METEOROLOGICAL CONDITIONS AFFECTING FLOODS AND HEAVY SNOW IN NORTH DAKOTA AND MINNESOTA, APRIL 24–26, 1950

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INTRODUCTION

Serious floods during the 1950 spring season in the Red River of the North and some of its tributaries were accentuated by variations of weather from one extreme to another. Flooding in the upper reaches of the basin in late March and early April was alleviated somewhat by cooler weather during the first half of April, but during this period new storms added several inches to the snow cover (fig. 1). On April 15 and for the next two days maximum temperatures over the upper (southern) portion of the basin went up to over 60° F., resulting in rapid melting and almost complete disappearance of the snow cover. Extensive flooding resulted in the area of Grand Forks, N. Dak. and northward into Canada, with a second flood crest even higher than the first occurring in May. Adding to the hazard, on April 24, 25, 26, was a heavy snow storm accompanied by high winds and record low temperatures, which added more than a foot of new snow in some areas.

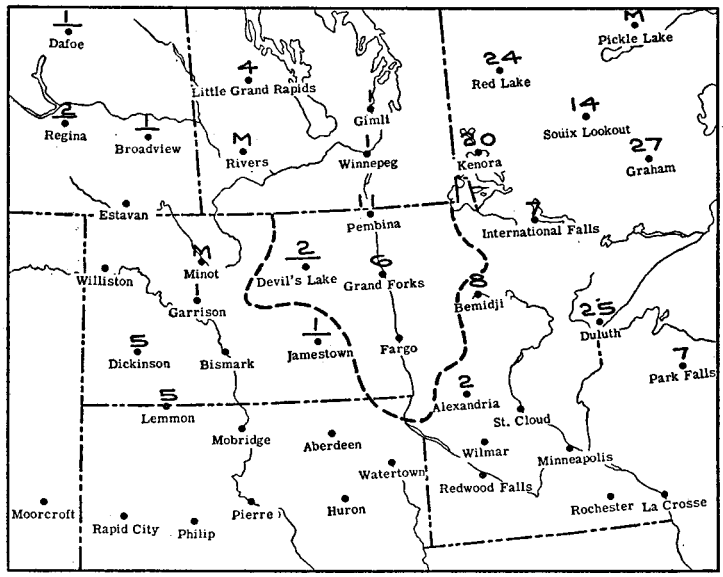

FIGURE 1.—Snow cover chart for 0730 EST, April 15, 1950, for North Dakota, Minnesota, southern Manitoba, southern Saskatchewan, and southwestern Ontario. Dashed line shows the boundary of the water shed in the United States for the Red River of the North.

PRECEDENT CONDITIONS

A study of the large scale air flow in the troposphere during the period of April 15–23 will aid in an understanding of some of the factors associated with the heavy snow storm of April 24–26.

A moderately strong meridional circulation maintained a flow of cold air from the north over Canada and the northern United States during the week ending April 15. Within 48 hours however, there was a marked change in the upper-level streamlines. The meridional flow became more zonal in character as shown by the 500-mb. chart of 2200 EST on April 15 (fig. 2). Cold air previously transported from the north was replaced by comparatively warm air brought into the area by the long westerly sweep that extended well out into the Pacific Ocean.

On the 15th, 16th, and 17th the temperatures rose to above 60° F. over most of the watershed of the Red River of the North. The deep snow cover melted with an ensuing run-off of millions of gallons of new water, delaying and augmenting the flood crest as it moved northward. The flood crest at Moorhead, Minn., on April 8 was about 27 feet (flood stage 17 feet). It was not until the 24th–25th of the month that the peak of 43.9 feet (flood stage 30 feet) occurred at Grand Forks, N. Dak. The Red Lake River, which empties into the Red River from the east just upstream from Grand Forks, contributed to the crest there. The 43.9-foot flood peak was the second

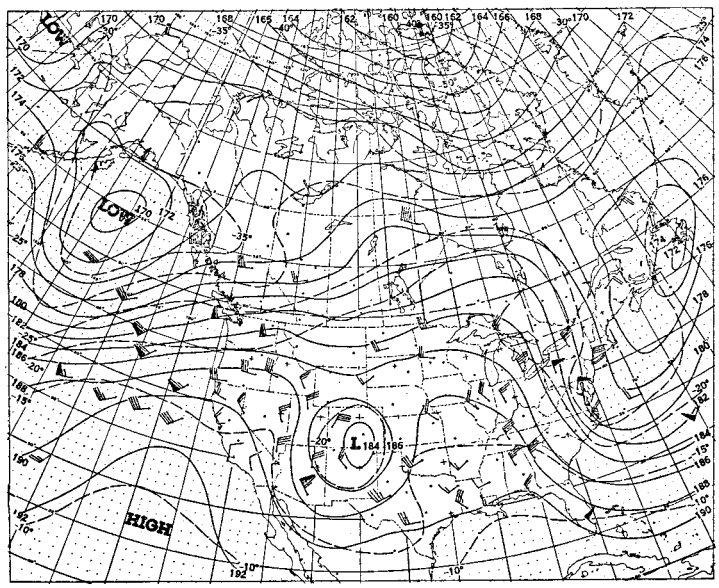

FIGURE 2.—500-mb. chart for 2200 EST, April 15, 1950. Contours (solid lines) at 200-ft. intervals are labeled in hundreds of geopotential feet. Isotherms (dashed lines) are drawn for intervals of 5° C. Barbs on wind shafts are for wind speeds in knots; full barb for every ten knots, half barb for every 5 knots, and pennant for every 50 knots.

highest since 1897 when a stage of 50.2 feet was measured. (The crest of 43.9 feet was exceeded by a second crest of 45.7 feet on May 12.)

However, the zonal flow was only transitory. The wave amplitude increased again and at 2200 EST, April 18 (fig. 3) there was a well marked ridge just off the west coast extending northward into Canada. The ridge did not advance into the area from the west, but was dynamically formed as air parcels moving through a trough near longitude 155° W. "overshot" the trough, moved outward across the contours, slowed down and then were turned more northward by the pressure gradient [1]. The more southerly wind presumably carried cold stratospheric air northward to build up the pressure at higher latitudes. The 500-mb. surface at Annette Island, Alaska, rose from 17,430 feet to 18,180 feet in 24 hours.

The ridge then moved eastward and by 1000 EST, April 23 (fig. 4) it was located over central Canada at about 100° W. The Low shown on this chart about 240 miles northeast of Spokane, Wash., had moved inland from the Gulf of Alaska and filled approximately 1,000 feet. This Low was the one which later caused the heavy snow and near-record cold weather over North Dakota and Minnesota. The Low moved east-southeastward during the next 24 hours to a position slightly northwest of Bismarck, N. Dak. (fig. 5). The axis of the warm tongue in the lower troposphere to the east of the Low was then closer in phase with the surface Low. This upper Low was evident on the surface chart for 3 hours earlier, 0730 EST, April 24 (fig. 6) as a small closed cyclonic circulation southwest of Bismarck. However, the major low pressure system was the broad trough along the cold front from northern Missouri to western Oklahoma.

STORM OF APRIL 24–26, 1950

The Low near Bismarck was an interesting whirl which played an important role in producing some of the heavy snow in North Dakota. It developed suddenly in the northern end of an inverted trough, and appeared to be mostly a dynamic development because there was no marked temperature contrast within it. The southwesterly winds in the southeast quadrant were as much a result of the build-up of the ridge over eastern South Dakota as of the deepening near the Low center. It might be argued that there was a warm-type occlusion extending to the east-southeast of the center. The type of development that took place precludes such a front, and also a study of the hourly reports shows a very gradual shift of wind and a slow rise in temperature as the surface trough advanced eastward. By 1330 EST (not shown), a pseudo-warm front might have been introduced on the chart between the easterly current over Minnesota and North Dakota and the southwesterly flow over South Dakota.

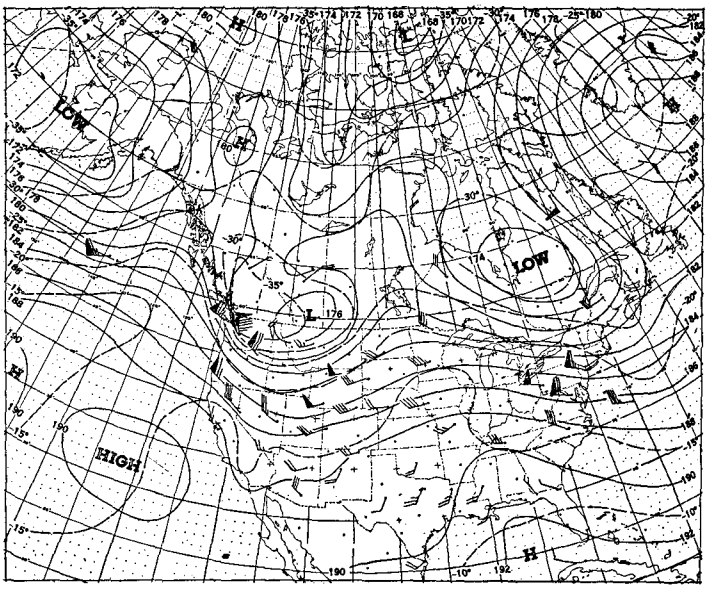

FIGURE 4.—500-mb. chart for 1000 EST, April 23, 1950.

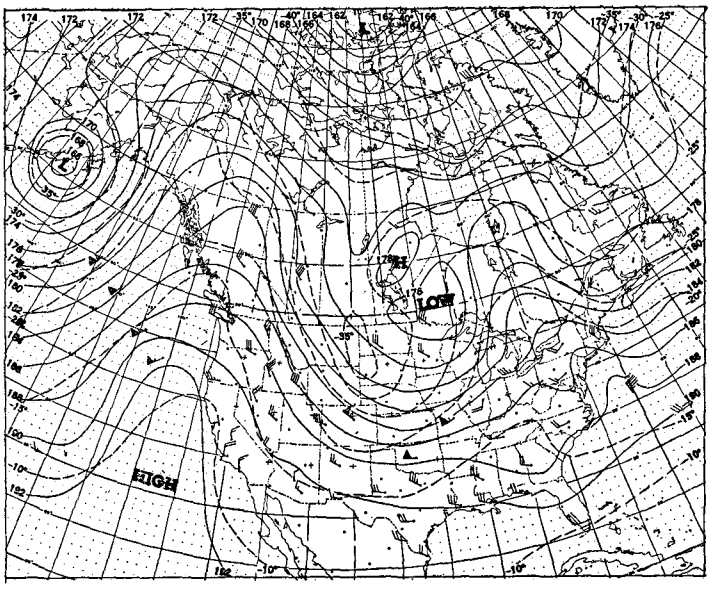

FIGURE 3.—500-mb. chart for 2200 EST, April 18, 1950.

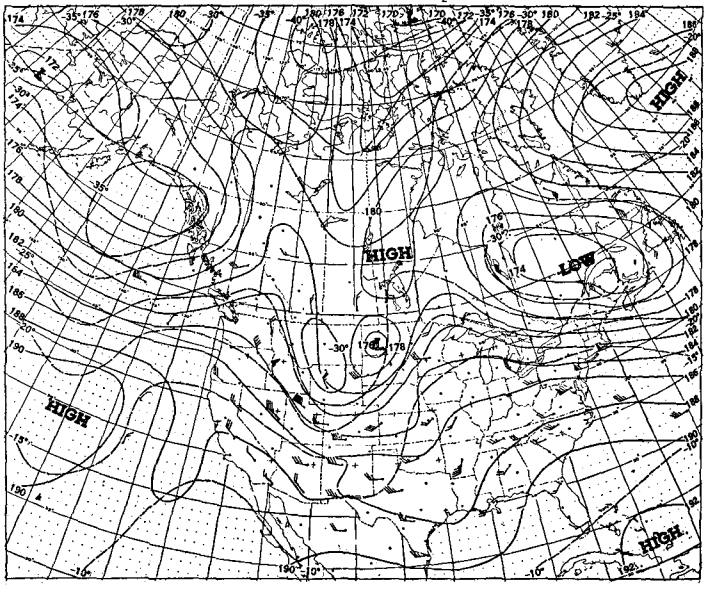

FIGURE 5.—500-mb. chart for 1000 EST, April 24, 1950.

This would have been a shallow front as it did not appear on the 850-mb. chart, and evidence for it disappeared with nocturnal cooling in the less cloudy air to the south.

The cold front extending from eastern South Dakota into central Kansas (fig. 6) developed earlier over the Rockies as the upper-air trough advanced into that area. Even though the air behind this front was moving down slope, it was cold enough to displace the modified Polar air in the easterly current ahead of it over Kansas and southern Nebraska. Because the easterly current had a steeper horizontal temperature gradient to the north and a more stable lapse rate than the cold air to the west, the cold front was running aloft a short distance over the surface air in northern Nebraska and South Dakota. When it reached the peak of the frontal wave over southeastern Iowa, this front became the mechanism which started the deepening of the major low-pressure system.

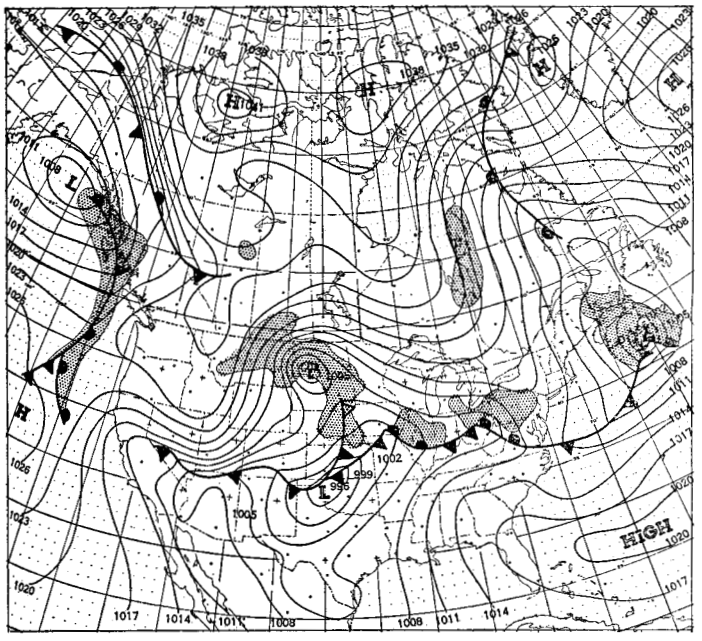

FIGURE 6.—Surface weather map for 0730 EST, April 24, 1950. Shading indicates areas of active precipitation.

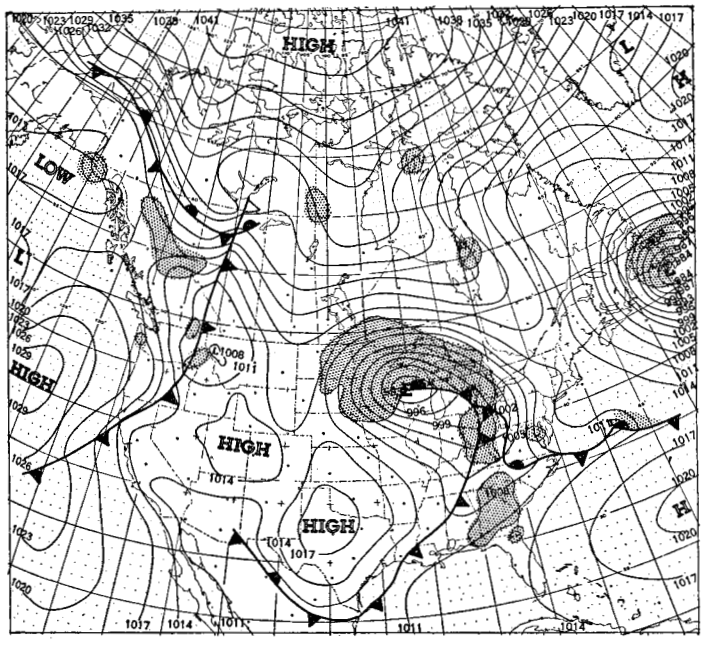

FIGURE 7.—Surface weather map for 1330 EST, April 25, 1950. Shading indicates areas of active precipitation.

At the time of the map in figure 6, the stage was being set for the Low to begin occluding. Over northern and central Canada a massive anticyclone was building and a broad stream of very cold air on its eastern side poured southward across Hudson Bay and then eastward into the complex cyclone in the Missouri Valley.

The deepening of the Low started in western Illinois after 2230 EST, April 24 (not shown). As the deepening and occluding process progressed, the Low center curved more to the north passing west of Rockford, Ill., and Madison, Wis. At the same time the cyclonic whirl in the cold air that developed over North Dakota decreased in intensity and moved almost straight east. By 1330 EST, April 25 (fig. 7) the two Lows had combined into one center with a pressure of 992 mb. to the southwest of Wausau, Wis. The Low center then moved north-northwestward to the vicinity of Park Falls, Wis., where it became stationary for a period of 9 hours. It then drifted off to the northeast and filled slowly.

Throughout this period the snow, which had begun to fall during the night of April 23, continued to accumulate on the ground. It was not until the morning of April 27 that the snow fall ceased. By that time there was a snow-cover of four inches to over one foot on the ground across North Dakota and northern Minnesota. The snow and subfreezing temperatures, which were driven by winds up to 40 m. p. h., increased the difficulty of evacuation around Grand Forks and northward.

In its early stages the surface low-pressure system had a rather complicated structure. However, aloft above

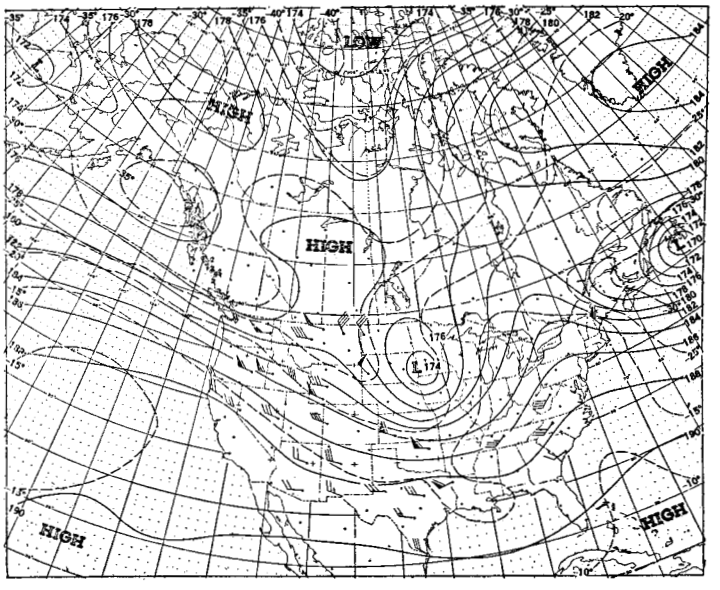

FIGURE 8.—500-mb. chart for 1000 EST, April 25, 1950.

the 850-mb. surface it was a simple closed Low with a tongue of warm moist air on its eastern side and a flow of cold air on its western periphery. The upper-level Low decelerated once it reached North Dakota, moving only 300 miles from April 24 to April 25 (figs. 5 and 8). Thus the protracted snowfall over the Red River Basin at the beginning of the period was caused by lifting in the middle troposphere of the warm moist air from the south and later the southeast over the colder surface air. During the last two days, the snow was more in the form of showers produced in the unstable cold air by convergence in the area to the rear of the storm where the cyclonic curvature of the isobars was marked.

The flood in the Red River Valley of the North caused higher crests at some stations than had been observed during the past 50 years. At Pembina, N. Dak. (near the international boundary) the river rose until the end of the month when it crested at 51.7 feet, the highest since 1826. This crest and another slightly higher on May 14 caused severe damage at Winnipeg, Manitoba. At the time of this writing (June 6) the river had not returned to normal and the total loss from this flood will not be known for many months.

REFERENCE

1. H. B. Wobus and L. C. Norton, "Some Synoptic Aspects of a Change in Weather Regime During February 1950," *Monthly Weather Review*, vol. 78, No. 2, February 1950, p. 31–40.

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