NOAA TM NWS WR 66

A UNITED STATES DEPARTMENT OF COMMERCE PUBLICATION

NOAA Technical Memorandum NWS WR 66

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

A Preliminary Report on Correlation of ARTCC Radar Echoes and Precipitation

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Western Region

SALT LAKE CITY, UTAH

June 1971

NOAA TECHNICAL MEMORANDA

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U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

NOAA Technical Memorandum NWSTM WR-66

A PRELIMINARY REPORT ON CORRELATION OF ARTCC RADAR ECHOES AND PRECIPITATION

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WESTERN REGION
TECHNICAL MEMORANDUM NO. 66

SALT LAKE CITY, UTAH
JUNE 1971

TABLE OF CONTENTS

LIST OF FIGURES AND TABLE

A PRELIMINARY REPORT ON CORRELATION OF ARTCC RADAR ECHOES AND PRECIPITATION

I. INTRODUCTION

It is quite important for the radar observer and all users of radar data to be familiar with detection capabilities of the various radars used throughout the National Weather Service. It is also important that studies be made of radar data in hopes of finding possible ways of better utilization of raw radar data.

This study was made to determine how accurately moderate or greater precipitation can be detected, utilizing returns which break through Circular Polarization (CP) and Moving Target Indicator (MTI) circuit of Federal Aviation Administration Air Route Traffic Control Center (FAA/ARTCC) radars. We also hope to give users an idea of what degree of confidence they can have in reports of moderate or greater precipitation areas.

II. RADARS

Since ARTCC radars are used primarily for air-traffic control, some are equipped with anticlutter circuits. These are used by controllers to eliminate from their scopes unwanted targets which may obscure aircraft targets. Weather echoes sometimes fall into the unwanted category.

ARTCC systems employ various modes of polarization of the radiated waves. The two most common are Linear Polarization (LP) and Circular Polarization (CP). CP and MTI are used to help eliminate unwanted targets.

Circular polarized waves are used to reduce strength of signals returned by precipitation targets. This technique takes advantage of the fact that raindrops are more symmetrical than most other targets. Obviously the degree of reduction is dependent on the shape of the precipitation particles. The more spherical the particles, the greater the reduction.

When linear polarized waves are employed, all precipitation signals detectable by the radar are returned.

For this study, observations from five radars were utilized (Figure 1). Four are equipped with CP and MTI capability. These four are Mt. Laguna, San Pedro, Paso Robles, and Edwards Air Force Base. The fifth radar, Las Vegas, is not equipped with CP. The Mt. Laguna, San Pedro, Las Vegas, and Paso Robles radars are 23cm radar with similar weather detection capability and range (200 nautical miles). The radar used at Edwards Air Force Base has a wavelength of 10.3 centimeters and a maximum range of 60 nautical miles.

ARTCC radar systems utilize two video signals, "Normal" and MTI. The "normal" video carries all signals as received by the radar system from the target unaltered by MTI circuitry. The MTI channel carries a video signal that has been processed to eliminate stationary targets. In essence, the MTI video is completely void of any ground-clutter targets. This feature helps the radar observer delineate precipitation in mountainous areas. Targets in mountainous areas are normally obscured by heavy ground clutter. Unfortunately MTI has an undesirable effect on signal back-scatter from precipitation targets, i.e., it reduces the signal strength of weather targets by about 9 db 1/.

With the use of LP and CP, two contours of radar echo intensity can be presented to the observer. Echoes observed in the LP mode represent all precipitation detectable by the radar and echoes observed in the CP mode represent moderate or greater precipitation only.* By switching from LP to CP or vice versa, echoes representing these two levels of precipitation intensity are displayed.

III. METHOD OF DATA COLLECTION

Hourly radar observation maps were prepared depicting the two contours of precipitation intensity discussed above. Moderate to heavy (CP) echoes were shaded in solid black and lighter than moderate precipitation (LP) echoes were unshaded. Hourly data for the period of one month was considered (February 1969) (See sample data sheet, Fig. 2).

An acetate overlay showing the geographical location of each climatological hourly-precipitation recording station was constructed. This overlay was placed over each hourly radar map. If a climatological station was located within a CP echo area, it was logged on charts which were prepared by day and hour. After all the CP echoes were logged, February climatological records for California were consulted. Precipitation reporting stations used in the study are listed in Table 1.

Hourly precipitation totals from climatological stations were matched with radar observations taken during the same hour. A 2130Z radar observation was considered a 2200Z observation for comparison with climatological records. To qualify as a hit for verification purposes,

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*One tenth inch or more hourly precipitation was used in this study as the criterion for moderate or greater precipitation as described in the Weather Radar Manual 2/ and the Introduction to Weather Radar Booklet 3/.

.10 inch or more precipitation had to be recorded either for that particular hour or for the preceding or following hour to take into consideration time-lag error possibilities. A miss was scored if .10 inch or more precipitation was not recorded.

IV. ANALYSIS OF DATA

Climatological stations which were not within CP echoes or which were very close to the edges of the CP echoes were eliminated to allow for possible parallax errors. Stations initially within CP echoes but which did not fall within the CP echo on the verification hour due to echo movement were also eliminated. Echoes which fell on days or hours for which climatological data were missing were omitted from the study. After eliminating echoes described above, the remaining echoes were checked to see if they met the verification criteria established.

On each day, for each station, a percentage of hits out of the total CP echoes logged was calculated. A percentage of all echoes and the number verified for the whole period of study was also calculated. Of 304 total CP echoes observed over climatological stations, 87% were verified to have had .10 inch or more precipitation recorded.

V. SUMMARY AND CONCLUSIONS

It is quite apparent that by utilizing CP and MTI radar modes, areas of moderate or greater precipitation can be detected with an excellent degree of accuracy. In this study 87% verification was achieved.

Results of this study have given radar observers at Palmdale a much greater confidence in estimating precipitation intensities. The study also shows that the 9db reduction in signal caused by MTI does not appreciably affect radar detection capabilities of moderate or greater precipitation areas.

While CP echoes are not the only criterion used in estimating intensity of echoes, they do play a large role. It is hoped that in the future, two contours of radar weather intensity may be depicted on National Facsimile radar charts for Western United States.

VI. ACKNOWLEDGMENTS

Appreciation is due Mr. John Fassler, MIC, Palmdale, and Mr. H. P. Benner, Western Region Marine and Radar Service Meteorologist for their assistance.

VII. REFERENCES

1/ Benner, H. P. and D. B. Smith. "Joint ESSA/FAA ARTC Radar Weather Surveillance Program," Weather Bureau Western Region Technical Memorandum, Salt Lake City, Utah, December 1968.

2/ Weather Radar Manual (WBAN) Washington, D. C., August 1967 With Change Number One, September 1967, Part A paragraph 5.5.2 Table 5-3.

3/ Introduction to Weather Radar, U. S. Department of Commerce, ESSA, April 1969, p. 75, Table III and paragraph 4.1.5.4.

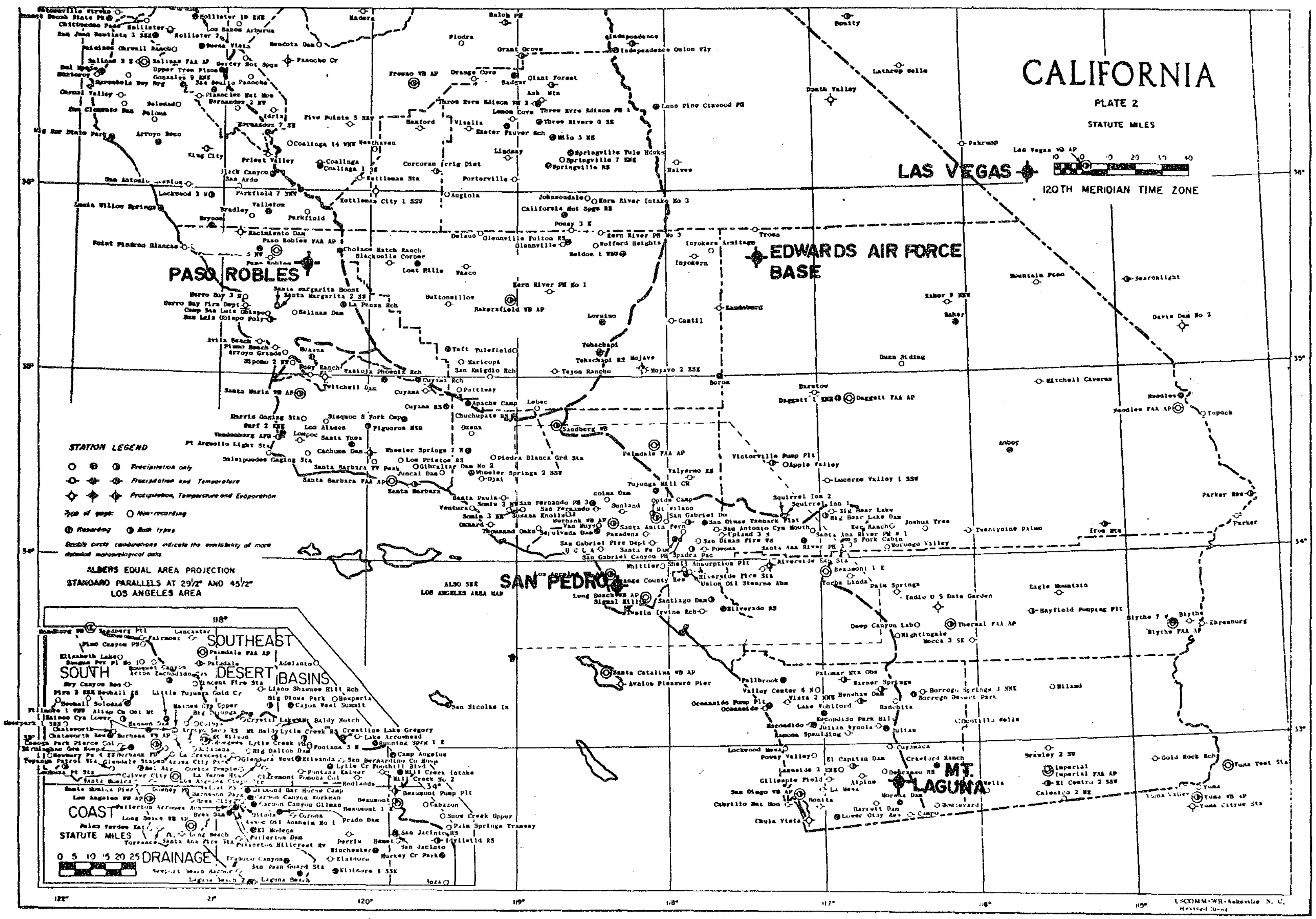

FIGURE 1. LOCATION OF RADARS AND CLIMATOLOGICAL STATIONS IN SOUTHERN CALIFORNIA AND SOUTHERN NEVADA.

PAGE 1

V CP ECHOES AND HOURLY PRECIPITATION

DATE: 2/5/69

GMT	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8	TOTAL		
STATION	1	2	3	4	5	6	7	8	9	10	11	NOON	1	2	3	4	5	6	7	8	9	10	11	MID	HIT	MISS	%
91																.01	.02	✓ .12	✓ .16	.15					2	1	66
133																	✓	.04✓	.15✓	.23✓	.24				3	1	75
65																.02	.09✓	.18✓	.20✓	.20✓					4	0	100
56																.01	✓	.03✓	✓	.08✓	.23				2	2	50
134																.01	.11✓	.22	.35✓	.63					2	0	100
96																.02	.02✓				.06	.12✓	.13		1	1	50
44																	.10✓			✓	.10✓		.30		2	1	66
42																.10	.10✓	.10							1	0	100
135																.01	.08✓	.14							1	0	100
47																.03	.16✓	.22✓	.32						3	0	100
67																		.05✓	.07						1	0	100
54																		.04✓	.03	.17					0	1	0
63																	.05	.15✓	.16✓	.09					2	0	100
103																		.23✓							1	0	100
104																		.10✓	.11✓						2	0	100
89																	.01	.01✓	.04						0	1	0
55																		.01	.03✓	.06✓	.23✓				2	1	66
90																				.26✓					1	0	100
71																				.14			.30✓		2	0	100
107																				✓					0	1	0
39																				.20✓					1	0	100
46																			.01	.04✓	.04✓				0	2	0
37																					.10✓	✓	.10		2	0	100
68																						.11✓	.13✓		2	0	100
75																						.07✓	.28		1	0	100
45																					.01	.10✓	.19		1	0	100
32				.06	.06✓	.08																			1	0	100
122				.03	.25✓	.09																			1	0	100
31				.05	.29✓	✓ .36																			2	0	100

FIGURE 2. SAMPLE ECHO AND HOURLY PRECIPITATION DATA SHEET.

TABLE 1

KEY TO LOCATIONS OF HOURLY PRECIPITATION REPORTING STATIONS IN CALIFORNIA

1. San Diego WB
2. Prado Dam
3. El Capitan Dam
4. Cuyamaca
5. Warner Springs
6. Henshaw Dam
7. Lake Wohlford
8. Escondido #2
9. Oceanside Pumping Plant
10. Palomar (Mt.)
11. Idyllwild Ranger Station
12. San Jacinto Ranger Station
13. Winchester
14. Elsinore
15. Trabuco Canyon
16. Laguna Beach #2
17. El Modena
18. Santiago Dam
19. Beaumont
20. Mill Creek Intake
21. Santa Ana River PH3
22. Big Bear Lake Dam
23. Running Springs I E.
24. Lytle Creek Foothill Boulevard
25. Etiwanda
26. Mt. Baldy FC 856
27. Spadra Pac. FC
28. Brea Dam
29. Los Angeles WB
30. Los Angeles Civic C.
31. Sepulveda Dam
32. San Fernando PH3
33. Tujunga Mill FC
34. San Gabriel Dam
35. Victorville Pumping Plant
36. Palmdale
37. Churchpate Ranger Station
38. Ventucopa Ranger Station
39. Pine Mountain Inn
40. Carpinteria Reservoir
41. Santa Barbara
42. San Marcos Pass
43. Cachuma Dam
44. Figueroa Mountain
45. Surf 2 ENE
46. Sandberg WB
47. Arroyo Seco
48. Badger
49. Baker
50. Bakersfield WB
51. Balch Power House
52. Boulder C Locatelli R.
53. Bishop WB
54. Buena Vista
55. Cholame Alley Ranch
56. Coalinga I SE
57. Corcoran Irrig. District
58. Corralitos
59. Del Monte
60. Exeter Fauver Ranch
61. Fresno WB
62. Gilroy 8 NE
63. Gonzales 9 NE
64. Grant Grove
65. Hernandez 7 SE
66. Hollister 2
67. Hollister 10 NE
68. Huasna
69. Imperial
70. King City
71. La Panza Ranch
72. Little Panoche Dam
73. Lockwood 2 N
74. Lone Pine Ctnwood PH
75. Lost Hills
76. Merced 2
77. Milo 5 NE
78. Modesto 2
79. Mojave
80. Morgan Hill 6 WSW
81. Morgan Hill SCS
82. Mt. Givens
83. Mt. Modonna
84. Musick Creek Guard Station
85. Needles
86. Orange County Reservoir
87. Oxnard
88. Palo Alto City Hall
89. Parkfield 7 NNW
90. Paso Robles 5 NW
91. San Benito
92. San Felipe Highway Station
93. San Jose
94. San Juan Bautista 35 SE
95. San Nicholas Island
96. Santa Maria WB
97. Springville Ranger Station
98. Springville Tole Howks
99. Sunset Beach St. Park
100. Taft

TABLE 1 (CONTINUED)

KEY TO LOCATIONS OF HOURLY PRECIPITATION REPORTING STATIONS IN CALIFORNIA (Continued)

101. Tehachapi Airport
102. Three Rivers Edison PHI
103. Upper Tres Pinos
104. Valleton
105. Weldon I WSW
106. Amboy
107. Apache Camp
108. Daggett I ENE
109. Crawfort Ranch
110. Borrego Desert Park
111. Lower Otay Reservoir
112. Blythe 7 W
113. Fallbrook
114. Hayfield PP
115. Thermal Airport
116. Boron
117. Signal Hill
118. Little Tujunga Creek
119. Mt. Wilson
120. San Dimas Tanbark Flat
121. Chatsworth Reservoir
122. Hansen Dam
123. Wheeler Springs
124. Santa Ynez
125. Cuyama Ranch
126. Wasioja Phoenix Ranch
127. San Luis Obispo Poly
128. Glennville Fulton Ranger Stn.
129. Uhl Ranger Station
130. Three Rivers 6 SE
131. Independence
132. Independence Onion Valley
133. Slack Canyon
134. Bryson
135. Lucia Willow Springs
136. Big Sur St. Park
137. Hurkey Creek Park
138. San Juan Guard Station
139. Cajon West Sum
140. Big Pines Park
141. Pacheco Pass
142. Wawona Ranger Station
143. Catheys Valley Bull Ranch
144. San Joaquin Exp. Range
145. Iron Mountain
146. Parker Reservoir

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