POSITION AND INTENSITY OF THUNDERSTORMS IN NORTHEASTERN COLORADO, 1963

Final Report

to

Central Radio Propagation Laboratory

National Bureau of Standards

Contract No. CST-7419

by

Richard A. Schleusener

Civil Engineering Section
Colorado State University
Fort Collins, Colorado

December 1963

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INTRODUCTION

In conjunction with studies being made at Colorado State University on hailstorms and attempts at modification of hailstorms, data were collected during the summer of 1963 to assist the Bureau of Standards in their studies of radio propagation. Information on the dimensions, position, intensity, and movement of individual precipitation cells were obtained by Colorado State University from 3-cm weather radar sets located at New Raymer, Colorado and Lowry Air Force Base, Colorado.

The geometry of the experiment has been described by Dennis and Fernald (1). Communications were established to permit simultaneous scanning of individual precipitation cells with the weather radars and the Central Radio Propagation Laboratory (CRPL) scatter equipment.

This report presents meteorological and radar data for ten cases which were selected for maximum interest and availability of simultaneous data.

PROCEDURES

New Raymer - PPI Radar of Atmospherics, Inc.

The method of operation of the weather radar set operated by Atmospherics, Inc. at New Raymer has been described by Schleusener and Henderson (2). Time-lapse photographs of the PPi scope provide the basic data on position and movement of precipitation cells. Estimates of echo tops were made by raising the antenna until the echo disappeared from the scope.

New Raymer - CSU Radar

A Navy SO-12 radar, modified to give a vertical scanning capability, was also operated from New Raymer. After a decision was made to scan a particular cell (based on examination of the PPi scope), the SO-12 was employed to make vertical scans along azimuth lines which encompassed the cell of interest.

A "program" included one series of vertical scans through a particular cell. The "program" was begun by scanning along an azimuth which was at the left hand edge of the cell of interest. A series of scans were made, again with each successive scan at a reduced gain step. This procedure was continued until the right-hand edge of the cell was scanned, which completed the "program."

The data were recorded with a Keystone 16 mm camera, modified to give a "normally open" shutter.

A step-gain system was incorporated into the set for making reflectivity measurements. An eleven-position stepper switch was automatically tripped after each vertical scan, at which time an increment of attenuation was applied to the receiver. The five steps were calibrated in five-10 db. steps, 10 through 50, then repeated with the eleventh position of the stepper in a gain "normal" (no attenuation) position. A series of Nixie tubes were used to identify the appropriate step for photographic purposes.

Field Data

Data on rainfalls and hailfalls were obtained from a combination of field surveys, reports from cooperative observers, and the network maintained by Colorado State University.

SUMMARY OF DATA

Data Supplied Previously

Appendix 1 lists the data supplied to CRPL prior to submission of this report.

Identification of Cases Selected for Special Study

The following cases were selected for special study. Meteorological and radar data for these cases are presented in this report.

		Time (MST)	Cell Ident.
1963	June 14	1451-1640	3-4-5
	27	1530-1633	Line
	July 5	1338-1607	2-3-4-5
	11	1331-1552	2-3
	12	1515-1654	9
	22	1430-1637	1-2-3-4
	22	1655-1835	7-8-9-10
	23	1728-1742	1-2
	25	1543-1628	8-9-10
	26	1523-1645	2

Position and Movement of Radar Echoes

Maps showing the position and movement of individual radar echoes for each of the dates of special study are given in Appendix 2.

Prints From Time-Lapse Film of PPI Scope

Prints were made from the 16-mm film of time-lapse pictures taken of the PPI scope of Atmospherics, Inc., radar operated at New Raymer. These prints, taken at approximately 15-minute intervals, are presented in Appendix 3.

Cross-Section Profiles of Reflectivity

Data from the photographic record of the RHI scope were reduced to yield cross-sections of reflectivity for the 10 cases selected for special study. These data, presented in Appendix 4, are presented as cross-section of a given gain-step. The conversion to reflectivity (Z) may be accomplished by reference to the calibration graph of gain step vs "Z."

The data from Appendix 4 were taken from film records of the RHI scope. The outline of the echo viewed at the highest gain step was checked a second time for accuracy after the profiles were prepared.

Field Data

Field data on rainfalls and hailfalls are presented in Appendix 5

for the 10 cases selected for study. The plotting code is presented at the beginning of Appendix 5.

Supporting Photographic Data

An index of supporting photographic data for the days selected for study is given in Appendix 6. These supporting data are available for use, if desired.

FREQUENCY OF OCCURRENCE OF RADAR ECHO TOPS

The radar set of Atmospherics, Inc., at New Raymer, Colorado, was operated to give frequent estimates of tops of echoes by raising the antenna until the echo disappeared from the scope. These data from 1962 and 1963 were used to determine the cumulative frequency of radar echo observations exceeding given heights. Figure 1 shows a comparison between "hailers" and "non-hailers." Figure 2 shows a comparison between the months of May, June, and July, and Figure 3 compares 1962 with 1963.

Data from Figures 1, 2, and 3 may be used to make a comparison of the height of a given echo with the spectra of heights experienced in 1962 and 1963.

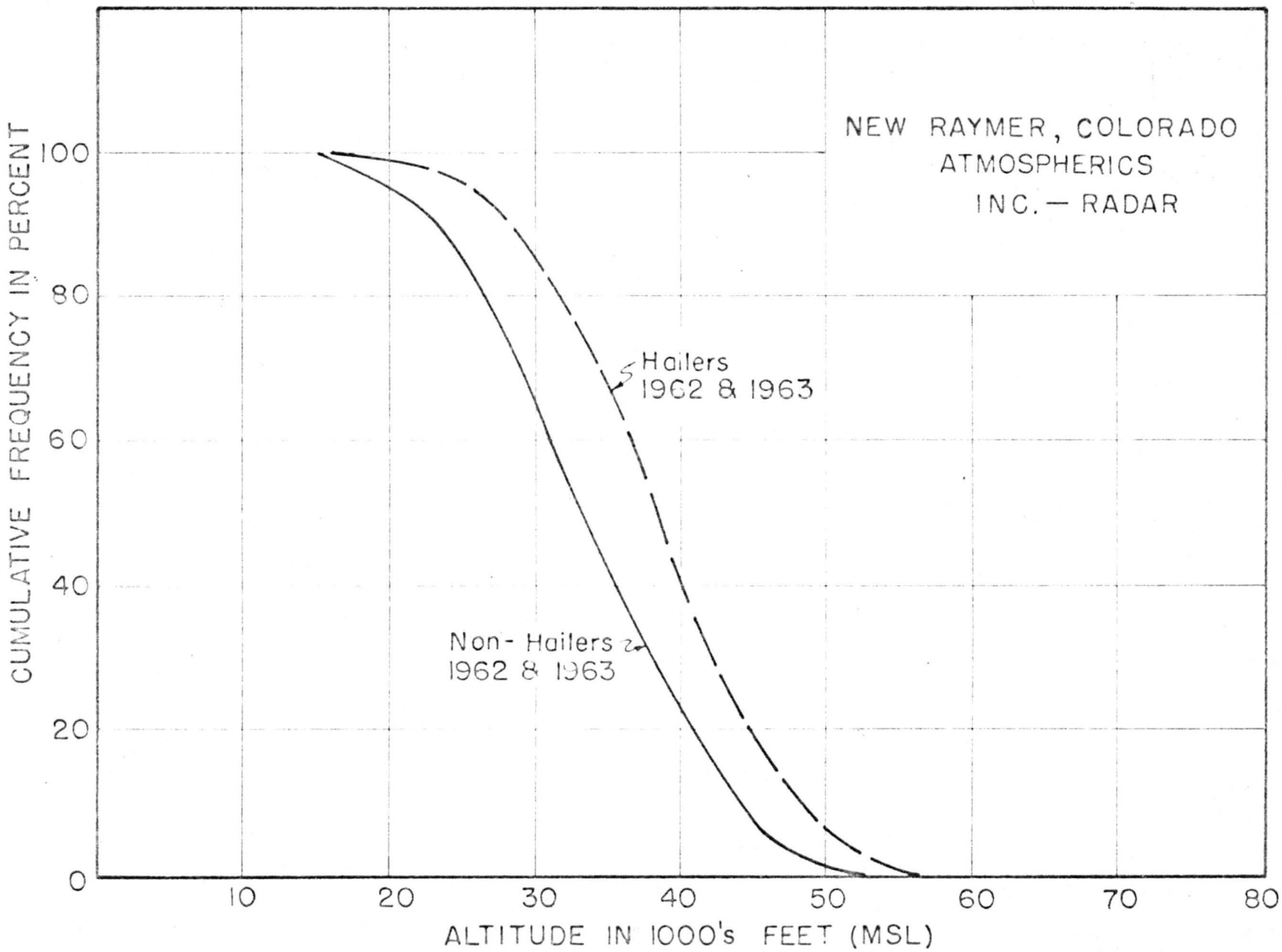

Fig. 1 CUMULATIVE FREQUENCY OF RADAR ECHO OBSERVATIONS EXCEEDING GIVEN HEIGHTS AT A RANGE OF LESS THAN 40 NAUTICAL MILES (UNCORRECTED FOR BEAM WIDTH)

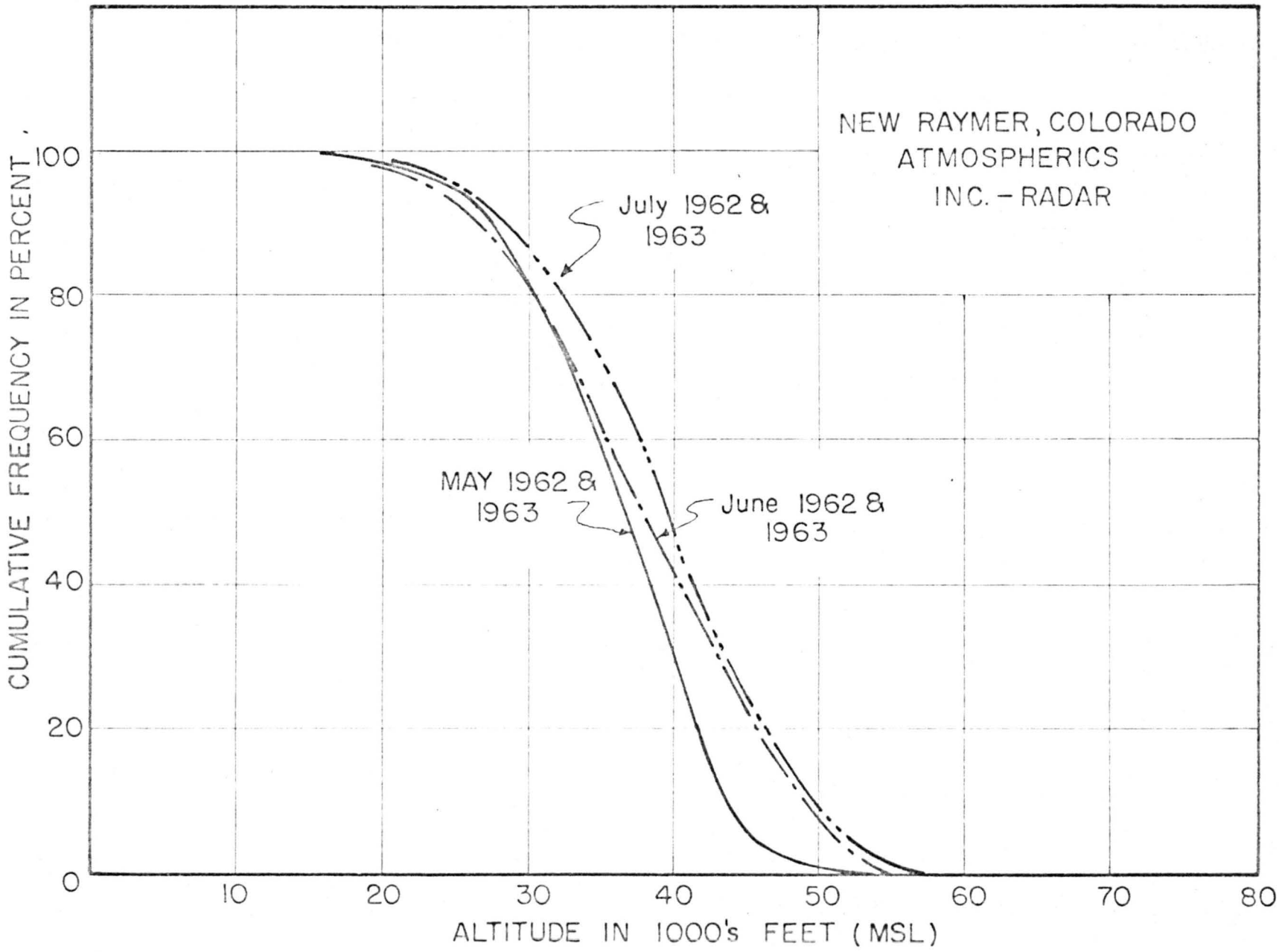

Fig. 2 CUMULATIVE FREQUENCY OF RADAR ECHO OBSERVATIONS EXCEEDING GIVEN HEIGHTS AT A RANGE OF LESS THAN 40 NAUTICAL MILES FOR "HAILERS & NON-HAILERS" (UNCORRECTED FOR BEAM WIDTH)

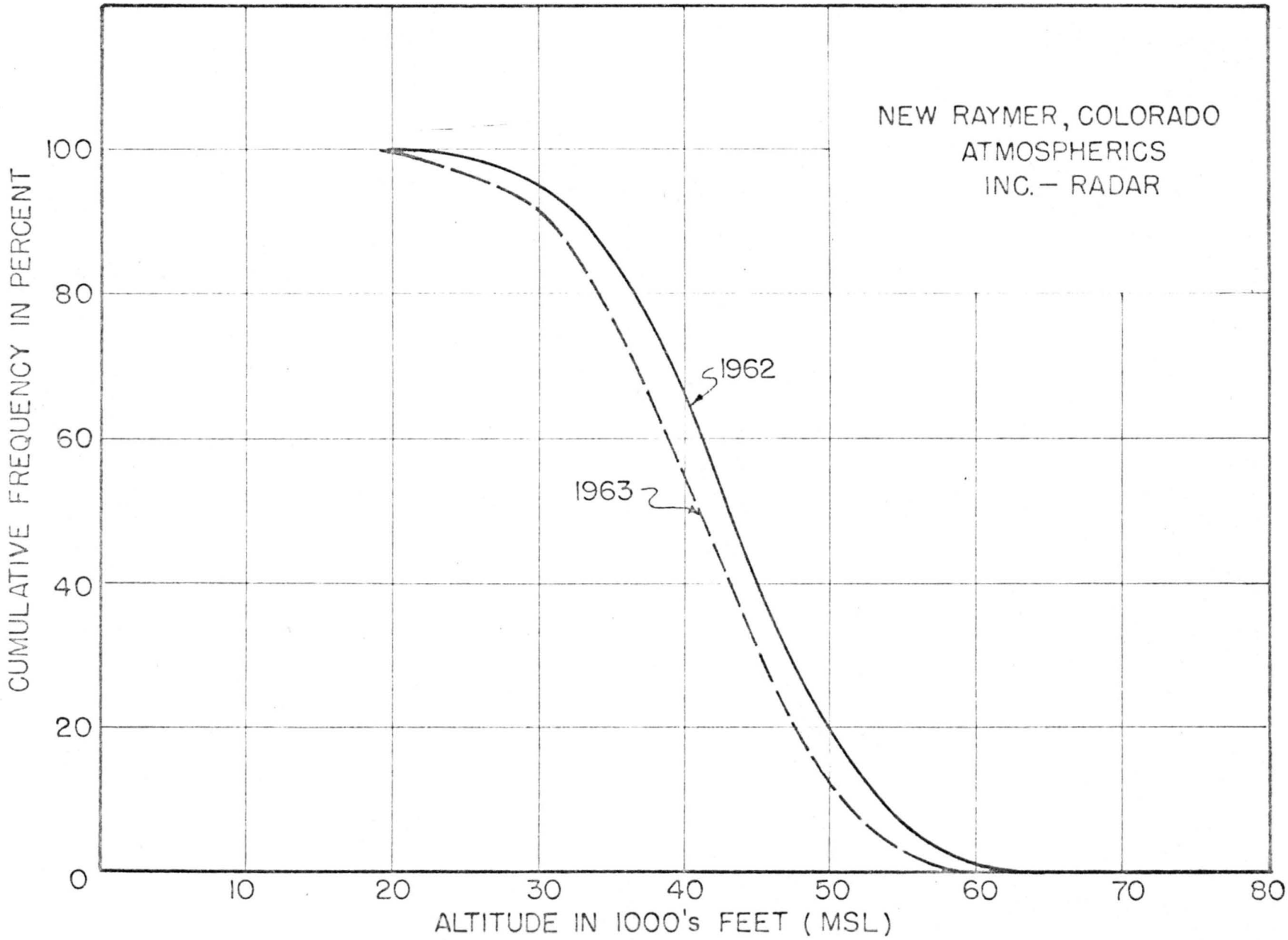

Fig. 3 CUMULATIVE FREQUENCY OF RADAR ECHO OBSERVATIONS EXCEEDING GIVEN HEIGHTS AT A RANGE OF LESS THAN 40 NAUTICAL MILES, "HAILERS & NON-HAILERS." (UNCORRECTED FOR BEAM WIDTH)

REFERENCES

1. Dennis, Arnett, and Fernald, F. G., 1963: A preliminary analysis of forward-scatter signals from showers. Stanford Research Institute Research Memorandum 5, SRI Project No. 3773, Menlo Park, California, 19 p.

2. Schleusener, Richard A., and Henderson, Thomas J., 1962: Radar climatology of hailstorms in and near northeastern Colorado, 15 May - 31 July 1962, with comparative data for 1961. Civil Engineering Section. Report CER62RAS79, Colorado State University, Fort Collins, Colorado.

APPENDIX 1

Listing of data supplied to CRPL previously.

Item	Description	Date of cover letter
Atmos. Inc. Radar	Copies of PPI 16-mm film 14, 26, and 27 June	23 Aug. 63 (To Arnett Dennis)
	Index of dates and time of operation	23 Aug. 63
	Copies of basic data including tops and reflectivity	23 Aug. 63
	Calibration-dial setting vs "Z"	23 Aug. 63
	Storm tracks from PPI scope for which RHI data are available	16 Oct. 63
RHI Radar	Index of dates and time of operation	23 Aug. 63
	Copy of basic data	23 Aug. 63
	Calibration-step gain vs "Z"	23 Aug. 63
CPS - 9	Index of dates and time of operation	23 Aug. 63
	Copies of scope overlays - 15 May - 31 July 63	23 Aug. 63
	1 - 16 Aug. 63	16 Oct. 63
	Daily composite storm tracks	16 Oct. 63
	Calibration - step gain vs "Z"	16 Oct. 63
Seeding Data	Overlays of PPI position of cells	23 Aug. 63
	Seeding tracks	23 Aug. 63
	Times of generator "on" and "off"	23 Aug. 63
CRPL	Conversion between and vs Z	4 Dec. 63

APPENDIX 2

Maps showing the position and movement of radar echoes for each day selected for special study. Cells shown in solid black were identified as having produced hail at the ground at some time during their life history. Cells shown in outline only were not identified as having produced hail at the ground at some time during their life cycle.

APPENDIX 3

Prints from time-lapse film of PPI scope of Atmospherics, Inc., radar operated at New Raymer. (All range marks are 20 nautical miles. Gain setting is "normal" in all cases.)

APPENDIX 3

Prints from time-lapse film of PPI scope of Atmospherics, Inc., radar operated at New Raymer. (All range marks are 20 nautical miles. Gain setting is "normal" in all cases.)

Date		Time	Elevation Angle	
Calendar	Code	MST	Degrees	
June 14	337	1450	+01	
		1500	↓	
		10	↓	
		20	↓	
		30	↓	
		40	↓	
		50	↓	
		1600	↓	
		10	↓	
		20	↓	10 prints
June 27	308	1530	+01	
		40	↓	
		50	↓	
		1600	↓	
		10	↓	
		20	↓	
		30	↓	7 prints
July 5	363	1330	+01	
		50	+01	
		1400	-01	
		10	-01	
		20	+01	
		30	↓	
		40	↓	
		50	↓	
		1500	↓	
		10	↓	
		20	↓	
		30	↓	
		40	↓	
		50	↓	
		1600	↓	
		10	↓	
		20	↓	17 prints
July 11	306	1330	+01	
		45	↓	
		1400	↓	

Date		Time	Elevation Angle	
Calendar	Code	MST	Degrees	
July 11	306	1415	+01	
		30	↓	
		45		
		1500		
		15		
		30		
		45		11 prints
July 12	327	1515	+01	
		30	↓	
		45		
		1600		
		15		
		30		
		45		
		1700		8 prints
July 22	351	1430	+01	
		45	↓	
		1500		
		15		
		30		
		45		
		1600		
		15		
		30		
		45		
		1700		
		15		
		30		
		45		
		1800		15 prints
July 23	322	1730	+07	
		45	+01	2 prints
July 25	364	1545	±0	
		1600	↓	
		15		
		30		4 prints
July 26	334	1515	±0	
		30	+01	
		45	↓	
		1600		4 prints

APPENDIX 4
Reflectivity Profiles

Profiles are given of the RHI scope presentations, showing the echo visible on the scope at various gain steps. On each profile an outline is given of the echo viewed at the maximum receiver sensitivity at that azimuth. The outline of the echo viewed at the highest gain step for which an echo is still visible is also shown.

For each date, a plot is given of the plan position of the maximum Z and maximum radar echo height for each program. A graph of time-changes in these two parameters, plus elevation of maximum Z, is also given for each day.

Notes: 1. For 14 June and 5 July, the cycles of gain-step on the stepping switch were

N 12345
12345

For other days, the cycles were

N 123451
2345

2. Scale:

Vertical: 1/10" = 6,000 ft.

Horizontal: 1" = 20 nautical miles

APPENDIX 5

Field Data

These data were obtained from a combination of field surveys, reports from cooperative observers, and the network maintained by Colorado State University.

All reports are plotted to a scale of 1 to 500,000. The closed box shown on each figure is an approximation of the region of location of the particular radar cells of interest for the case being considered.

Data from all sources available to CSU are given in this appendix. For cases for which no data were available for rainfalls or hailfalls, a closed box only is shown to show the approximate region of location of the cells of interest.

APPENDIX 6

SUPPORTING PHOTOGRAPHIC DATA AVAILABLE

Time lapse cloud photography

PPI scope time-lapse photography

Cloud Photographs

1963

Time-lapse Cloud Photography

June 14	NRR	1430-1636	68 ft
June 27	NRR	1435-1650	82 ft
July 5	NRR	1427-1630	56 ft
July 11	NRR	1320-1500	48 ft
July 11 ? 12	NRR	---------	86 ft
July 12	NRR	---------	17 ft
July 22	FCL	1605-1815	73 ft
July 25	NRR	1630-1655	11 ft
July 26	FCL	1200-1320	33 ft
July 26	FCL	1450-1820	92 ft
July 26	NRR	1510-1710	46 ft

PPI Scope Time-lapse Photography

June 14	NRR	1435-1930	77 ft
June 24	NRR	1509-1645	29 ft
July 5	NRR	1305-1640	64 ft
July 11	NRR	1240-1747	92 ft
July 12	NRR	1335-1938	100 ft
July 22	NRR	1400-2100	80 ft
July 23	NRR	1529-1920	68 ft
July 25	NRR	1304-1721	77 ft
July 26	NRR	1440-1940	43 ft

Cloud Photographs

Date	Location	Number of Photos
June 14	---	0
27	NRR	11
July 5	NRR	2
11	---	0
12	NRR	18
22	NRR	20
25	---	0
26	---	0