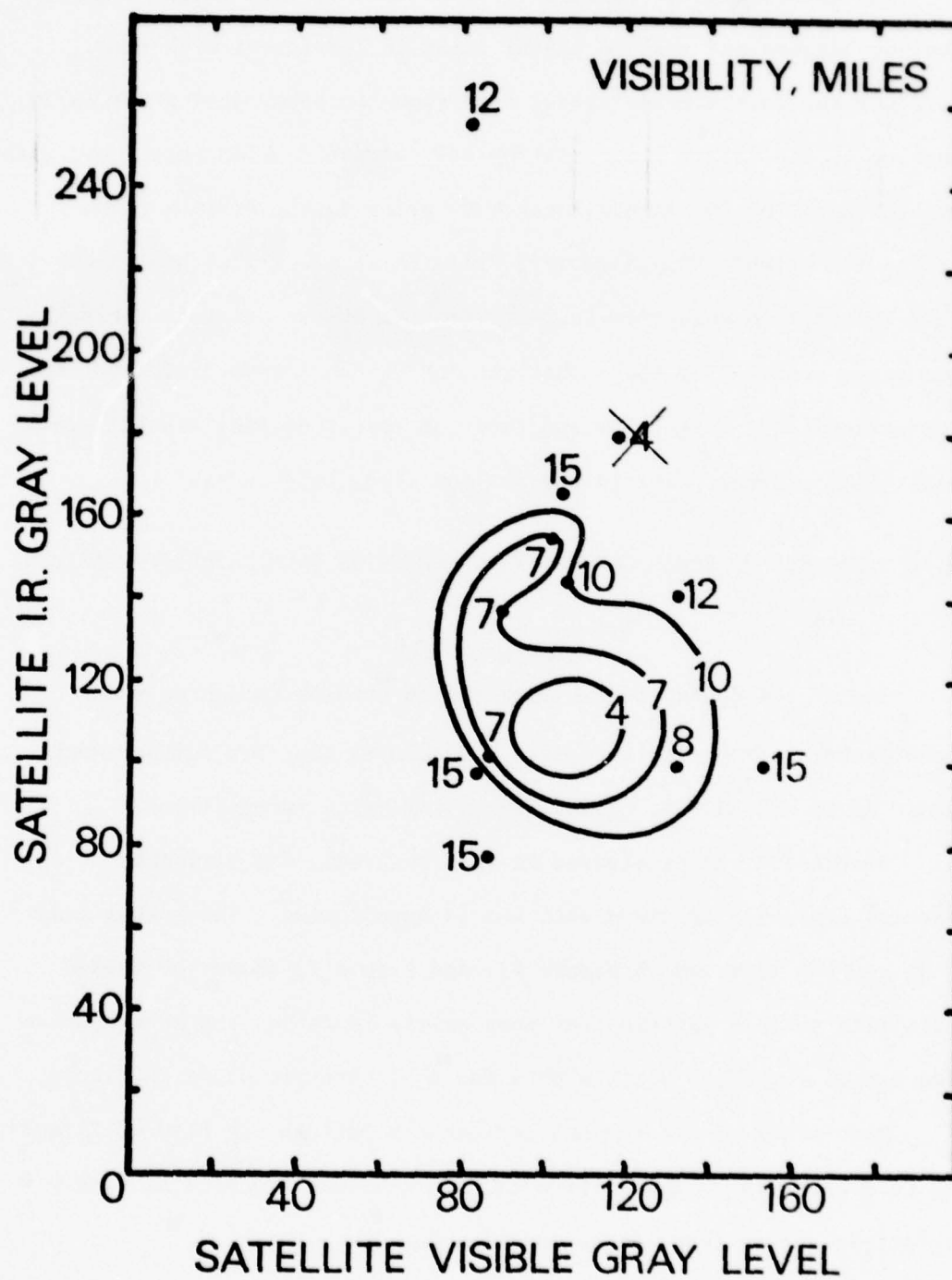


FIG. 26 - Surface visibility vs. satellite visible and I.R. gray level.

The observation of relatively low satellite gray levels with low ceiling heights and surface visibilities is consistent with the tendency for such meteorological conditions to occur during the early portion of the mature stage of tropical cumulus development, i.e., with the onslaught of the rainfall which is prior to the maximum cloud growth and brightness. Moreover, Griffith et al. (1976) have shown that the maximum echo area in South Florida occurs prior to the maximum cloud area. From those observations it can also be inferred that the maximum echo brightness and thus the lowest ceiling and surface visibilities occur prior to the maximum cloud brightness.

2.10 EXAMPLE OF RADAR ECHO PATTERN DEPICTION FROM SATELLITE VISIBLE DATA

One of the goals of this work was to attempt to depict radar echo patterns from satellite data. A natural goal for further work would be to extend that capability to intensity recognition.

Of the four cases studied in this contract, the best echo pattern depiction occurred with the 14 August case. The actual radar echo pattern is shown in Figure 27, and Figure 28 shows the themed satellite visible pattern that most nearly resembled the echo pattern. The actual satellite visible data for this case are shown in Figure 13. The rather good agreement between the patterns in Figures 27 and 28 is encouraging. The pattern in Figure 28 was produced by simply selecting a gray level range and then pushing a button.



FIG. 27 - Actual radar echo pattern, 14 August 1975 case

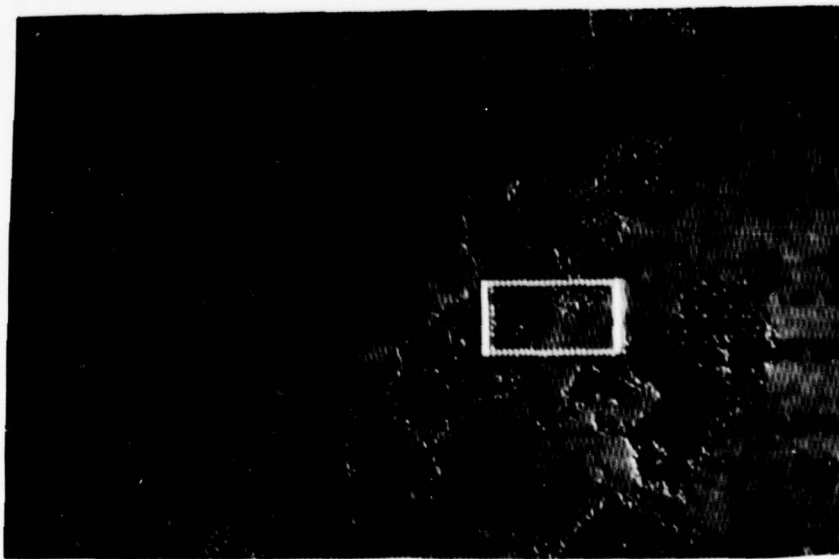


FIG. 28 - Simulated radar echo pattern produced from themed satellite visible data, 14 August 1975 case

ACKNOWLEDGEMENTS

We are grateful to the National Hurricane and Experimental Meteorology Laboratory for providing digital radar, rain gauge and radiosonde data; to the Satellite Field Services Station in Miami and the Atmospheric Science Laboratory, WSMR, for providing satellite data; to the National Climatic Center for providing surface observations; and to the Kennedy Space Center Data Analysis Facility for their role in analyzing the satellite and radar data on the Image 100 system.

The difficult task of overcoming the computer incompatibilities was accomplished by Bob Orgaz who produced the programs in the appendix. Ms. Lynn Zakevich-Gheer drafted the figures.

We are especially appreciative to Mr. Bruce Miers (WSMR) for his prompt assistance and overall efficiency as contract monitor, and to Mr. Stormy Horn (WSMR) for his role in arranging analytical time on the KSC Image 100 system. The concern and support of the Atmospheric Sciences Laboratory, WSMR, is gratefully acknowledged.

BIBLIOGRAPHY AND REFERENCES

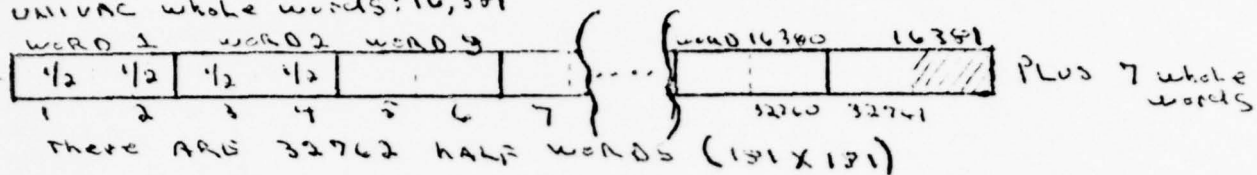
- Byers, H.R., and R.R. Braham, Jr., 1949, The Thunderstorm, Report of the Thunderstorm Project, U.S. Weather Bureau, Washington, D.C., June.
- Gerrish, H.P., 1966, "Radar Aspects of the Mid-October 1965 Deluge in South Florida", Proc. 12th Conf. on Radar Meteorology, Norman, Oklahoma, 17-20 October, pp. 386-391.
- Gerrish, H.P., 1975, Satellite and Radar Analysis of Mesoscale Weather Systems, Final Report, Division of Atmospheric Science, University of Miami, February.
- Griffith, C.G. and W.L. Woodley, 1973, "On the Variation with Height of the Top Brightness of Precipitating Convective Clouds", J. Appl. Meteor., Vol. 12, pp. 1986-1989.
- Griffith, C.G., W.L. Woodley, S. Browner, J. Teijeiro, M. Maier, D.W., Martin, J. Stout, D.N. Sikdar, 1976, Rainfall Estimation from Geosynchronous Satellite Imagery During Daylight Hours, NOAA Technical Report ERL 356-WMP07, Boulder, Colorado, February.
- Ostlund, S.S., 1974, Computer Software for Rainfall Analyses and Echo Tracking of Digitized Radar Data, NOAA Technical Report ERL WMP0-15, Boulder, Colorado, March.

APPENDIX

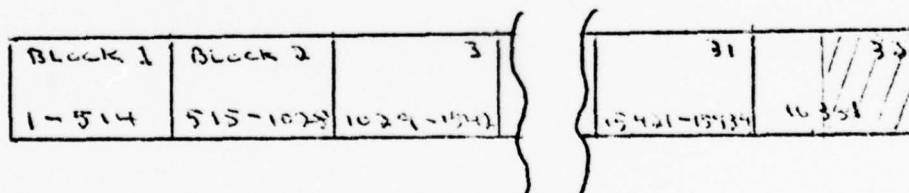
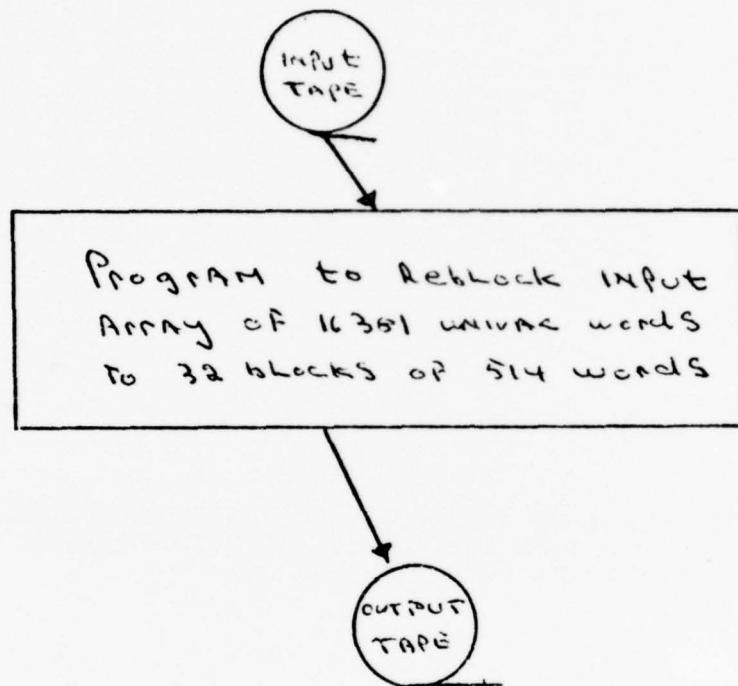
COMPUTER PROGRAMS FOR CONVERTING 7-TRACK NHEML KART DIGITAL
TAPES TO 9-TRACK TAPES WITH SUITABLE BLOCK SIZE AND FORMAT
FOR THE KSC PDP 11/35 COMPUTER SYSTEM

PRECEDING PAGE BLANK

UNIVAC whole words: 16,381



There ARE 32762 HALF WORDS (131 X 131)



Q1 FOR DLL,DBL
 UNIVAC 1106 FORTRAN V LEVEL 2206 0018 F5018P
 THIS COMPILATION WAS DONE ON 19 FEB 76 AT 12:28:57

MAIN PROGRAM

STORAGE USED (BLOCK, NAME, LENGTH)

0001	*CODE	000071
0000	*DATA	040122
0002	*BLANK	000000

EXTERNAL REFERENCES (BLOCK, NAME)

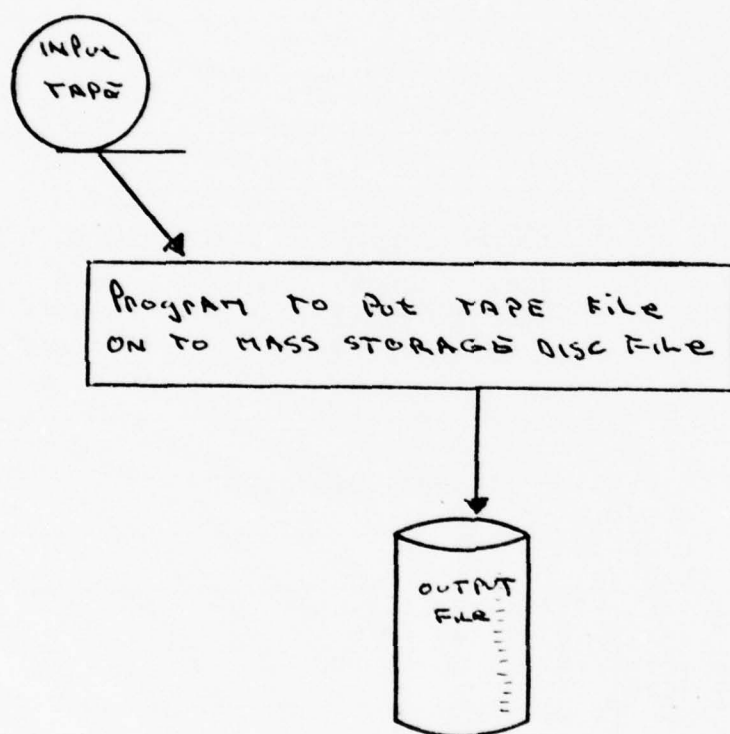
0003	NTRAN
0004	EXIT
0005	NWDUS
0006	NI025
0007	NSTOP5

STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001	000004	1L	0001	000042	105L	0001	000026	115G
0001	000057	500L	0000	I 000011	I	0000	I 000003	IC
0000	I 000002	LS	0000	I 000000	L1	0000	I 000001	L2

00101	1*	DIMENSION I(16388),J(514,32)
00103	2*	EQUIVALENCE (I,J)
00104	3*	L1=16388
00105	4*	L2=514
00106	5*	1 CALL NTRAN(7,2,L1,I,LS)
00107	6*	5 IF (LS.EQ.-1) GO TO 5
00111	7*	IF (LS.EQ.-2) GO TO 500
00113	8*	IC=0
00114	9*	DO 110 H=1,32
00117	10*	IC=IC+1
00120	11*	CALL NTRAN(8,1,L2,J(1,N),IS)
00121	12*	105 IF (IS.EQ.-1) GO TO 105
00123	13*	110 CONTINUE
00125	14*	WRITE(6,120) IC
00130	15*	120 FORMAT(1X,'COUNT=',I3)
00131	16*	GO TO 1
00132	17*	500 CONTINUE
00133	18*	CALL NTRAN(8,9,9,10)
00134	19*	CALL EXIT
00135	20*	END

END OF UNIVAC 1106 FORTRAN V COMPILATION. 0 *DIAGNOSTIC* MESSAGE(



ORUN ORGM36,006626,ORGZ

```
*****
***** REMINDER TO ALL USERS *****
*****
* A USERID WILL BE REQUIRED ON -ALL- RUN STATEMENTS AFTER *
* MAY 31, 1976. STUDENT AUTHORIZATION CARDS WILL INCLUDE *
* THE USERID. ALL OTHERS PLEASE CONTACT COMPUTER SERVICES *
* DISPATCH OFFICE FOR FORMS AND INFORMATION..... *
*****
*****
```

FOR,IS

FOR S11A-05/12/76-13:07:17

MAIN PROGRAM

STORAGE USED: CODE(1) 000052; DATA(0) 001017; BLANK COMMON(2) 000000

EXTERNAL REFERENCES (BLOCK, NAME)

```
0003 NTRAN
0004 EXIT
0005 NINTR$
0006 NWDUS$
0007 NI02$
0010 NSTOP$
```

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

```
0001 000004 1056 0000 001004 110F 0001 000041 9999L 0000
0000 I 001003 L
```

```
00101 1* IMPLICIT INTEGER(A-Z)
00103 2* DIMENSION A(514)
00104 3* DO 3000 II=1,32
00107 4* CALL NTRAN(4,2,514,A,L)
00110 5* CALL NTRAN(4,22)
00111 6* IF(L.EQ.-2) GO TO 9999
00113 7* CALL NTRAN(3,1,514,A,L)
00114 8* CALL NTRAN(3,22)
00115 9* 3000 CONTINUE
00117 10* 9999 CONTINUE
00120 11* WRITE(6,110)
00122 12* 110 FORMAT(1X,'COMPLETE')
00123 13* CALL EXIT
00124 14* END
```

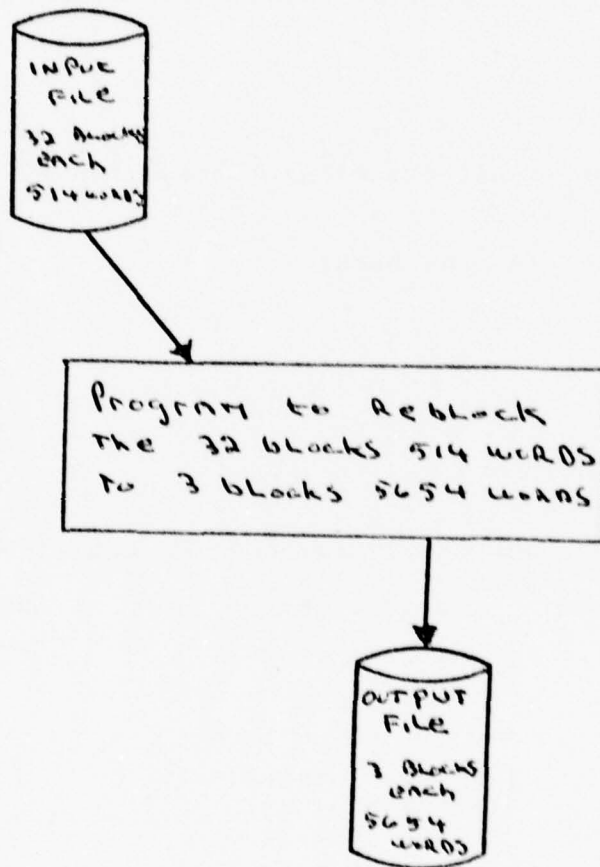
END OF COMPILATION:

NO DIAGNOSTICS.

MSG.F INTAPE.16N,RNW226

USE 4.,INTAPE

MSG.CP HL226.



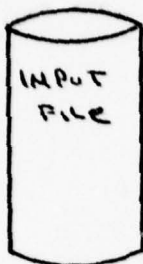
ORG AZ*DOWN.P1

```

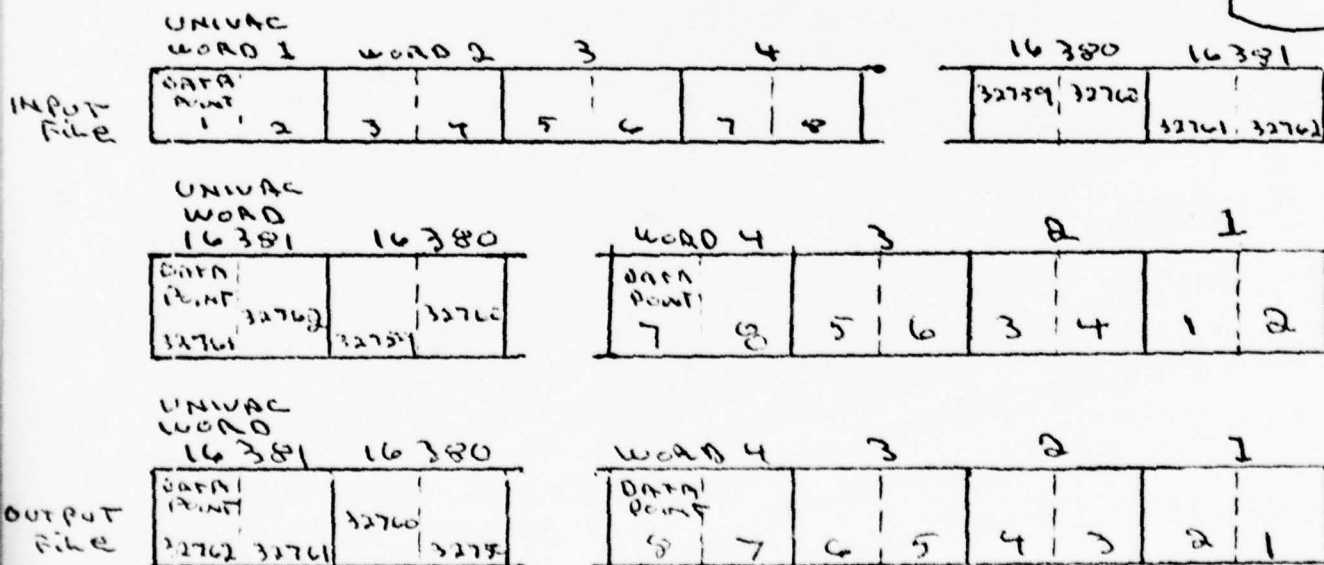
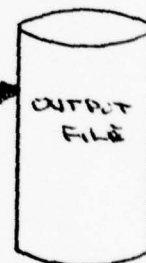
1      IMPLICIT INTEGER(A-Z)
2      DIMENSION A(514),B(5654)
3      K1=1
4      K2=11
5      KC=1
6      10 CONTINUE
7      K=1
8      DO 25 I=K1,K2
9      CALL NTRAN(4,2,514,A,L)
10     CALL NTRAN(4,22)
11     DO 20 J=1,514
12     B(K)=A(J)
13     K=K+1
14     20 CONTINUE
15     25 CONTINUE
16     IF(KC.EQ.3) GO TO 30
17     GO TO 35
18     30 CONTINUE
19     DO 33 K=5141,5654
20     33 B(K)=0
21     35 CONTINUE
22     CALL NTRAN(3,1,5654,B,L)
23     CALL NTRAN(3,22)
24     K1=K1+11
25     K2=K2+11
26     IF(K2.EQ.33) K2=32
27     KC=KC+1
28     IF(KC.EQ.4) GO TO 100
29     GO TO 10
30     100 CONTINUE
31     WRITE(6,110)
32     110 FORMAT(1X,'COMPLETE')
33     CALL EXIT
34     END

```

GPPT,S DOWN.P2



PROGRAM TO CREATE A NEW FILE
WITH THE LAST WORD FIRST
AND FIRST WORD LAST.
THEN
REORDER EACH HALF WORD
TO MAKE A CONTINUOUS STRING
OF NUMBERS FROM 32,762 TO 1



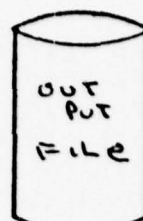
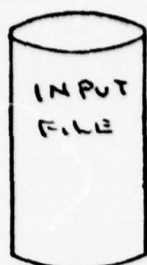
ORGAN*DOWN.P2

```

1      IMPLICIT INTEGER(A-Z)
2      DIMENSION A(5654),B(5654)
3      DO 10 I=1,2
4      CALL NTRAN(4,2,5654,A,L)
5      CALL NTRAN(4,22)
6      10 CONTINUE
7      K=1
8      CALL NTRAN(4,2,5654,A,L)
9      CALL NTRAN(4,22)
10     DO 20 I=5654,1
11     FLD(0,18,B(K))=FLD(18,18,A(I))
12     FLD(18,18,B(K))=FLD(0,18,A(I))
13     K=K+1
14     20 CONTINUE
15     CALL NTRAN(3,1,5654,B,L)
16     CALL NTRAN(3,22)
17     CALL NTRAN(4,10)
18     CALL NTRAN(4,22)
19     CALL NTRAN(4,2,5654,A,L)
20     CALL NTRAN(4,22)
21     K=1
22     CALL NTRAN(4,2,5654,A,L)
23     CALL NTRAN(4,22)
24     DO 25 I=5654,1
25     FLD(0,18,B(K))=FLD(18,18,A(I))
26     FLD(18,18,B(K))=FLD(0,18,A(I))
27     K=K+1
28     25 CONTINUE
29     CALL NTRAN(3,1,5654,B,L)
30     CALL NTRAN(3,22)
31     CALL NTRAN(4,10)
32     CALL NTRAN(4,22)
33     K=1
34     CALL NTRAN(4,2,5654,A,L)
35     CALL NTRAN(4,22)
36     DO 30 I=5654,1
37     FLD(0,18,B(K))=FLD(18,18,A(I))
38     FLD(18,18,B(K))=FLD(0,18,A(I))
39     K=K+1
40     30 CONTINUE
41     CALL NTRAN(3,1,5654,B,L)
42     CALL NTRAN(3,22)
43     WRITE(6,110)
44     110 FORMAT(1X,'COMPLETE')
45     CALL EXIT
46     END

```

6PRT,S DWN.S1



The univac 1100 has 36 bits per word or 18 bits per half word. The POP has 16 bits per word. This program generates a new data file by taking away the leading 2 bits from each original univac half word and dumps the remaining 16 bits into a new string of 36 bits univac words.

For every 8 words in the new string

$$\left[\frac{8 \text{ univac words} \times 36 \text{ bits/word}}{16 \text{ bits/POP word}} \right]$$

10 POP words are generated.

The type written numbers are the bits of the new string of sentence words. The number written under each type written number is the corresponding bit of the original data.

Nov	30	1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
"	"	2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
"	"	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
"	"	4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
"	"	5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
"	"	6	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
"	"	7	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
"	"	8	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36

ORCAZ*DOWN.51

```

1      IMPLICIT INTEGER(A-Z)
2      DIMENSION KO(352)
3      DIMENSION D(1905),E(1223),F(541)
4      DIMENSION A(8000),B(2816),C(5654)
5      DIMENSION X1(24),Y1(24),X2(24),Y2(24)
6      READ(2,1) X1
7      READ(2,1) Y1
8      READ(2,1) X2
9      READ(2,1) Y2
10     1 FORMAT(24I2)
11     CALL NTRAN(4,2,5654,C,L)
12     CALL NTRAN(4,22)
13     J1=2
14     DO 1000 I=1,8000
15     1000 A(I)=0
16         JB=0
17         DO 600 JA=582,5654
18         JB=JB+1
19         600 A(JB)=C(JA)
20         JTEST=1
21         216 CONTINUE
22         ITEST=1
23         K=0
24         J=-1
25         2 CONTINUE
26         DO 30 KK=1,352
27         I=0
28         DO 20 I1=1,2
29         K=K+1
30         DO 5 I2=1,2
31         I=I+1
32         J=J+1
33         M=J/3+1
34         5 FLD(X1(I),Y1(I),B(M))=FLD(X2(I),Y2(I),A(K))
35         DO 15 I3=1,3
36         K=K+1
37         DO 10 I4=1,3
38         I=I+1
39         J=J+1
40         M=J/3+1
41         10 FLD(X1(I),Y1(I),B(M))=FLD(X2(I),Y2(I),A(K))
42         15 CONTINUE
43         20 CONTINUE
44         K=K+1
45         DO 25 I5=1,2
46         I=I+1
47         J=J+1
48         M=J/3+1
49         25 FLD(X1(I),Y1(I),B(M))=FLD(X2(I),Y2(I),A(K))
50         30 CONTINUE
51         DO 873 OZ=1,352
52         873 RQ(OZ)=B(OZ)
53         CALL NTRAN(3,1,2816,B,L)
54         CALL NTRAN(3,22)
55         ITEST=ITEST+1
56         IF(ITEST.GE.2) K=3168

```

```

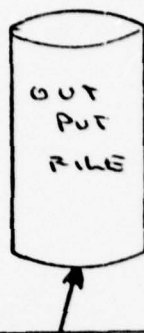
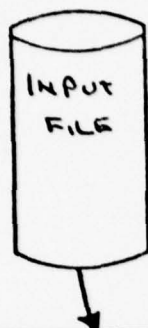
57      IF (JTEST.LT.J1) GO TO 2
58      IF (JTEST.EQ.1) GO TO 695
59      IF (JTEST.EQ.2) GO TO 795
60      IF (JTEST.EQ.3) GO TO 895
61      IF (JTEST.EQ.4) GO TO 999
62      695 JB=Q
63      DO 700 JA=3159,5073
64      JB=JB+1
65      700 D(JB)=A(JA)
66      DO 701 LP=1,8000
67      701 A(LP)=Q
68      CALL NTRAN(4,2,5654,C,L)
69      CALL NTRAN(4,22)
70      DO 710 JA=1,1905
71      710 A(JA)=D(JA)
72      JB=1905
73      DO 715 JA=1,5654
74      JB=JB+1
75      715 A(JB)=C(JA)
76      JTEST=JTEST+1
77      J1=3
78      GO TO 216
79      795 JB=Q
80      DO 800 JA=6337,7559
81      JB=JB+1
82      800 E(JB)=A(JA)
83      DO 801 LP=1,8000
84      801 A(LP)=Q
85      CALL NTRAN(4,2,5654,C,L)
86      CALL NTRAN(4,22)
87      DO 810 JA=1,1223
88      810 A(JA)=E(JA)
89      JB=1223
90      DO 815 JA=1,5654
91      JB=JB+1
92      815 A(JB)=C(JA)
93      JTEST=JTEST+1
94      J1=3
95      GO TO 216
96      895 JB=Q
97      DO 900 JA=6337,6877
98      JB=JB+1
99      900 F(JB)=A(JA)
100     DO 901 LP=1,8000
101     901 A(LP)=Q
102     DO 905 JA=1,541
103     905 A(JA)=F(JA)
104     DO 915 JA=542,4000
105     915 A(JA)=Q
106     J1=2
107     JTEST=JTEST+1
108     GO TO 216
109     999 CONTINUE
110     WRITE(6,2000)
111     2000 FORMAT(1X,'COMPLETE')
112     CALL EXIT
113     END

```

ORGANIZATION.D1

1	001632001228000824000420001632001228000824000420
2	161604121608081612041616161604121608091612041616
3	022002062002102002142002200220240220280220320220
4	161604121608081612041616161604121608091612041616

OPERATION.D2



The PDP has 16 bits per word or 8 bits per half word. This computer reads the second half word first (bits 9-16) and the first half word second (bits 1-8). This program generates a new data file by alternating every 8 bits in the string of words generated by the program that eliminates the leading 2 bits of each half word in the original data set.

OR 3AZ*DOWN.S2

```

1      IMPLICIT INTEGER(A-Z)
2      DIMENSION A(2816),B(2816)
3      DIMENSION X1(22),X2(22),Y1(22),Y2(22)
4      DIMENSION Z1(22),Z2(22)
5      DIMENSION ZA(22),ZB(22)
6      READ(7,1) X1
7      READ(7,1) Y1
8      READ(7,1) Z1
9      READ(7,1) X2
10     READ(7,1) Y2
11     READ(7,1) Z2
12     1 FORMAT(22I2)
13     DO 201 LP=1,22
14     ZA(LP)=Z1(LP)
15     201 ZB(LP)=Z2(LP)
16     DO 600 LP=1,6
17     CALL NTRAN(4,2,2816,A,L)
18     CALL NTRAN(4,22)
19     DO 500 II=1,704
20     DO 450 I=1,22
21     M=Z1(I)
22     K=Z2(I)
23     FLD(X1(I),Y1(I),B(M))=FLD(X2(I),Y2(I),A(K))
24     450 CONTINUE
25     DO 475 J=1,22
26     Z1(J)=Z1(J)+4
27     475 Z2(J)=Z2(J)+4
28     500 CONTINUE
29     CALL NTRAN(3,1,2816,B,L)
30     CALL NTRAN(3,22)
31     DO 425 LZ=1,22
32     Z1(LZ)=ZA(LZ)
33     425 Z2(LZ)=ZB(LZ)
34     600 CONTINUE
35     WRITE(6,700)
36     700 FORMAT(1X,'COMPLETE')
37     CALL EXIT
38     END

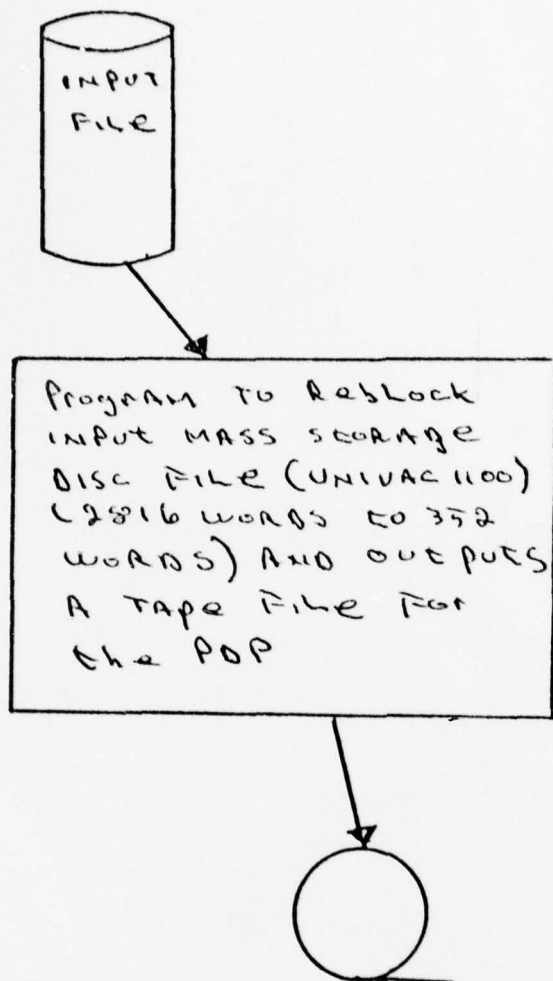
```

OPRT,S DOWN.D1

ORGAZ*DOWN.DZ

1	00081624320004081220280008162428320004122028
2	08080808040404040404080808080804040404080808
3	0101010101020202020203030303030404040404
4	08002416040932002012002816093200242812042820
5	03080808040404040808080808080804040404080808
6	010101010202010202020303030304030304040404

aFIN



@FOR,IS

FOR S11A-06/09/76-11:42:43

MAIN PROGRAM

STORAGE USED: CODE(1) 000065; DATA(0) 006164; BLANK COMMON(2) 000000

EXTERNAL REFERENCES (BLOCK, NAME)

0003 NTRAN
0004 EXIT
0005 NINTR\$
0006 NWDU\$
0007 NIO2\$
0010 NSTOP\$

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001	000003	105G	0000	006145	110F	0001	000020	113G	000
0000	I	005400	B	0000	I	006140	I	0000	I
0000	I	006141	N			0000	I	006143	J

00101	1*	IMPLICIT INTEGER(A-Z)
00103	2*	DIMENSION A(2816),B(352)
00104	3*	DO 30 I=1,6
00107	4*	N=0
00110	5*	CALL NTRAN(4,2,2816,A,L)
00111	6*	CALL NTRAN(4,22)
00112	7*	DO 25 J=1,8
00115	8*	DO 20 K=1,352
00120	9*	N=N+1
00121	10*	20 B(K)=A(N)
00123	11*	CALL NTRAN(3,1,352,B,L)
00124	12*	CALL NTRAN(3,22)
00125	13*	25 CONTINUE
00127	14*	30 CONTINUE
00131	15*	CALL NTRAN(3,9,9,10)
00132	16*	WRITE(6,110)
00134	17*	110 FORMAT(1X,'COMPLETE')
00135	18*	CALL EXIT
00136	19*	END

END OF COMPILATION:

NO DIAGNOSTICS.

WASG,A Z4.

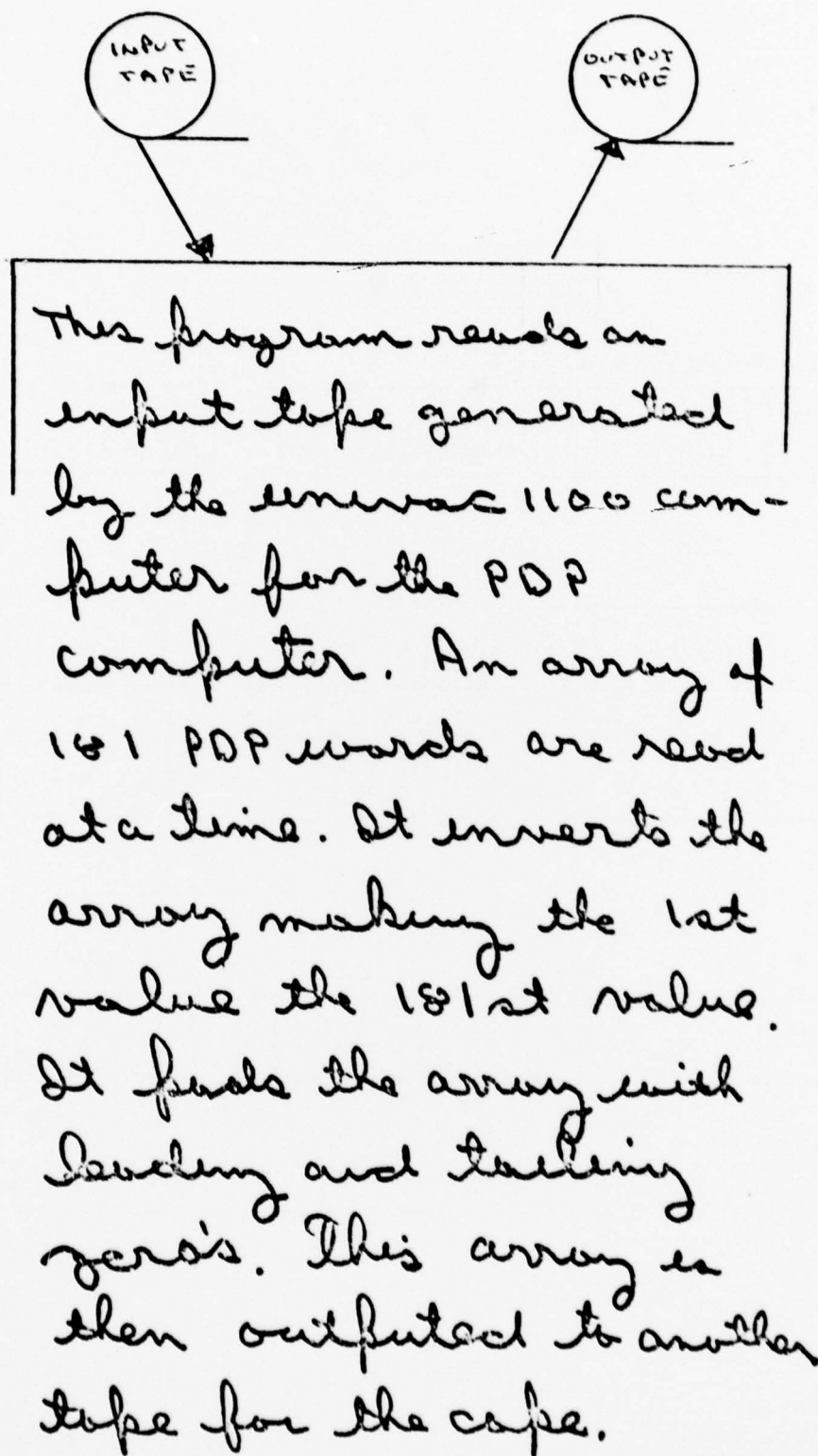
WUSE 4..Z4.

WASG,TH OUTAPE,16N,MEDPLT

WUSE 3..OUTAPE.

WXQT

RMAP-9-06/09-11:43



PDP words (16 bits)

INPUT

DATA POINT						
32761	32760	32759	32758	32757	32756	32755

OUT
PUT

DATA POINT						
32580	32581	32582	32583	32584	32585	32586

①

DATA POINT						
32399	32400	32401	32402	32403	32404	32405

①

DATA POINT						
1	2	3	4	5	6	7

180

181

```

0001      IMPLICIT INTEGER(A=Z)
0002      DIMENSION V(27)
0003      DIMENSION A(2600),B(792),C(256)
0004      DIMENSION D(181),E(200)
0005      CALL SETFIL(6,'LP',IERR,'LP')
0006      CALL SETFIL(4,'MT',IERR,'MT',2)
0007      CALL SETFIL(3,'MT9',IERR,'MT',3)
0008      V(01)=12799
0009      V(02)=12593
0010      V(03)=12593
0011      V(04)=12593
0012      V(05)=12849
0013      V(06)=12850
0014      V(07)=12850
0015      V(08)=13106
0016      V(09)=13107
0017      V(10)=12595
0018      V(11)=12336
0019      V(12)=12592
0020      V(13)=12336
0021      V(14)=48
0022      V(15)=13616
0023      V(16)=48
0024      V(17)=12337
0025      V(18)=49
0026      V(19)=13616
0027      V(20)=48
0028      V(21)=12337
0029      V(22)=21711
0030      V(23)=0
0031      V(24)=0
0032      V(25)=0
0033      V(26)=0
0034      V(27)=0
0035      MC=0
0036      IC=0
0037      CALL WTRAN(3,V,27)
0038      CALL WAIT(3)
0039      DO 805 I=1,38
0040      DO 800 J=1,256
0041      800 C(J)=0
0042      CALL WTRAN(3,C,256)
0043      CALL WAIT(3)
0044      805 CONTINUE
0045      1000 CONTINUE
0046      ICOUNT=1
0047      KTEST=2376+MC
0048      JZ=MC
0049      KK=MC
0050      1 CONTINUE
0051      DO 10 I=1,3
0052      CALL RTRAN(4,B,792)
0053      CALL WAIT(4)
0054      DO 5 K=1,792
0055      JZ=JZ+1
0056      5 A(JZ)=B(K)
0057      10 CONTINUE
0058      JJ=0
0059      DO 150 I1=1,13

```

65

```
0060      DO 100 J=1,181
0061      JJ=JJ+1
0062      K=182-J
0063      100 D(K)=A(JJ)
0064      DO 105 J=1,39
0065      105 C(J)=0
0066      K=0
0067      DO 110 J=40,220
0068      K=K+1
0069      110 C(J)=D(K)
0070      DO 115 J=221,256
0071      115 C(J)=0
0072      IC=IC+1
0073      IF(IC,EQ,182) GO TO 999
0074      CALL WTRAN(3,C,256)
0075      CALL WAIT(3)
0076      WRITE(6,7000) C
0077      7000 FORMAT(10I6)
0078      150 CONTINUE
0079      KK=KK+23
0080      JZ=KK
0081      DO 200 K1=1,KK
0082      K2=KTEST-(KK-1)=1
0083      200 E(K1)=A(K2+K1)
0084      KTEST=KTEST+23
0085      DO 210 K3=1,2600
0086      210 A(K3)=0
0087      DO 215 K4=1,KK
0088      215 A(K4)=E(K4)
0089      ICOUNT=ICOUNT+1
0090      IF(ICOUNT,EQ,8) GO TO 225
0091      GO TO 1
0092      225 CONTINUE
0093      DO 600 J=1,181
0094      JJ=JJ+1
0095      K=182-J
0096      600 D(K)=A(JJ)
0097      DO 605 J=1,39
0098      605 C(J)=0
0099      K=0
0100      DO 610 J=40,220
0101      K=K+1
0102      610 C(J)=D(K)
0103      DO 615 J=221,256
0104      615 C(J)=0
0105      IC=IC+1
0106      IF(IC,EQ,182) GO TO 999
0107      CALL WTRAN(3,C,256)
0108      CALL WAIT(3)
0109      E(1)=A(2558)
0110      E(2)=A(2559)
0111      E(3)=A(2560)
0112      DO 650 IO=1,2600
0113      650 A(IO)=0
0114      MC=3
0115      DO 675 IO=1,3
0116      675 A(IO)=E(IO)
0117      GO TO 1000
0118      999 CONTINUE
0119      DO 815 I=1,37
```

```
0120      DO 810 J=1,256
0121      810 C(J)=0
0122      CALL WTRAN(3,C,256)
0123      CALL WAIT(3)
0124      815 CONTINUE
0125      CALL SPCL(3,2)
0126      CALL WAIT(3)
0127      CALL SPCL(3,2)
0128      CALL WAIT(3)
0129      WRITE(6,2000)
0130      2000 FORMAT(1X,'COMPLETE')
0131      CALL EXIT
0132      END
```

SEED

ROUTINES CALLED:

SETFIL, WTRAN, WAIT, RTRAN, SPCL, EXIT

OPTIONS =/ON,/OP12

BLOCK	LENGTH
MAIN,	5104 (023740)*

COMPILER *** CORE**		
PHASE	USED	FREE
DECLARATIVES	00622	13934
EXECUTABLES	01503	13053
ASSEMBLY	01617	17628