NO. 17

WESTERN REGION TECHNICAL MEMORANDUM

A Digitalized Summary of Radar Echoes within 100 Miles of Sacramento, California

by

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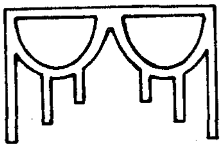

A western Indian symbol for rain. It also symbolizes man's dependence on weather and environment in the West.

Western Regional Technical Memorandum No. 17, December 1966

A DIGITALIZED SUMMARY OF RADAR ECHOES WITHIN 100 MILES OF SACRAMENTO, CALIFORNIA

by

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I. INTRODUCTION

The radar staff at WBO, Sacramento, has made hourly overlays of the radarscope, depicting areal coverage and intensities of weather echoes since July 1962. One study [1] was made of summer convective cell patterns, but no previous attempt had been made to analyze or summarize, in a climatological way, all of the data graphically depicted on the radarscope overlays. When an IBM 1620 computer became available in the River Forecast Center, adjacent to the Weather Bureau Office in Sacramento, exploring this possibility was made feasible.

II. THE RADAR

The radar in use at Sacramento WBO is the WSR-57, with a wavelength of 10cm, peak power of 500kw, and maximum range of 250 miles*. All techniques for standardization of the radar as set forth in the Weather Surveillance Manual [2] were followed. Normally, the antenna was tilted at an angle of +1 degree, which is necessary to prevent extensive masking of precipitation echoes by ground clutter. Assuming normal propagation and a tilt angle of 1 degree, the axis of the radar beam at 50 miles is approximately 7000 feet high, with the base at 1700 feet and the top at about 12,400 feet. (Base and top as referred to here are the 1/2 power points.) At a distance of 100 miles, the axis of the beam is at approximately 17,000 feet, with the base at 6700 feet and top at 27,700 feet.

The radar is located near the middle of the broad, north-south Central Valley of California. Forty miles to the west lies the coastal range, rising to an elevation of about 4000 feet. Twenty miles to the east, the western foothills of the Sierra Nevada begin. The crest of the Sierra is about 10,000 feet and 100 miles away.

III. DATA COLLECTION

For purposes of this study, only data within a 100-mile radius of the radar were used. This was found by experience to be the optimum range for the detection of precipitation, particularly for the broadscale precipitation patterns of the winter season.

The overlays were prepared by contouring the echo area for various range-corrected intensities on the reflection plotter, then tracing the echo areas on an acetate overlay for transfer to a paper chart. The areas for various intensities were shaded in with an appropriate color according to a locally established code. Radar echo intensities

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*All mileages given are in nautical miles.

were assigned values from 1 through 5. These numbers correspond to the categories shown below which are taken from the Theoretical Radar Rainfall Rate Intensity Chart used by the Weather Bureau [2].

1.	Very weak	(less than .01/hour)
2.	Weak	(.01 to 0.2 inches/hour)
3.	Moderate	(0.2 to 1 inches/hour)
4.	Strong	(1 to 5 inches/hour)
5.	Very strong	(greater than 5 inches/hour)

Grid values were obtained from the finished chart in the following way:

> The 100-mile radius scanning area was divided into 64 grid squares, 22.15 miles on a side. To reduce bias, the 22.15-mile square was quartered and a 5.54-mile square was centered in each large grid square. The entire grid was transferred to opaque cardboard and a 5.54-mile-square window was punched out for each square, through which the intensities were read. Figure 2, grid number 12, illustrates the size of the window used.

IV. THE COMPUTER PROGRAM AND CARDS

The first eight numbers of the punch card were used to depict a date-time group, with numbers 9 through 72 (Figure 2) corresponding to the 64 grid squares. Column 73 of the punch card was used to indicate PPINE (no echoes on radar), PPIOM (out for maintenance), PPINA (not available), etc., thus showing when there was a break in the continuity of the echo observations. The card was placed over the echo chart; and for each echo visible in a window, a number representing its intensity was punched in the corresponding column of the punch card. Whenever two or more intensities appeared in the window, the higher number in the radar intensity category was punched. If no echo was visible, the punch card space was left blank. To a large extent, the number of grid squares used was limited by available card columns, manual data reduction, and computer program simplicity.

The computer program was set up to read the intensity values at the grid points and to total them over a predetermined time period. The readout presented totals for each of the 64 grid squares in a form such as Figures 1 and 1(a), where the numbers represent the total number of occurrences of each intensity. The location of each group of numbers in the overall configuration corresponds to the location of the grid square within the 100-mile radius of data coverage.

V. RESULTS

The first computer run summarized the data for July 1962 through August 1964. The results are given in Figure 2. The distribution of the echo totals, regardless of intensity, for each grid area indicates some very distinct features of the echo patterns, i.e. the implied precipitation occurrences.

1. The area of maximum echo activity lies over the westward slopes of the Sierra Nevada, from about 1000 to 5000 feet elevation. This would indicate a strong orographic influence in this area.
2. There are significantly less total echo hours in the south as compared to northern grid areas.
3. A very sharp decrease in radar echoes occurs at about the Sierra Nevada crestline.

Another computer run summarized the data for the months of July and August 1962, 1963, and 1964. The results are given in Figure 3. These results are typical of the distribution of summertime convective activity. The most common area for echoes shifted upward to about the 7000-foot contour of the Sierra Nevada, (refer to plotted total occurrences in Figure 3) with a secondary maximum associated with the coast range in grid area 34 (Mt. St. Helena, 4344 feet, lies within this grid area). One rather unusual feature which shows up is the secondary maximum in grid 29. To see if this feature could be isolated, we made a run summarizing the months of July, August, September 1962, June, July, August, September of 1963, and June, July, August 1964. The results are shown in Figure 4. Note that the maximum in grid 29 is even more striking in this figure than in Figure 3. A possible explanation for this secondary maximum is orographic and associated with the Sutter Buttes which rise abruptly to an elevation of 2132 feet in grid 28. The harmonics of the lee waves in a west or southwest flow over the coast range may be such that the Sutter Buttes cause enough increased amplitude, when conditions for convective activity exist, to produce the secondary maximum as indicated. This follows, to some extent, the finding of Hosler, Davis, and Booker [3], in their lee-wave study.

VI. DISCUSSION AND CONCLUSIONS

The raw radar data as used are very basic, with complete disregard of storm type, echo tops, freezing level, rain, snow, rain and snow mixed, or any other parameters which would influence the detecting qualities of the radar. Rather, the procedure was devised to see if a rather simple summarization of the data would answer the following questions:

1. Will the radar show favored areas for the occurrence of precipitation? Obviously, the answer is yes (Figure 2). The windward slopes of the Sierra Nevada are the most prolific echo producers with a secondary maximum in the coastal mountains.

2. Is there a drop-off of echoes to the south? Again the answer is yes. This cannot at the present time be explained by peculiarities of the radar, but as indicated by Weaver [4], the influence of the Golden Gate break in the coastal mountains could amplify storminess to the north. Since most major winter frontal systems enter the state from the west or north, the comparatively warm, moist westerly winds flowing through the Golden Gate could certainly amplify any stormy situation of this nature until the storm front passes south of the Golden Gate.

3. We have, in essence, 64 "raingages" under constant surveillance. Can a weighting factor be assigned to each grid location to convert radar detected precipitation intensity to actual raingage catch? Our summarizations left this question unanswered. This is one of the next steps in the use of the data. Perhaps a new program can be evolved deriving a relationship between actual catch for each square and total hours of radar precipitation within the grid square, thus arriving at a bias number.

The basic digitalized operational radar data used in this study appear to offer exceedingly interesting information and many possibilities for further investigation. Radar data analyzed, even by this unsophisticated method, can contribute significantly to the meteorology and climatology of a region.

VII. ACKNOWLEDGMENTS

The authors wish to thank Mr. Herbert Benner, Regional Radar Meteorologist, who supplied the initial incentive for the undertaking, and Mr. Jack Hannaford, RFC, Sacramento, who wrote the computer program and gave much valuable advice.

VIII. REFERENCES

[1] Benner, H. P., R. E. Hambidge, L. B. Overaas, D. B. Smith, and J. A. Youngberg, "Summer Convective Cell Radar Patterns Over Central and Northern California", Monthly Weather Review, vol. 90, No. 10, October 1962, pp 425-430.

[2] Weather Surveillance Radar Manual, USWB, 1963, pp 184.

[3] Hosler, C. L., Project Director, "The Role of Orographic Barriers of Less Than 3000 Feet in the Generation and Propagation of Showers", Part II - Lee Wave Studies, Pennsylvania State University, pp 101-145.

[4] Weaver, R. L., "Meteorology of Hydrologically Critical Storms in California", Hydro. Met. Report No. 37, USWB, December 1962, pp 100-105.

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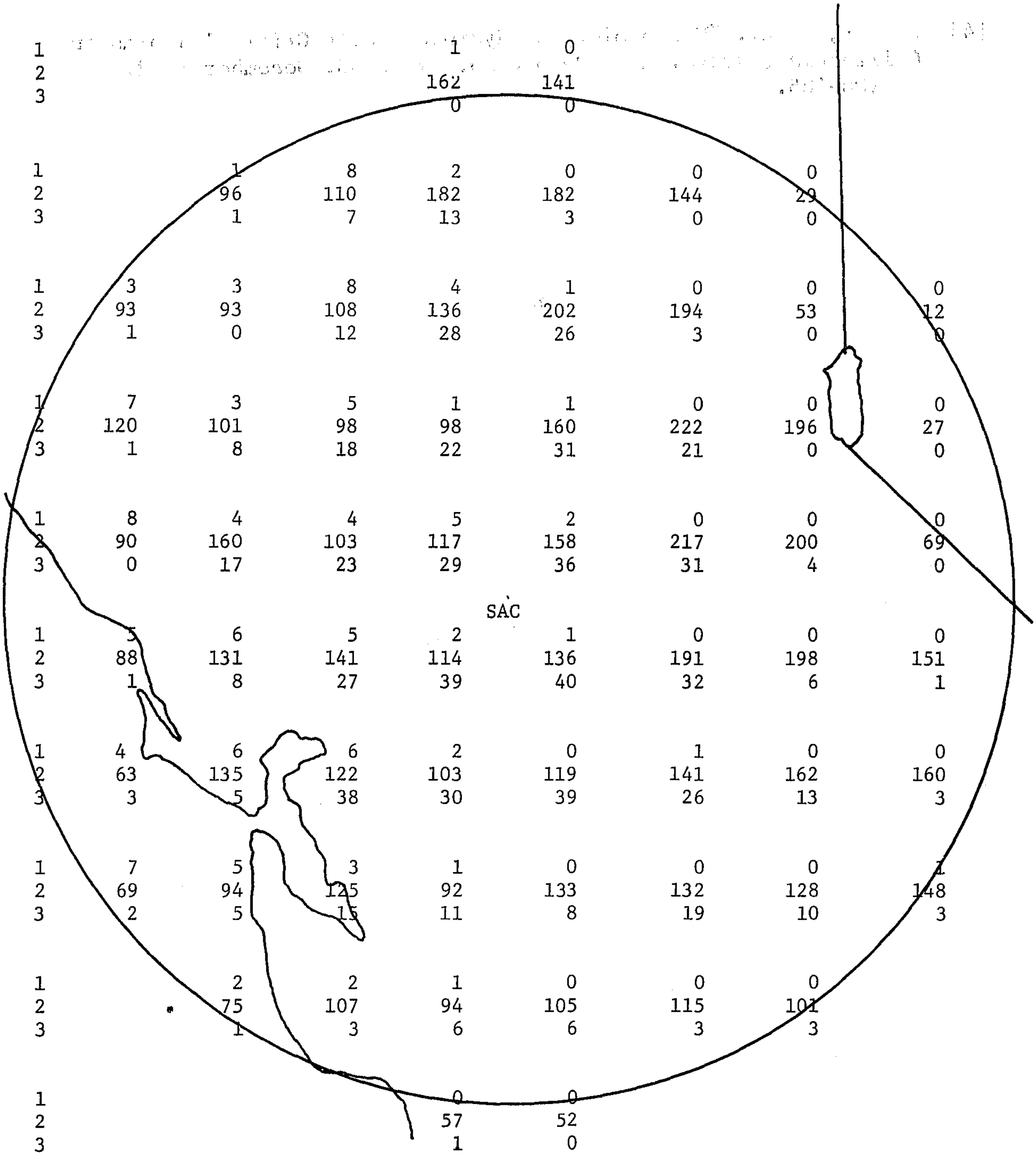
MONTHLY SUMMARY FOR APRIL 1963 SHOWING TOTAL NUMBER OF ECHO INTENSITIES 1 THROUGH 3 FOR EACH GRID SQUARE



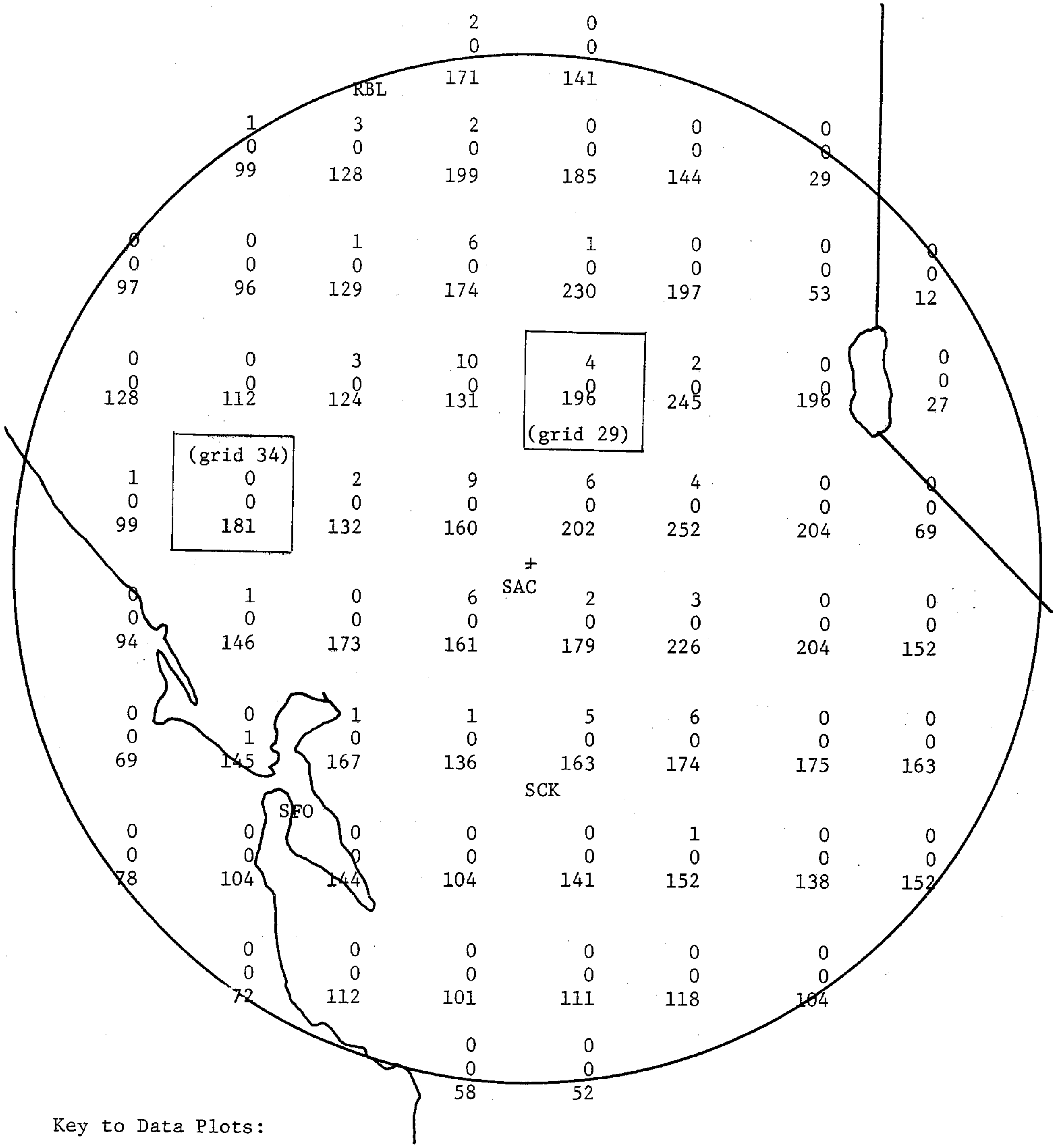
1				1	0			
2				162	141			
3				0	0			
1		1	8	2	0	0	0	
2		96	110	182	182	144	29	
3		1	7	13	3	0	0	
1	3	3	8	4	1	0	0	0
2	93	93	108	136	202	194	53	12
3	1	0	12	28	26	3	0	0
1	7	3	5	1	1	0	0	0
2	120	101	98	98	160	222	196	27
3	1	8	18	22	31	21	0	0
1	8	4	4	5	2	0	0	0
2	90	160	103	117	158	217	200	69
3	0	17	23	29	36	31	4	0
1	5	6	5	2	1	0	0	0
2	88	131	141	114	136	191	198	151
3	1	8	27	39	40	32	6	1
1	4	6	6	2	0	1	0	0
2	63	135	122	103	119	141	162	160
3	3	5	38	30	39	26	13	3
1	7	5	3	1	0	0	0	1
2	69	94	125	92	133	132	128	148
3	2	5	15	11	8	19	10	3
1		2	2	1	0	0	0	
2		75	107	94	105	115	101	
3		1	3	6	6	3	3	
1				0	0			
2				57	52			
3				1	0			

Key to Data Plots:

1. VERY WEAK (a trace or loss)
2. WEAK (.01 to 0.2 inches/hour)
3. MODERATE (0.2 to 1 inch/hour)

FIGURE 1

CONTINUATION OF MONTHLY SUMMARY FOR APRIL 1963 SHOWING TOTAL NUMBER OF ECHO INTENSITIES 4 AND 5, AND TOTAL ECHO HOURS FOR INTENSITIES 1 THROUGH 5



Key to Data Plots:

4. STRONG (1 to 5 inches/hour)
5. VERY STRONG (greater than 5 inches/hour)
T TOTAL OF NUMBERS 1 THROUGH 5

FIGURE 1(a)

TOTAL ECHO HOURS BY GRID SQUARE FOR THE PERIOD JULY 1962 THROUGH AUGUST 1964 (26 MONTHS). DASHED LINES INDICATE TERRAIN CONTOURS IN THOUSANDS OF FEET.

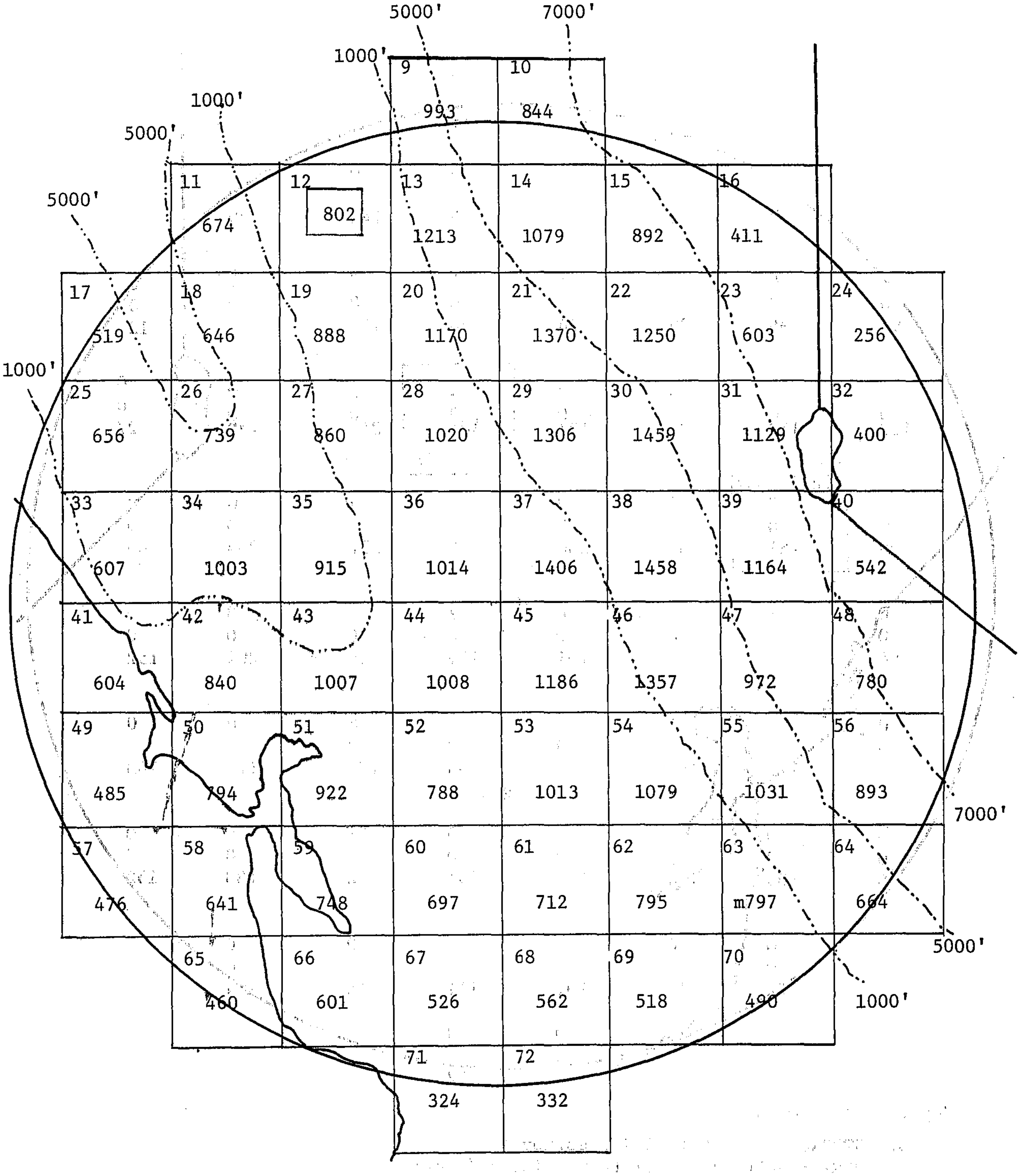
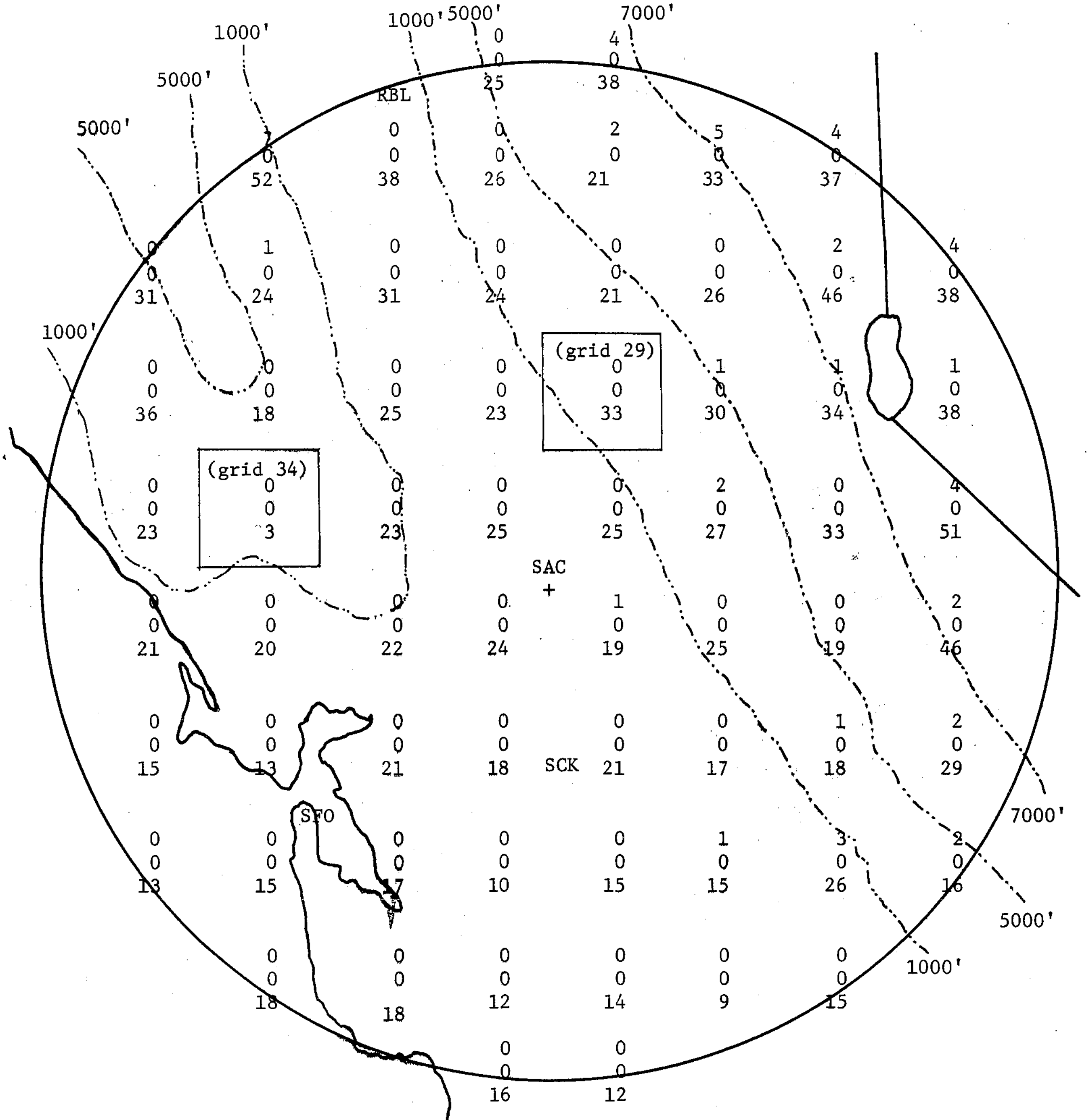


FIGURE 2

TOTAL ECHO HOURS BY GRID SQUARE OF ECHO INTENSITIES 4 AND 5, AND ALL INTENSITIES 1 THROUGH 5 FOR THE MONTHS JULY AND AUGUST 1962, 1963, 1964. DASHED LINES INDICATE TERRAIN CONTOURS IN THOUSANDS OF FEET.

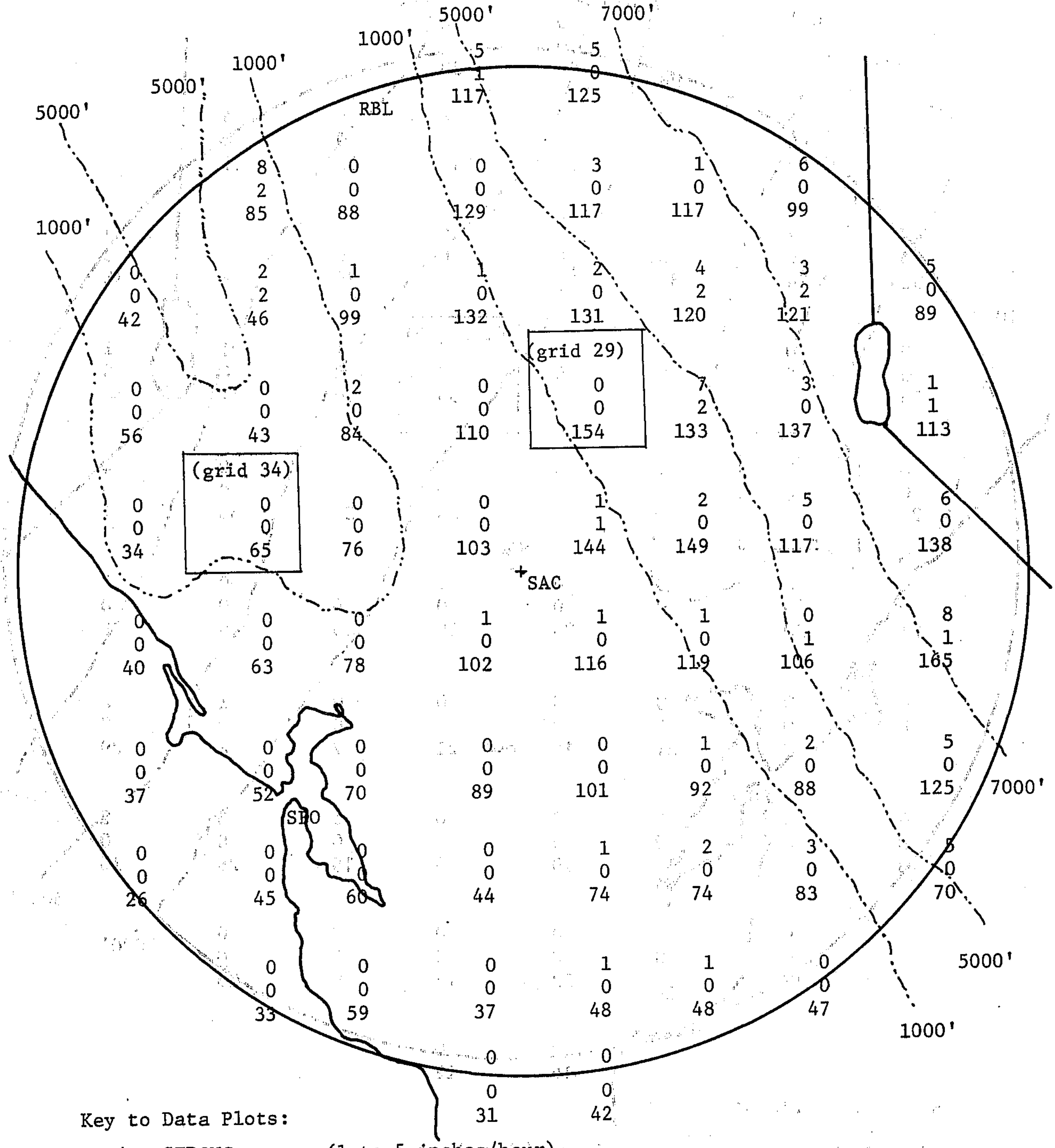


Key to Data Plots:

4.	STRONG	(1 to 5 inches/ hour)
5.	VERY STRONG	(greater than 5 inches/hour)
T	TOTAL OF NUMBERS 1 THROUGH 5	

FIGURE 3

TOTAL ECHO HOURS BY GRID SQUARE OF ECHO INTENSITIES 4 AND 5, AND ALL INTENSITIES 1 THROUGH 5 FOR THE MONTHS JULY, AUGUST, SEPTEMBER 1962, JUNE, JULY, AUGUST, SEPTEMBER 1963, AND JUNE, JULY, AUGUST 1964. DASHED LINES INDICATE TERRAIN CONTOURS IN THOUSANDS OF FEET.



Key to Data Plots:

4.	STRONG	(1 to 5 inches/hour)
5.	VERY STRONG	(greater than 5 inches/hour)
T	TOTAL OF NUMBERS 1 THROUGH 5	

FIGURE 4