WIDESPREAD GENERAL RAINS IN MONTANA DURING THE SUMMER

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ABSTRACT

Widespread general mid-summer rains in Montana during the last 40 years were examined. Such weather events can result in significant rainfall over a large area and are caused by a strong upper Low or trough diverted across the State by a blocking upper High over the central United States. The storm of July 9-10, 1983 is used as case study to show the precipitation pattern and weather associated with these systems. These synoptic-scale weather systems are rare in Montana during the summer, and their occurrence is an indication of an abnormal summertime general circulation pattern.

1. INTRODUCTION

Montana has large seasonal variation of weather. Its mid-latitude continental location puts the State in the belt of the westerlies. The convergence and resulting vertical motions associated with general storms embedded in these westerlies are the primary source of cold-season precipitation in the State (2).

The Rocky Mountains in the western and southern parts of the State cause orographic intensification of precipitation (depending on the large-scale flow pattern) and serve as a destabilizing agent for summer convection, which is the primary source of warm-season precipitation.

Convective precipitation does not occur in the cold and stable air masses that dominate the State in the winter. However, winter-type weather systems have been known to traverse Montana in the summer and generate significant amounts of rainfall. This paper will summarize these processes and demonstrate the importance of synoptic-scale weather systems to summertime precipitation.

1.1 Typical Winter Weather

Although the western cordillera of the United States generally tends to weaken and dry out synoptic-scale weather systems moving in the westerly flow, some of these systems are still intense enough to produce widespread general precipitation over Montana.

Under certain circulation patterns, cyclogenesis occurs over the Montana plains, with severe winter storms sometimes developing. The result is heavy snowfall over the mountains and upslope areas, and snow, strong winds and cold temperatures with local blizzard conditions over the plains. These winter-type storms are fairly common through mid to late spring.

1.2 The Importance of Synoptic-Scale Systems during the Summer Season

About 70 to 80 percent of the annual total precipitation in Montana normally falls during the April-to-September growing season. Most of the summer rainfall occurs in association with localized convective cells, i.e., showers and thunderstorms, which develop over the western and southern mountains and move onto the plains. Strong surface heating can result in enhancement of these cells, and severe weather sometimes develops. Very heavy rains are possible with these storms, but the resulting precipitation pattern is highly localized.

General widespread rains occasionally occur during the early summer in association with synoptic-scale weather systems, but they rarely happen at the height of summer (July and August). By definition, these systems are associated with the Polar Front/Jet Stream. Due to increased insolation and a weaker geopotential gradient, the summer location of the Polar Front is normally in northern Canada, so the occurrence of a summertime synoptic-scale system as far south as Montana is a very unusual event (3).

2. PREVIOUS STUDIES

There has been nothing published on summertime synoptic-scale storms in Montana. However, studies have been made of severe spring storms in the State (4, 5, 6). Examination of these studies is useful because the circulation pattern associated with springtime storms is similar to that responsible for widespread rainfall in the summer. The major differences are a stronger summertime North Atlantic High, a further poleward location of the Polar Front, and warmer air (resulting in rainfall instead of heavy snow).

In an analysis of 36 storms, Michael Oard (6) determined that severe spring storms are characterized by a relatively strong upper trough in the Great Basin and a ridge to the east. The strength of the storm is primarily dependent on the strength of the upper ridge over the Midwest. The more the ridge is blocking, negatively tilted, and/or has higher amplitude, the more intense the storm becomes and the further northward it tracks. The strength of the trough or upper Low over the Great Basin is also a significant factor affecting the strength of the storm.

3. SUMMERTIME SYNOPTIC-SCALE STORMS

3.1 Characteristic Circulation Parameters

Severe spring storms occur in the Northern and Central Rockies each year (6). But, as mentioned earlier, similar summertime synoptic-scale storms are not as common. Table 1 lists the more notable widespread heavy rain-producing systems that have occurred in Montana in July and August during the last 40 years.

As seen in the table, significant rainfall occurs with these systems. Comparison of these figures with the 1951-80 July and August normals shows that, in every case, at least two stations received more than the entire month's usual amount of precipitation. Each of these cases was characterized by a meridional circulation pattern over the western part of North America. An upper Low or trough moved across Montana and, in most cases, was associated with a surface Low and Pacific cold front (see Table 2).

The precipitation pattern and amounts produced by a system are strongly dependent on the path taken by the system. A blocking upper High over the midwest United States forces the system to curve northward over Montana. Because local topography plays an important role in the State, the favored path for the Low center (both at the surface and at mid-atmospheric levels) is one that causes an upslope flow along the Rocky Mountains; that is, a path across southwest Montana then northeastward across the central portion of the State. The strength and orientation of the High will also influence the speed at which the synoptic system moves, with a slower-moving system generally producing more precipitation.

	Station								Average Percent of Normal*
	Billings	Glasgow	Great Falls	Havre	Helena	Kalispell	Miles City	Missoula	
1951-80 Normal July Precipitation	.85	1.65	1.10	1.25	1.04	.94	1.52	.85	--
1951-80 Normal August Precipitation	1.05	1.43	1.31	1.15	1.18	1.44	1.26	.95	--
July 9-10, 1983	.20	1.49	2.45	2.61	2.33	.01	0	1.15	113%
July 2-6, 1978	.26	.85	1.39	.79	2.16	.77	.30	.11	74%
July 29-31, 1975	.78	.57	.80	1.93	1.90	.73	.28	.64	89%
August 19-21, 1974	1.17	.70	1.82	.30	1.86	.27	.73	.42	76%
July 18-21, 1972	1.47	1.12	1.17	.42	.47	.27	.93	.56	73%
July 6-7, 1969	.28	1.88	1.02	.72	1.50	Trace	1.84	.20	73%
August 22-24, 1965	.27	.10	.71	1.90	.77	1.16	.08	1.22	67%
July 12-14, 1962	.37	4.04	.58	.61	.49	.02	2.02	Trace	72%
July 2-4, 1958	2.02	.33	1.19	1.26	.27	.38	1.59	.10	81%
August 28-31, 1951	.05	.69	1.50	.71	.57	1.83	1.10	.35	66%
July 29-30, 1950	.74	.10	1.27	1.36	.15	.40	.16	.21	51%
July 19-21, 1948	.11	.58	1.24	1.20	.42	1.10	2.17	.77	81%
August 20-23, 1947	.27	.99	.07	.15	.34	2.16	.77	1.80	68%

*Determined by calculating the percent of normal for each station, then taking the average of the 8 stations.

Table 1. Total precipitation (inches) from synoptic storms in July and August at selected Montana First Order Weather Stations.

Storm	Strength of Surface Low (mb)	Presence of Front**	Strength of 500-mb Trough or Closed Low over Montana (meters)	Strength of 500-mb Ridge or High over the Midwest (meters)
July 9-10, 1983	1003	P	5760	5940
July 2-6, 1978	1004	P	5700	5880
July 29-31, 1975	1003	P	5670	5920
August 19-21, 1974	998	PC	5670	5880
July 18-21, 1972	1000	C	5580	5940
July 6-7, 1969	1000	C	5640	5940
August 22-24, 1965	1005	C	5670	5930
July 12-14, 1962	1005	P	5700	5920
July 2-4, 1958	1005	C	5680	5920
August 28-31, 1951	995	C	5550	5970
July 29-30, 1950	1000	P	5590	5850
July 19-21, 1948	1003	NA	5660	5920
August 20-23, 1947	1005	PC	5640	5940

*Determined from 12Z surface and 500-mb Daily Weather Maps.
** P - Pacific cold/occluded front
C - Canadian cold front
NA - none analyzed

Table 2. **Synoptic parameters associated with widespread precipitation events during the summer in Montana.**

The July 9-10, 1983 storm, which is the wettest storm listed in Table 1, will be examined in detail in the next section as a classic example of the pattern and weather events that can occur with these systems.

3.2 The July 9-10, 1983 Storm

A closed upper Low off the Pacific coast was well-developed by the last half of the week of July 3-9, 1983 (Figure 1). The central United States was suffering from a heat wave beneath a strong upper High, which was firmly entrenched over the area (7, 8). The summer heat extended into eastern Montana, where maximum temperatures were near the 100-degree mark.

The upper Low came ashore Friday evening, July 8. When the system reached Montana, it tracked northeastward across the State (Figures 2-7). The strong Pacific cold front that preceded the Low brought significant cooling to all of the State, with some temperature maxima by Sunday afternoon as much as 40 degrees cooler than a few days before (Table 3).

A few rain showers developed over the western and southwestern mountains Saturday morning, July 9. Scattered showers and thundershowers were reported by early afternoon, primarily in the southwest, spreading northward and eastward by evening.

The ingredients for severe weather were present over Montana by Saturday afternoon: surface convergence and frontal lifting, coupled with unstable air, in the east and a divergent southwesterly flow aloft on the front side of the upper Low (Figures 2-5). Severe thunderstorms occurred in the south central and northeastern portions of the State. A tornado, which touched down south of the town of Wolf Point around 0200 GMT Sunday (8:00 p.m. Saturday), caused one death and one injury, scattered power outages, and extensive damage to several farmsteads in the area (see Figure 8).

The showers in the southwestern portion of the State had given way to steady rain by early Saturday evening as the body of the upper Low approached the area (Figures 2 and 4). The general rain continued through the night and spread northeastward. By late Sunday morning, July 10, the rain had ended in much of the southwest, but rain continued to fall in the central and northeastern portions until late Sunday afternoon.

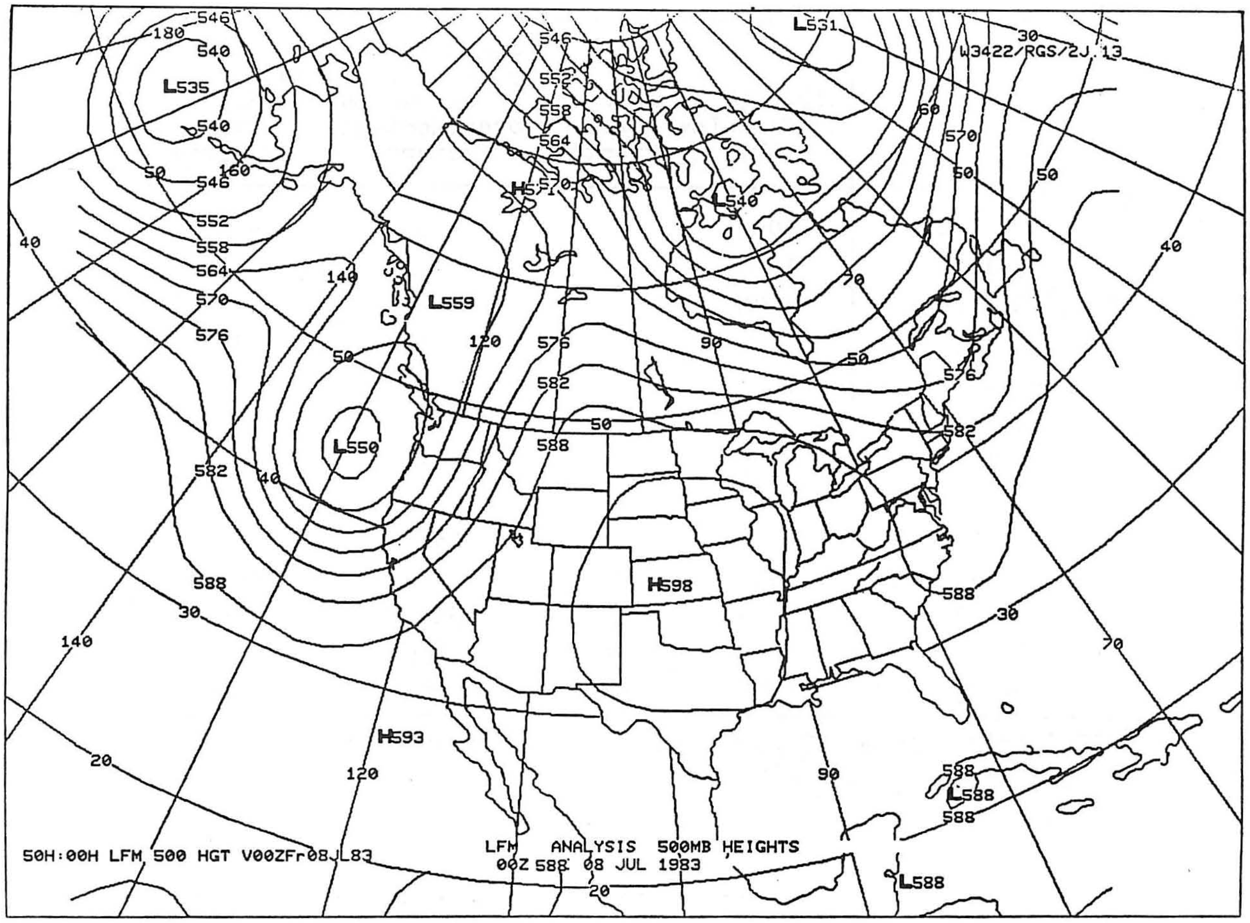

Figure 1. The 500-mb geopotential heights over North America at 0000 GMT Friday, July 8, 1983 (6:00 p.m. MDT Thursday, July 7). Heights are in dam.

Approximately half of the State received at least one inch of precipitation from the storm. Over three inches fell in a band stretching from near Great Falls to north central Montana (Fig. 9). The northwest and southeast corners of the State received the least precipitation.

4. SUMMARY

Synoptic-scale weather systems in Montana are rare in the summer. When they do occur, the widespread general rain pattern associated with these systems can result in considerable accumulations. In many instances more than the normal monthly precipitation amount has been recorded in just a couple days.

The circulation pattern responsible for these storms consists of a deep upper Low or trough along the west coast of North America and a strong High over the central and eastern United States. The blocking High forces the upper Low to move northeastward across Montana.

Such a pronounced meridional pattern is unusual for this time of year, being more characteristic of the winter, spring, and fall seasons. The summertime circulation pattern normally places synoptic-scale weather systems at arctic latitudes. Consequently, the presence of such a system in Montana during the summer indicates a significant departure of the general circulation pattern from normal.

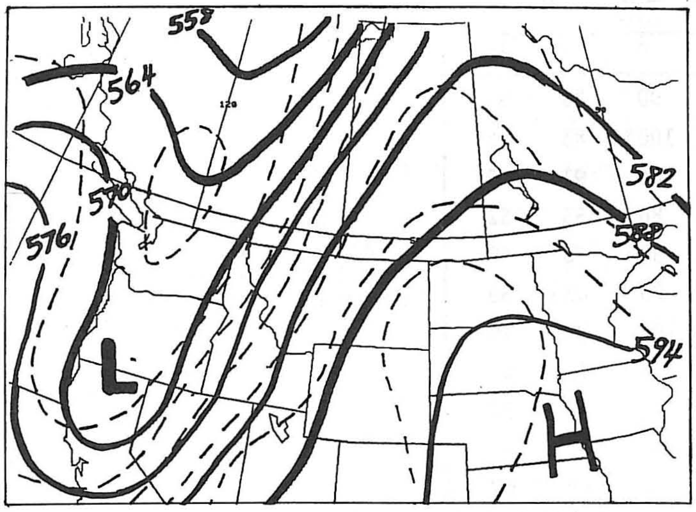

Figure 2. Redrawn NMC 500-mb analysis (solid) for 1200 GMT (6:00 a.m. MDT) Saturday, July 9. Dashed lines are corresponding 1000-500 mb thickness. Contours are in dam.

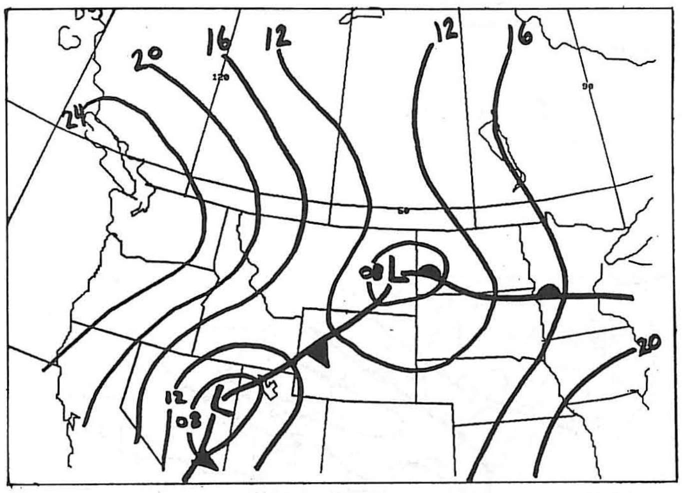

Figure 3. Redrawn NMC surface analysis for 1200 GMT Saturday, July 9.

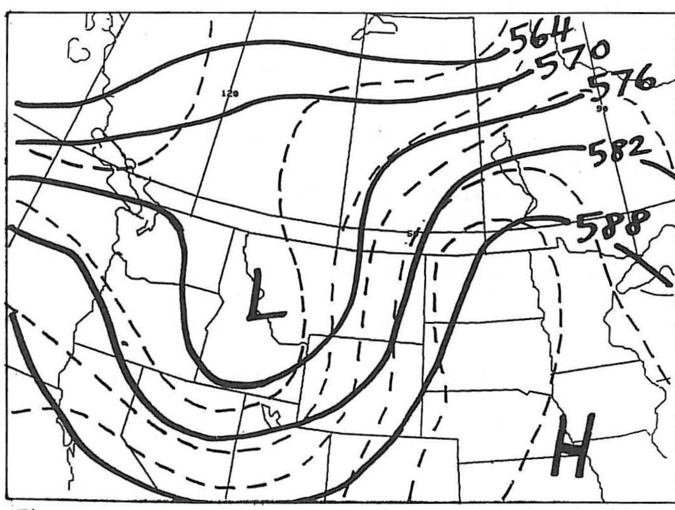

Figure 4. Redrawn NMC 500-mb analysis (solid) and thickness pattern (dashed) for 1200 GMT Sunday, July 10. Contours are in dam.

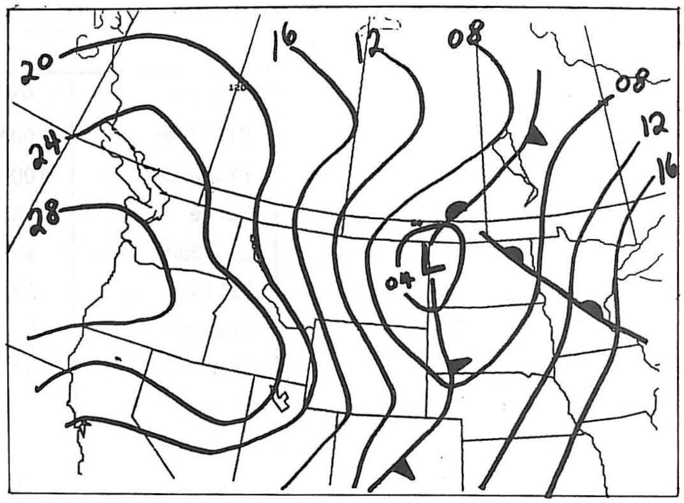

Figure 5. Redrawn NMC surface analysis for 1200 GMT Sunday, July 10.

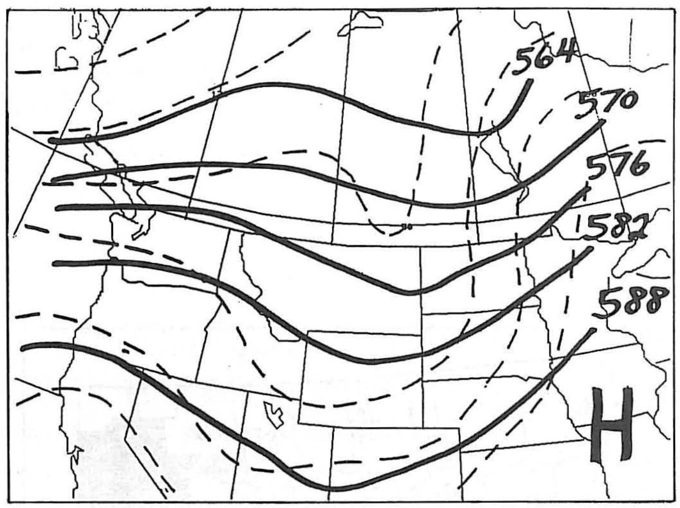

Figure 6. Redrawn NMC 500-mb analysis (solid) and thickness pattern (dashed) for 1200 GMT Monday, July 11. Contours are in dam.

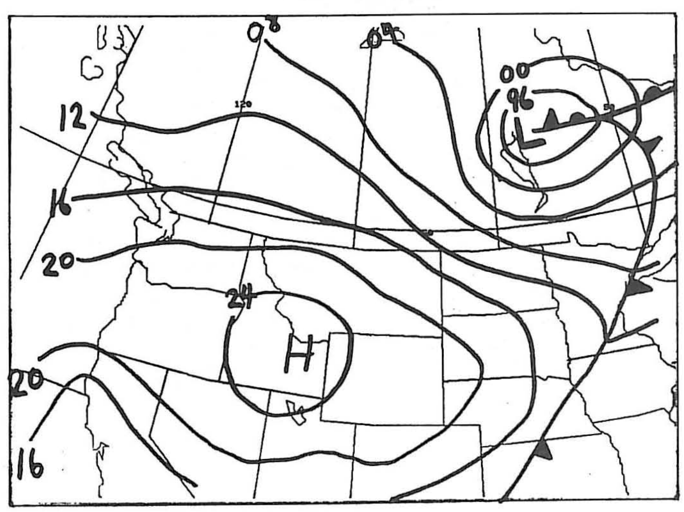

Figure 7. Redrawn NMC surface analysis for 1200 GMT Monday, July 11.

Station	Date 7	8	9	10
Belgrade	93	90	70	57
Billings	100*	100*	83	68
Broadus	100	104	93	80
Butte	88	86	53	52
Cut Bank	89	84	70	69
Dillon	87	86	63	59
Glasgow	99	104	91	70
Great Falls	87	96	71	62
Havre	97	95	76	57
Helena	96	94	66	62
Kalispell	83	71	68	67
Lewistown	94	93	72	54
Livingston	95	95	78	62
Miles City	102	107	94	77
Missoula	84	74	65	64

*Record-breaking temperature

Table 3. **Maximum temperatures (°F) for selected stations, July 7-10, 1983.**

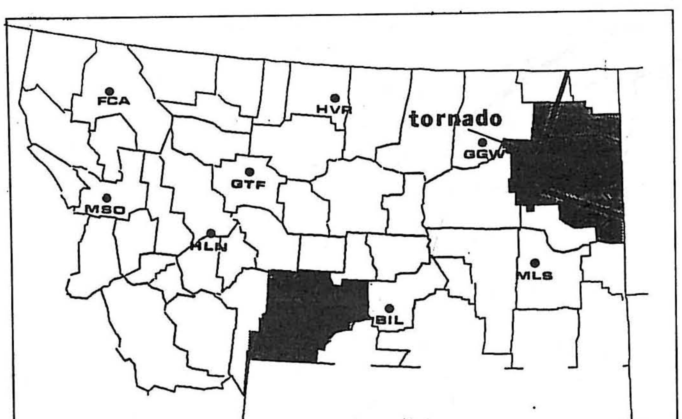

Figure 8. Severe weather occurrences in Montana on Saturday, July 9, 1983. Stipling indicates severe thunderstorm warning. The box in the northeast corner of the state is a severe thunderstorm watch area. Station abbreviations are as follows: BIL = Billings, GGW = Glasgow, GTF = Great Falls, HVR = Havre, HLN = Helena, FCA = Kalispell, MLS = Miles City, MSO = Missoula.

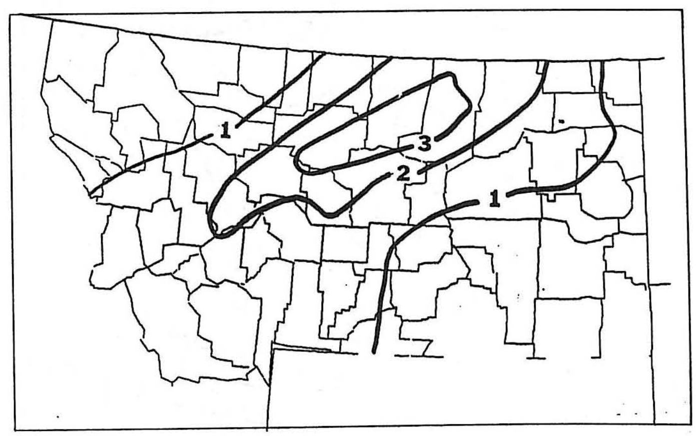

Figure 9. Total storm precipitation (48 hours ending 0000 GMT Monday, July 11, 1983), in inches, determined from First Order, Second Order, and Cooperative weather stations. There were unofficial reports of 5 to 7 inches of rain in the north central and northeast sections. These amounts (not plotted) occurred in association with a line of locally heavy thunderstorms moving through that area Saturday night and early Sunday morning.

NOTES AND REFERENCES

1. Richard Heim Jr. earned his B.S. in Mathematics in 1977 and M.A. in Geography (Meteorology/Climatology) in 1982, both from the University of Nebraska. This article was written while he was a meteorologist intern at the Great Falls WSFO. He is currently a meteorologist at the National Climatic Data Center.

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