RADAR CLIMATOLOGY OF HAIL STORMS IN AND NEAR NORTHEASTERN COLORADO 15 MAY - 31 JULY 1964

by

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and
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Prepared for the Crop-Hail Insurance Actuarial Association

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Civil Engineering Section
Colorado State University
Fort Collins, Colorado

March 1965

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COLORADO STATE UNIVERSITY
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March 1965

Mr. Philip S. Brown, Manager
Crop-Hail Insurance Actuarial Association
Room 700, 209 West Jackson Blvd.
Chicago 6, Illinois

Dear Mr. Brown:

I am pleased to transmit herewith the report "Radar Climatology of Hail Storms In and Near Northeastern Colorado, 15 May - 31 July 1964."

This report is essentially the same format as in previous years. We have chosen to examine only the radar climatological data available from 1961, 1962, 1963, and 1964. A more extensive study is planned on the relation of thunderstorm genesis areas to upper wind speed and direction.

For ease in reading, the Summary and Conclusions are presented at the beginning of the report.

As in previous years, most of the support for the hail research at Colorado State University has been supplied by the National Science Foundation.

I wish to take this opportunity to thank the Association for their assistance in support of this research.

Sincerely yours,

John D Marwitz

John D. Marwitz
Research Engineer

JDM:kc

SUMMARY AND CONCLUSIONS

The radar climatology of thunderstorms in northeastern Colorado was studied from 15 May - 31 July 1964 with a 3-cm radar located at New Raymer, Colorado. During 1964 the number of echoes identified as producing hail on the ground was only about 20% as many as during the previous years for which radar records are available (1961, 1962, 1963, and 1964).

Significant features of the radar climatology of the thunderstorms in 1964 included the following:

1. The summer of 1964 was a drought period with only 30% as many thunderstorm echoes observed as in 1961 and 1963 and only 20% as many thunderstorm echoes observed as in 1962.

2. The thunderstorms of 1964 were less intense than in previous years. This may be concluded from:

   a. The total number of storm days in 1964 was comparable with previous years, but the ratio of storm days with hail versus storm days without hail was approximately 1:1 during 1964 as compared to 2:1 to 4:1 in previous years.

   b. The total number of storm days in 1964 was comparable with previous years, but the total number of echoes cataloged and the total number of echoes identified as producing hail on the ground was only 20 to 30% as many as during previous years.

3. Hail-producing thunderstorms which occur during a heavy hail year move greater distances away from the mountains than do hail-producing thunderstorms which occur during light hail-producing years.

4. Less than 5% of the acres planted to sugar beets by Great Western Sugar Company were damaged by hail in May and July 1964. During June 1964 approximately 73% of the acres planted to sugar beets in the factory districts of Ovid, Sterling, and Fort Morgan sustained damage. A closer examination of the data revealed that most of this damage occurred on 20 and 21 June in the Fort Morgan district.

5. The direction of travel of hail-producing storms was always between WSW and NW during 1964 as opposed to being from the SW in previous years, especially during 1962, a year of heavy hail damage.

6. The time of first echo was more uniformly distributed during 1964 than during previous years.

7. Approximately 20% of the first echoes developed between 1400 and 1459.

8. The maximum number of first echoes develop in the South Platte Valley approximately 50 miles from the Continental Divide.

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INTRODUCTION

This report presents a summary of the 1964 radar climatology of hailstorms with comparative data for the years 1961, 1962, and 1963. The drought of 1964 gave little rainfall, only a small amount of crop damage by hail, few thunderstorms, and a low percentage of echoes which produced hail at some point in their life cycle.

RADAR CLIMATOLOGY OF HAIL STORMS

Radar systems, data, and methods:

Four radar systems were used in the hail project during the 1964 season. These were the weather radar system of Atmospherics Incorporated located near New Raymer, Colorado, the vertical scanning system as modified by Colorado State University and also located near New Raymer, the CPS-9 system as Lowry Air Force Base, and the M-33 system belonging to Colorado State University and located seven miles east of Fort Collins.

The radar system furnished and operated by Atmospherics Inc. provided the major portion of the data used to compile the information in this report. The equipment operated on a frequency of 9375 mc (3-cm) with a peak power of 50 kw. Four separate ranges were available in steps of 10-20-80 and 200 statute miles.

Two indicators were included as part of the system indicated in this report, and both employed seven inch PPI presentation. One of the indicators was used for general storm tracking plus black and white photographs of the more interesting precipitation echoes. The second indicator was used exclusively for time-lapse photographs with the 16 mm camera pulsed by the rotation of the radar antenna (five frames per minute).

This radar system located at New Raymer also employed a tilt indicator which gives the vertical angle of the antenna. During general scanning, the antenna was usually kept at the angle of +1° but was

occasionally raised to its maximum angle of +35° when measurements of echo tops were desirable. Precipitation echoes were tracked and hail paths identified from the Rocky Mountains to points as far east as the maximum 200 statute mile range.

Equipment used for documentation included an illuminated digital display and clock positioned around one of the indicators and photographed by the time-lapse camera. This display allowed film documentation of time, date, antenna angle, and radar range. A tape recorder unit for voice recording, map plotting facilities, a 16 mm time-lapse camera, several still cameras, communications equipment operating on 151.625 mc, and various data forms were provided by Atmospherics Incorporated for assistance in plotting storms. Details of the procedure were essentially the same as used in previous seasons (Schleusener, Henderson, Hodges, 1963).

Operation of the equipment was on a general 24-hour alert basis. While this radar system was new (recently designed and built by Atmospherics Incorporated) it proved to be very reliable. Only two hours of off-the-air time was logged due to equipment failure. Two cases of power failure were noted, one of which resulted from three direct lightning strikes on or very near the system. Total time on-the-air during the summer program was 310 hours.

Results:

Tables 1, 2, and 3 give a summary of the radar climatology of hailstorms for 1964 and comparative data for 1961, 1962, and 1963.

From Table 1, it is obvious that the summer of 1964 was a drought period, since only 30% as many thunderstorm echoes were noted as in 1963 and 1961, and only 20% as many thunderstorms as in 1962.

From Table 2, it may be concluded that the thunderstorms of 1964 were generally less intense than in previous years. This may be concluded from the following facts:

1. The total number of storm days in 1964 was comparable with previous years, but the ratio of storm days with hail versus storm days without hail was approximately 1:1 during 1964 as compared to 2 to 4:1 in previous years.

TABLE 1. Summary of PPI Radar Operations -- New Raymer
(15 May - 31 July 1964)

Date	Time-MST On	Time-MST Off	Number of Echoes Cataloged	Radar Scope Photography Time Lapse Begin	End	Total Frames
5/29	1100	1715	1	1105	1305	1440
				1500	1700	1440
6/3	1250	1715	16	1253	1502	1548
				1550	1650	720
6/5	1100	1745	12	1240	1458	1656
6/6	1300	1900	10	1321	1907	4152
6/12	1700	1900	8		NONE	
6/13	1300	1545	11	1330	1535	1500
6/16	1300	1430	2		NONE	
6/27	1415	1545	1		NONE	
6/29	1215	1630	6	1305	1630	2300
6/30	1145	1725	4		NONE	
7/1	1500	1800	4	1620	1800	1200
7/2	1115	1430	2		NONE	
7/6	1500	1930	4	1532	1914	2660
7/7	1500	1830	4	1535	1745	1560
7/8	1500	1915	7	1635	1827	1344
7/9	1700	2015	2	1730	2005	1865
7/10	1415	1500	4		NONE	
7/15	1330	1530	1	1330	1340	120
7/16	1315	1330	1		NONE	
7/17	1300	1600	4		NONE	
7/22	1545	1700	7		NONE	
7/27	1430	2030	4	1515	2028	3756
7/28	1830	2045	3		NONE	
7/29	1430	1830	4	1536	1830	2080
7/30	1215	1830	10	1345	1547	1464
				1600	1745	1260
7/31	1515	1800	3	1524	1800	1872
Totals (1964)			138			33937
(1963)			498			70288
(1962)			752			105680
(1961)			504			36400

TABLE 2. Thunderstorm Days and Days with Hail within Range of the PPI Radar System at New Raymer, Colorado

Period	Storm Days with Hail	Storm Days without Hail	Total	Total Echoes Cataloged	Number of Echoes Which Were Known To Have Produced Hail On Ground
			1964		
18-31 May	3	5	8	4	4
1-15 June	6	2	8	57	10
16-30 June	3	4	7	13	5
1-15 July	5	4	9	28	7
16-31 July	5	8	13	36	7
TOTAL	22	23	45	138	33
			1963		
15-31 May	9	1	10	117	32
1-15 June	8	0	8	81	42
16-30 June	3	3	6	25	8
1-15 July	6	3	9	110	30
16-31 July	11	2	13	165	43
TOTAL	37	9	46	498	155
			1962		
15-31 May	11	6	17	140	34
1-15 June	9	6	15	186	37
16-30 June	10	4	14	194	55
1-15 July	11	4	15	106	28
16-31 July	11	3	14	126	29
TOTAL	52	23	75	752	183
			1961		
15-31 May	10	2	12	98	26
1-15 June	13	0	13	124	42
16-30 June	7	2	9	79	21
1-15 July	8	4	12	104	43
16-31 July	9	2	11	99	17
TOTAL	47	10	57	504	149

2. The total number of storm days in 1964 was comparable with previous years, but the total number of echoes cataloged and the total number of echoes identified as producing hail on the ground was only 20 to 30% as many as during previous years.

Table 3 summarizes the origin and movement of echoes identified as producing hail on the ground. It may be noted that during a heavy hail year, such as 1962, there are a large number of echoes which originate in Colorado and Wyoming and subsequently move to Kansas and Nebraska respectively as compared to the low number which did this during a light hail year such as 1964. This indicates that hail producing thunderstorms which occur during heavy hail years move greater distances away from the mountains than do hail producing thunderstorms which occur during light hail producing years. This observation is further substantiated by comparing Figures 6-15 in Schleusener and Henderson (1962) and Figs. 1-5 in Schleusener, Grant, and Hodges (1963) with Figures 1-5 of this report.

TABLE 3. Origin and Movement of Echoes Identified as Producing Hail on the Ground

Echoes Originated In	Year	--- Echoes Moved To --- Colorado	Kansas	Nebraska	Wyoming
Colorado	1961	56	12	21	3
	1962	67	5	52	8
	1963	84	5	22	1
	1964	27	0	1	1
Kansas	1961	0	7	0	0
	1962	0	1	0	0
	1963	0	3	2	0
	1964	0	0	0	0
Nebraska	1961	12	6	11	0
	1962	1	1	19	0
	1963	2	0	12	1
	1964	1	0	0	0
Wyoming	1961	13	0	7	1
	1962	7	0	14	5
	1963	2	0	16	6
	1964	3	0	0	0

Total Echoes Identified As Producing Hail on the Ground	1961	1962	1963	1964
	149	183	155	33

Table 4 summarizes the amount of hail damage to sugar beets during 1964 in the various factory districts of Great Western Sugar Co. in northeastern Colorado. From this table it may be noted that only a few per cent of the acres were damaged in 1964 with the exception of June in the Fort Morgan district. A closer examination of the data revealed that most of the damage in June occurred during one storm on the 20th and 21st.

Figures 1-5 show the first echoes and subsequent tracks of precipitation cells identified as hail-bearing at some stage in the life cycle for each half-month period from 18 May-31 July 1964. In comparing 1964 with previous years (see Figures 6-15 in Schleusener and Henderson, 1962; and Figures 1-5 in Schleusener, Henderson, and Hodges, 1963) the following observations are apparent:

1. There were considerably fewer hail-bearing thunderstorms during 1964 than in previous years.

2. The length of echo travel was shorter during 1964 than in previous years.

3. The direction of travel was always between WSW and NW during 1964 as opposed to being from the SW in previous years, especially during 1962, a year of heavy hail damage.

4. Approximately 20% of the first echoes develop between 1400 and 1459.

5. The time of first echo was more uniformly distributed with time of day during 1964 than during previous years.

Figure 6 is the initial location of radar echoes which later produced hail during 1964. This figure indicates a definite dearth in number of hail producing echoes during 1964 as compared to 1961 and 1962 (Schleusener and Henderson, 1962, Figures 18 and 19) and 1963 (Schleusener, Henderson, and Hodges, 1963, Figure 6).

Figure 7 shows the frequency of occurrence by years (within grid squares 200,000 feet on a side) of first echoes that later produced hail. The maximum number of first echoes develop in the South Platte Valley approximately 50 miles from the Continental Divide.

TABLE 4. Total Number of Sugar Beets Planted and Damaged in Northeastern Colorado Factory Districts of Great Western Sugar Company for 1964.

Factory District	Acres Planted	Month	Acres Damaged	Per Cent of Acres Planted
Ovid	8,370	May	0	0
		June	1,235	15
		July	1,408	17
Sterling	11,041	May	0	0
		June	3,299	30
		July	315	3
Fort Morgan	27,695	May	0	0
		June	29,900	108
		July	840	3
Eaton	19,795	May	0	0
		June	0	0
		July	64	< 1
Greeley	16,942	May	3,359	20
		June	1,651	10
		July	70	< 1
Brighton	27,640	May	1,240	4
		June	2,685	10
		July	380	1
Fort Collins	10,050	May	1,046	10
		June	0	0
		July	390	< 1
Windsor	10,998	May	531	5
		June	280	3
		July	0	0
Loveland	13,068	May	2,127	16
		June	1,370	10
		July	0	0
Ovid, Sterling, and Fort Morgan	47,106	May	0	0
		June	34,544	73
		July	2,563	5
		May, June, July	37,107	79
All NE Colo. Factory Districts	145,599	May	8,303	6
		June	40,420	28
		July	3,467	2
		May, June, July	52,190	36

REFERENCES

Schleusener, Richard A., and Thomas J. Henderson, 1962: Radar Climatology of Hail Storms In and Near Northeastern Colorado, 15 May - 31 July 1962, With Comparative Data for 1961. Civil Engineering Report CER62RAS79, Colorado State University, Fort Collins, Colorado.

Schleusener, Richard A., Thomas J. Henderson, H. Hodges, 1963: Radar Climatology of Hail Storms In and Near Northeastern Colorado, 15 May-31 July 1963. Civil Engineering Report CER63RAS69, Colorado State University, Fort Collins, Colo.

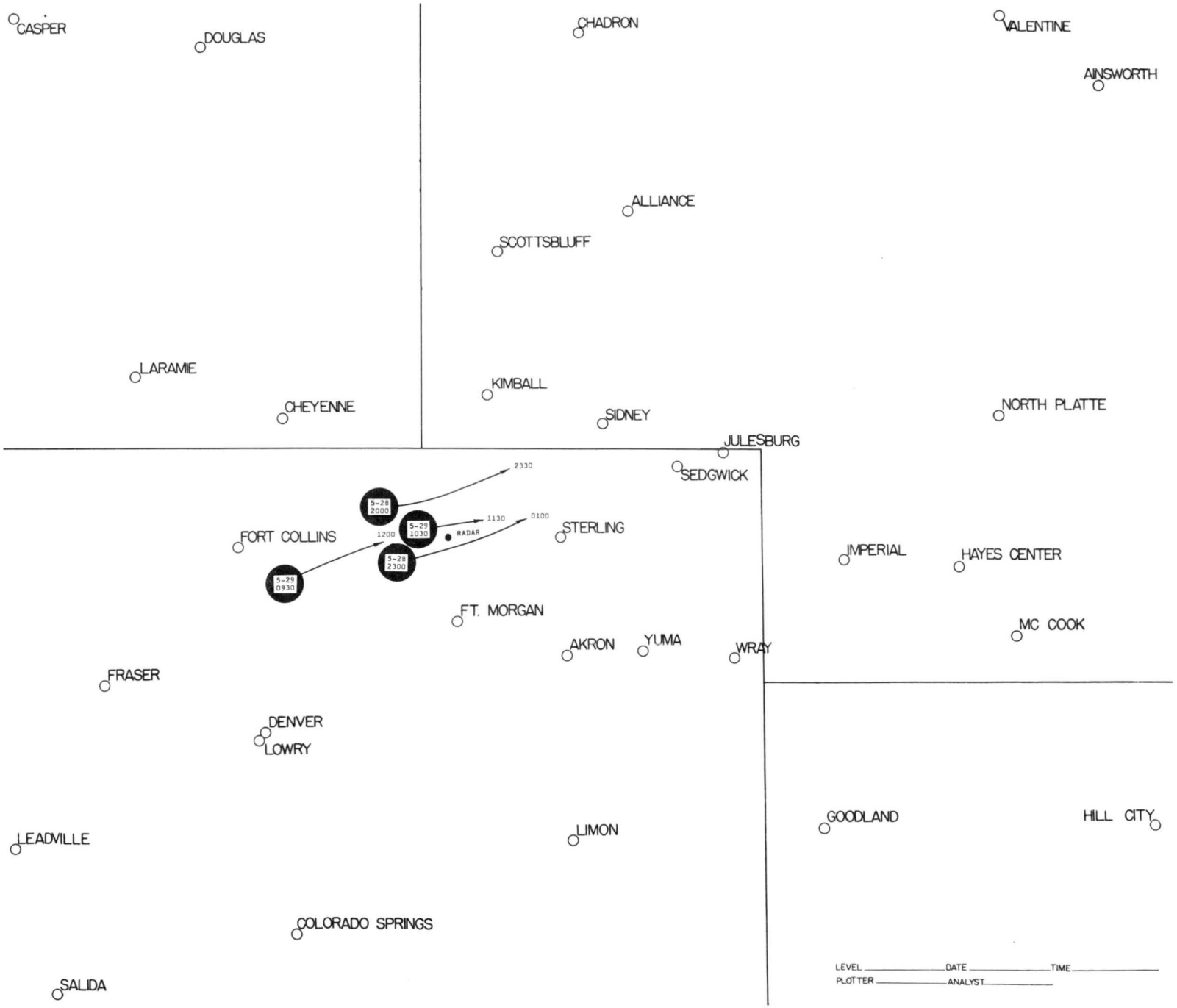

Fig. 1 First echoes and subsequent tracks of precipitation cells identified as hail-bearing at some stage of their life cycle, 18-30 May 1964.

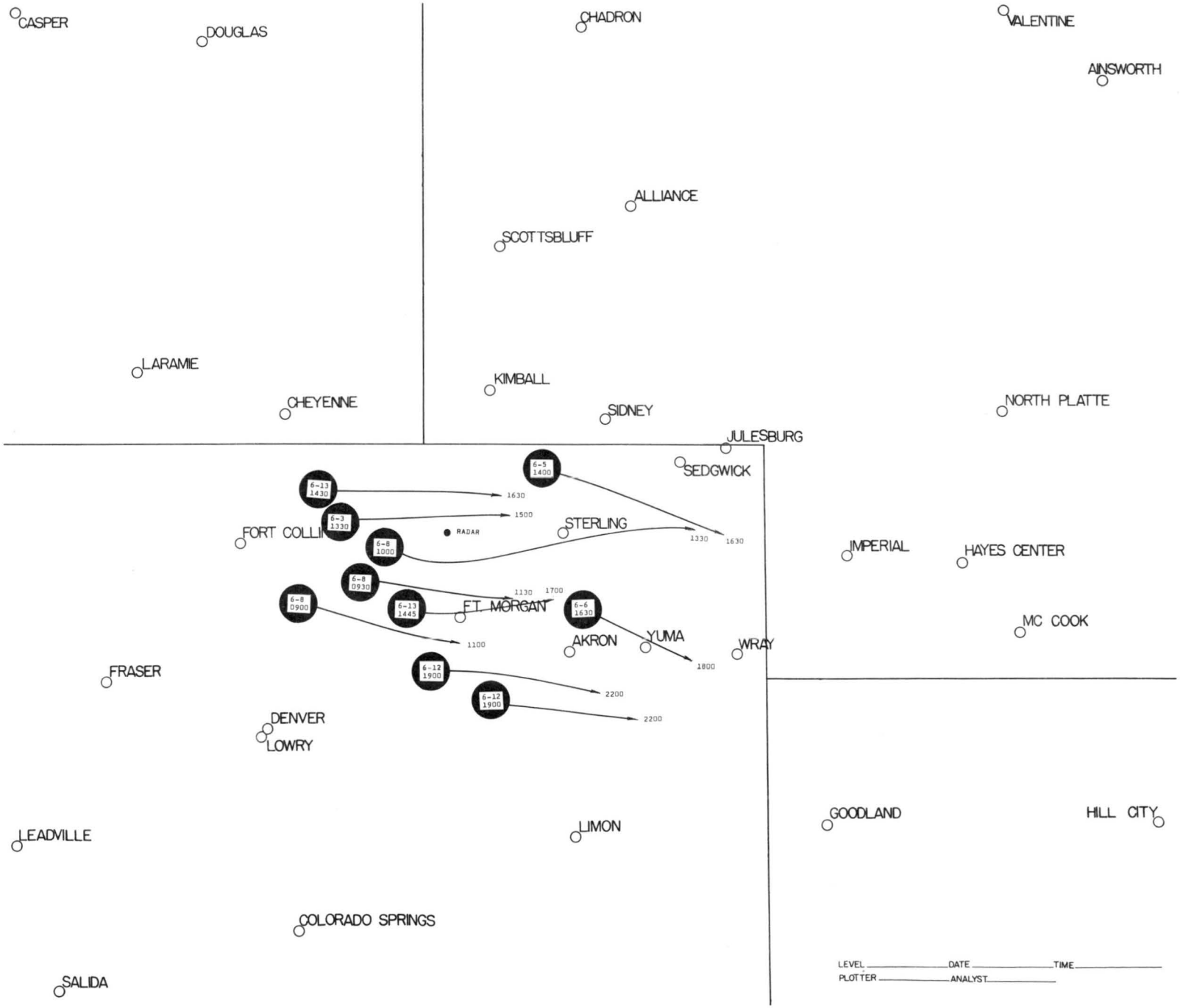

Fig. 2 First echoes and subsequent tracks of precipitation cells identified as hail-bearing at some stage of their life cycle, 1-15 June 1964.

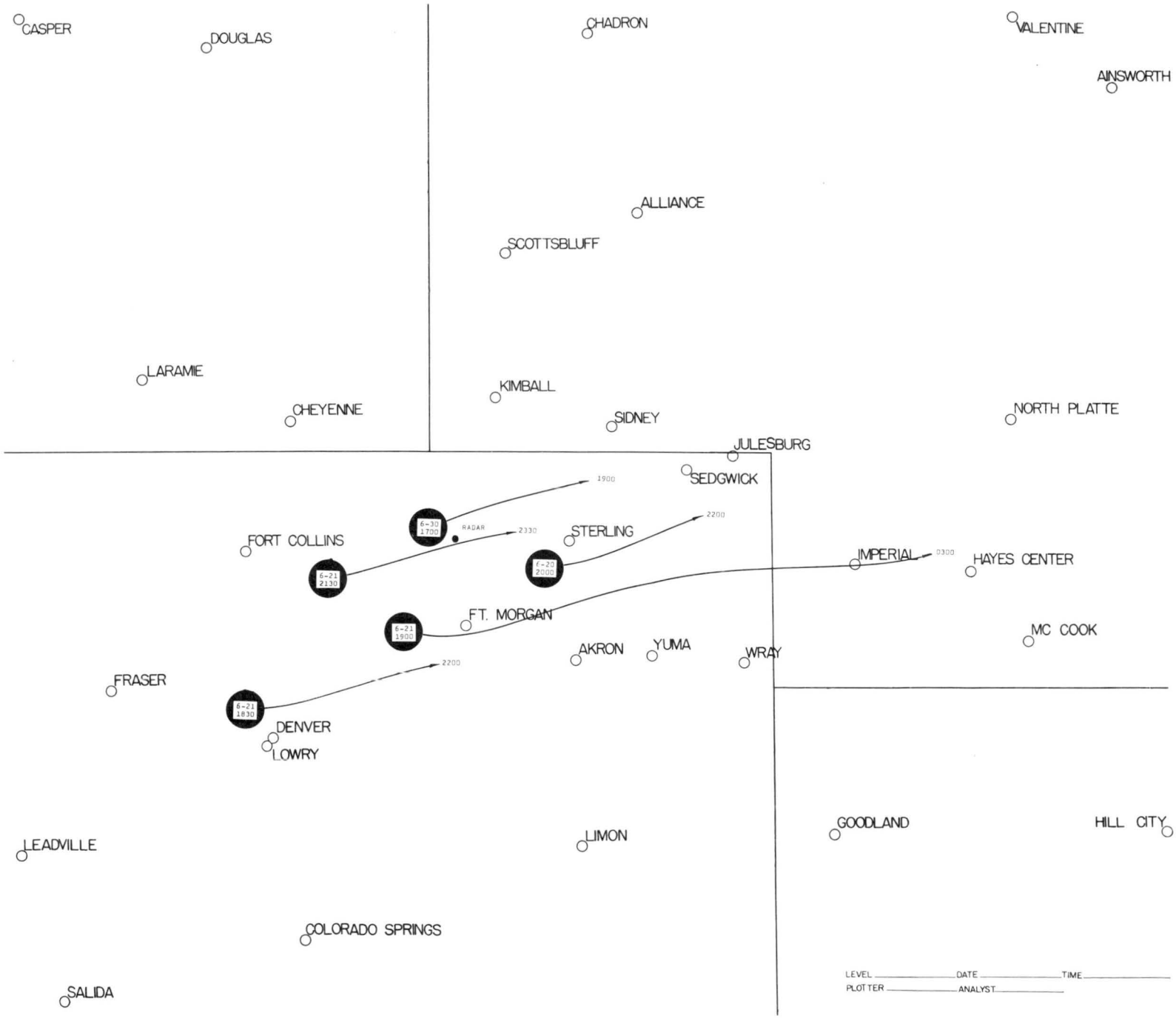

Fig. 3 First echoes and subsequent tracks of precipitation cells identified as hail-bearing at some stage of their life cycle, 16-30 June 1964.

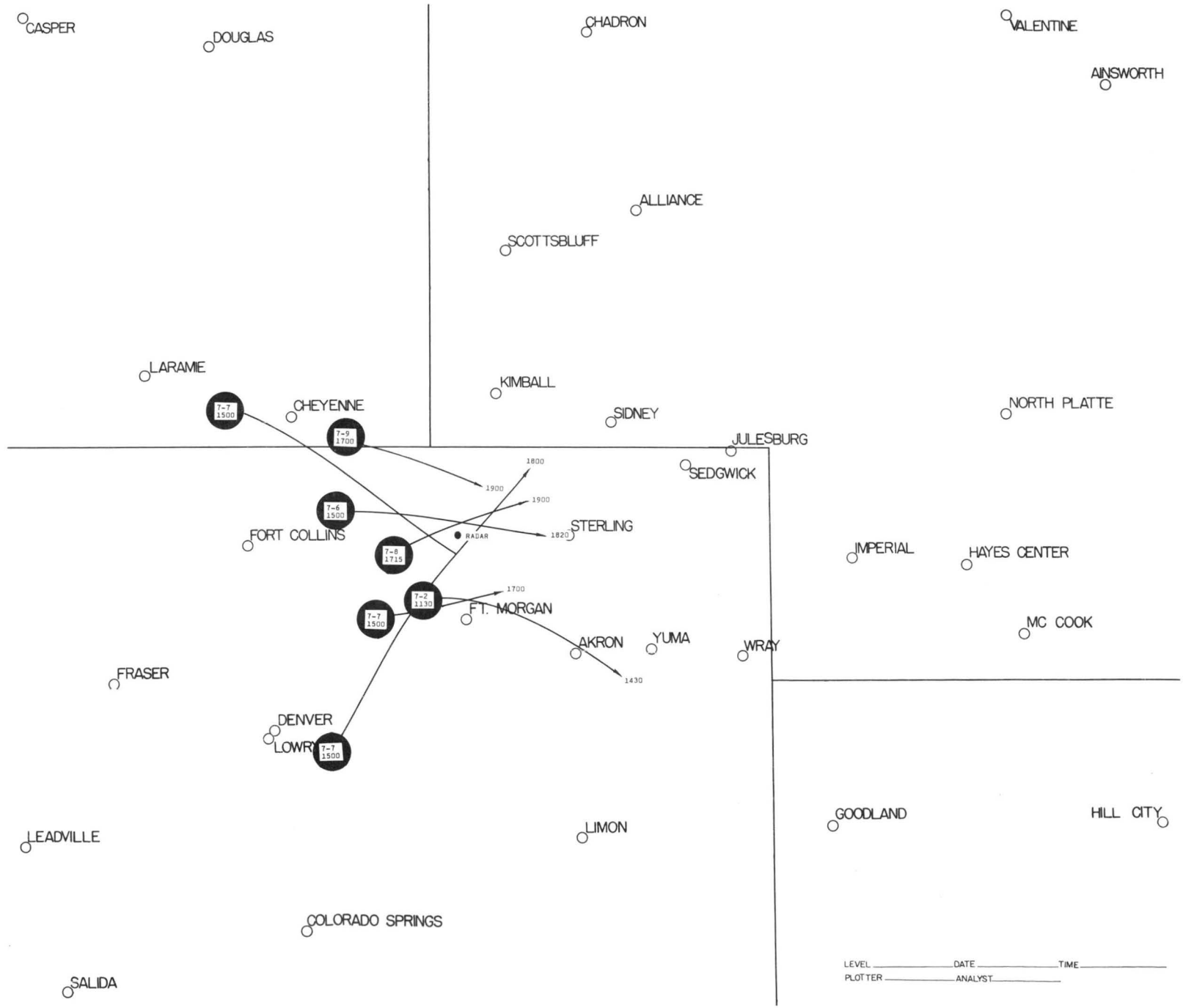

Fig. 4 First echoes and subsequent tracks of precipitation cells identified as hail-bearing at some stage of their life cycle, 1-15 July 1964.

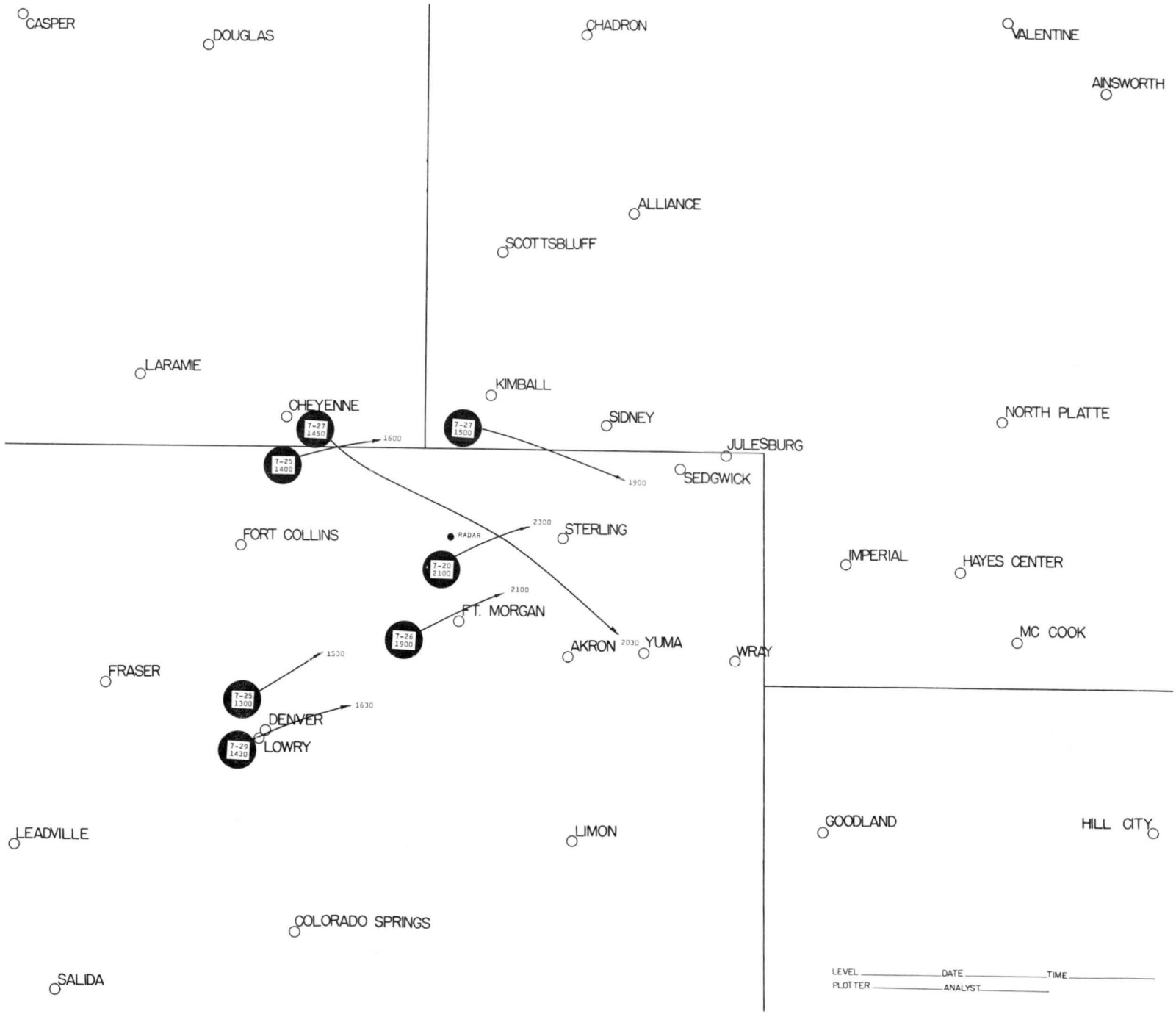

Fig. 5 First echoes and subsequent tracks of precipitation cells identified as hail-bearing at some stage of their life cycle, 16-31 July 1964.

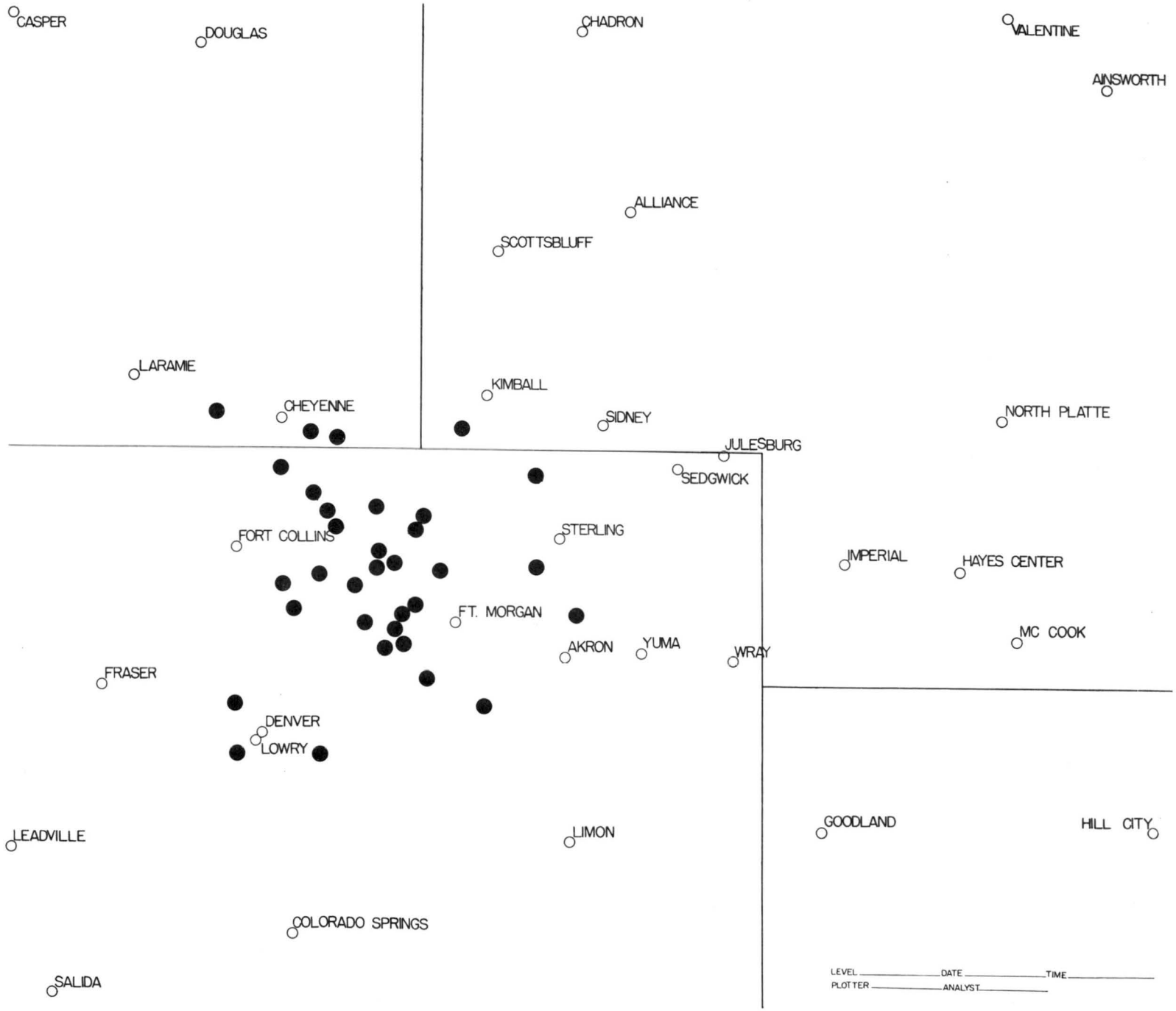

Fig. 6 Initial locations of echoes which later produced hail, 18 May--31 July 1964.

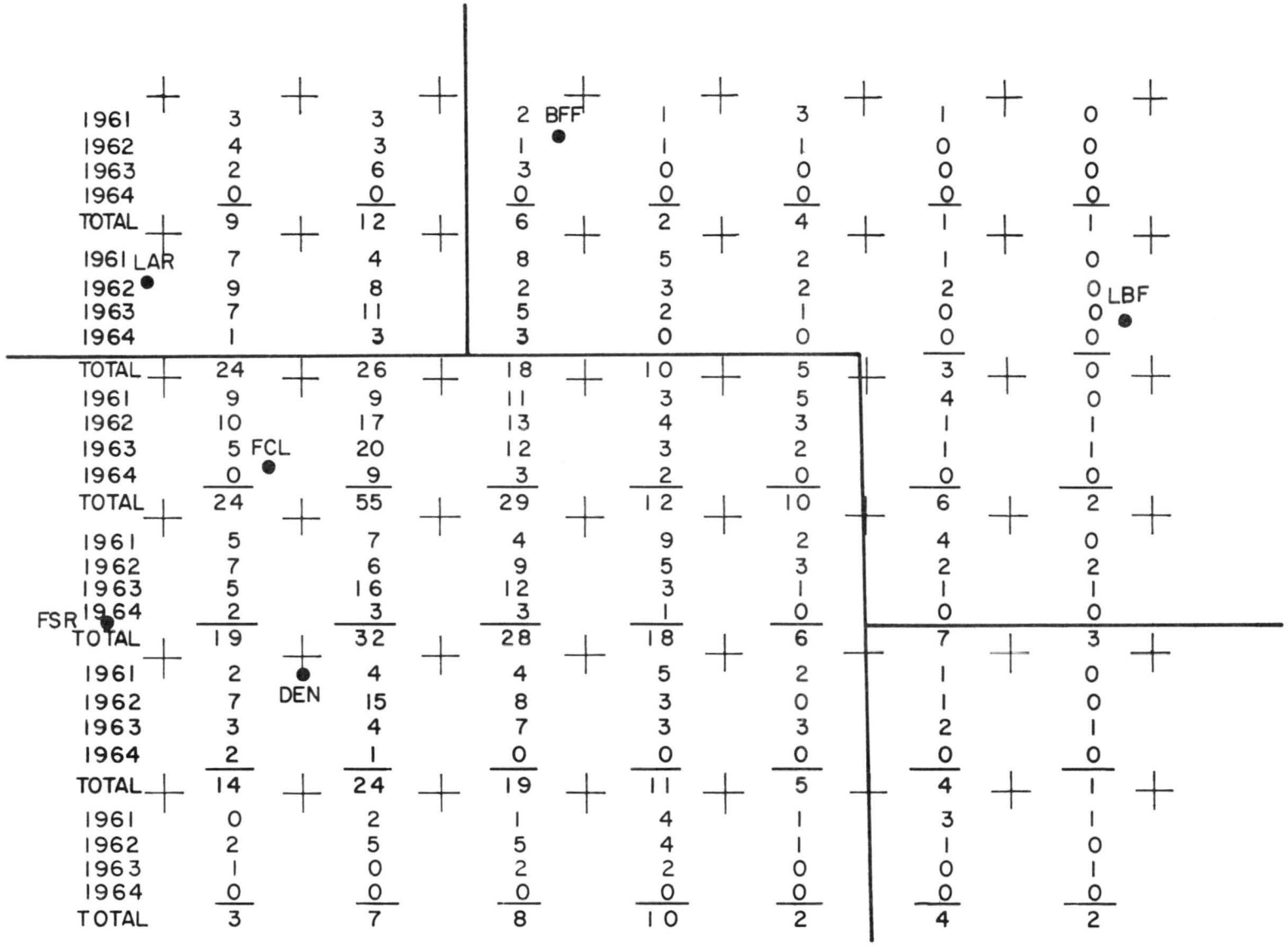

Fig. 7 Frequency of occurrence (within grid squares 200,000 feet on a side) of first echoes that later produced hail.