

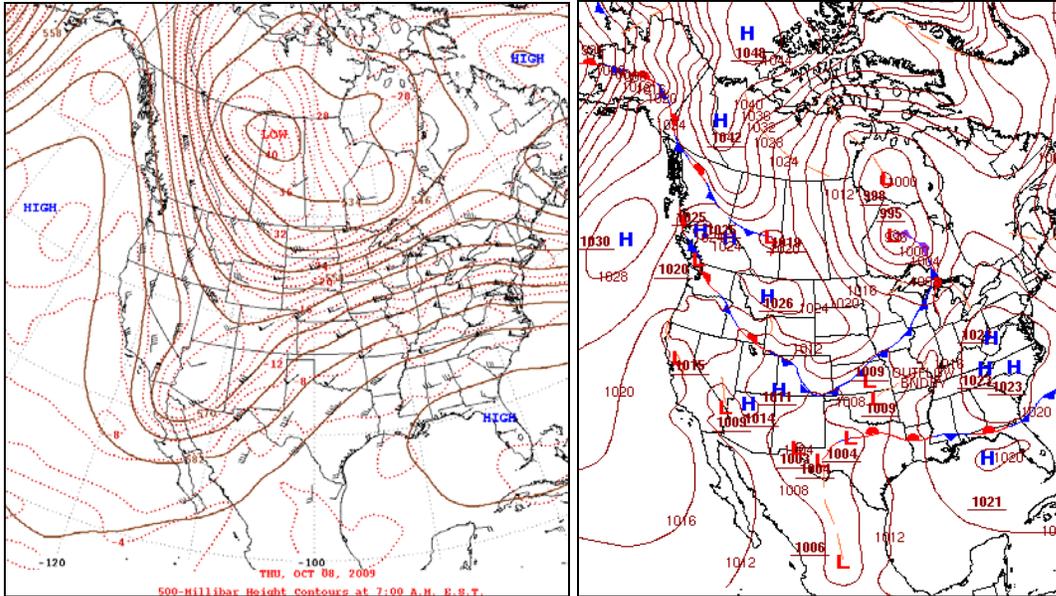
# AN ANALYSIS AND SUMMARY OF THE COLD TEMPERATURES IN CENTRAL AND SOUTHWEST MONTANA FROM 9-12 OCTOBER 2009

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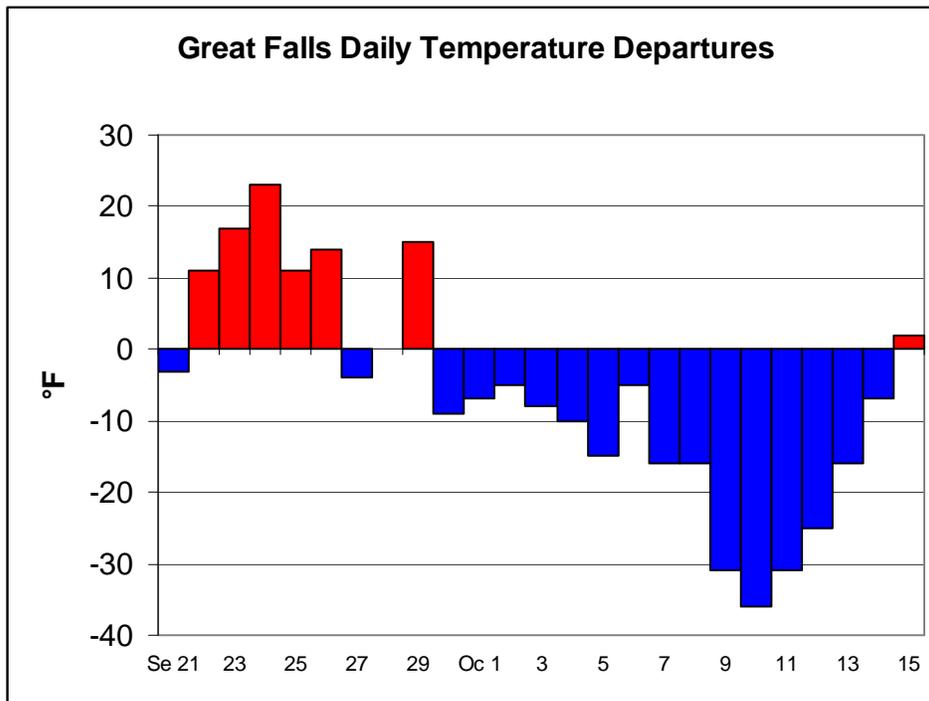
The cold spell of 9-12 October 2009 in north central and southwest Montana was nearly unprecedented in duration and coldness for any October. Some areas of southwest and central Montana had snow cover that enhanced the cold temperatures during brief clear periods, but overall, clouds and the lack of snow cover moderated the cold. At one point, however, it was so cold that the high temperature at Great Falls of 23°F (Oct 11) was only 2°F warmer than the previous record low temperature for the date (21°F on 11 October 1969). More than 100 new temperature records were established during this period. The new records ranged from daily cold maximum and minimum temperatures; to cold temperatures so early in the season; to cold duration so early in the season (Table 1). Records first established in the 1880s fell during this event.

**1-7 OCTOBER 2009 – PRIOR TO COLD ONSET.** After a very warm September, the first week of October 2009 produced unsettled weather. Below average temperatures also prevailed over north central and southwest Montana. By 8 October, the upper-level flow turned to a northerly direction and looked like a pattern from mid-winter. A deep upper-level low over northern Alberta and Saskatchewan and an accompanying shortwave extending to the west were the harbingers of the colder temperatures (Fig. 1). Figure 1 also shows the surface systems associated with this pattern. Note the cold front and weak low-pressure area across central Alberta, along with the 1048-hPa high-pressure area off the coast of the Northwest Territories. The strong surface high-pressure area was intensifying over the dark Arctic ice pack. A piece of this cold air mass started to slide down the spine of the Rockies by the morning of 8 October. The below normal temperatures for the first week of October were followed by a period of much below temperatures, with temperatures averaging 35-40 (F) degrees below the seasonal normal (Fig. 2).

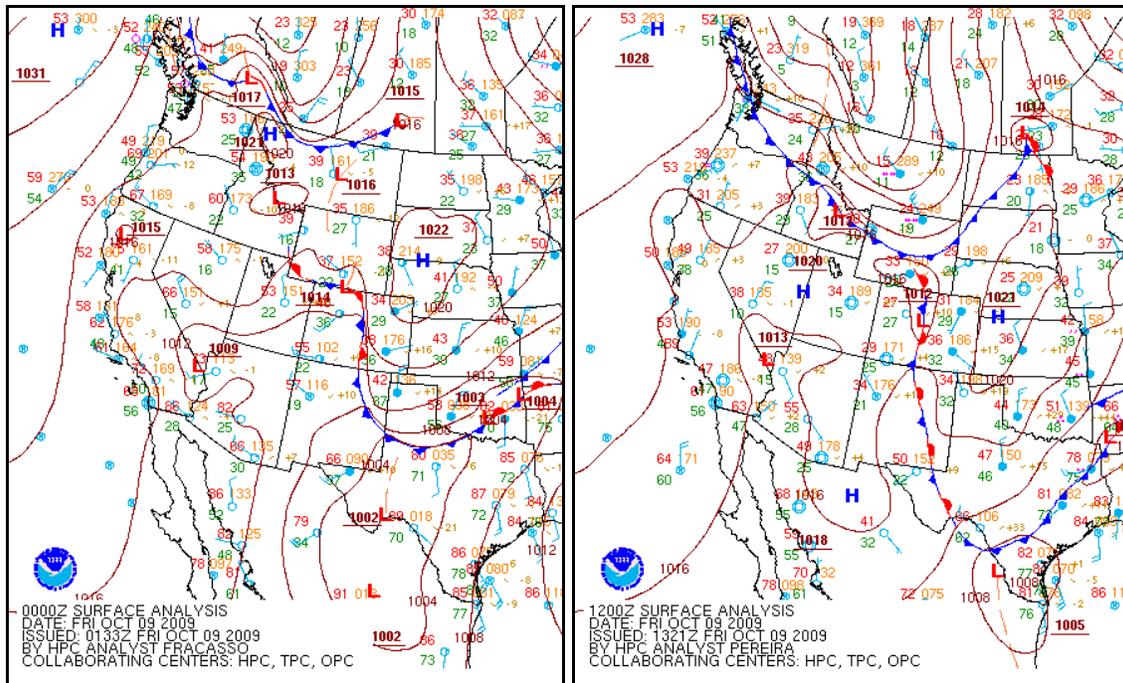
**8 OCTOBER 2009.** On the evening of 8 October, the leading edge of the cold air crossed into northern Montana, after a mild day with high temperatures in the 40s and lower 50s (F). The front was accompanied by strong winds and rapid pressure rises. Three-hour pressure rises of 5-hPa accompanied the front. The pressure rises and strong cold front produced wind gusts near 50 mph as the front rushed through the area on the evening of 8 October (Fig. 3). Snowfall accompanying the front reduced visibilities for a brief period. Some areas measured 4-6 inches of snow, mostly over southwest and southern portions of central Montana.



**Fig. 1.** 500-hPa height contours at 1200 UTC October 8 2009 (left). North American surface analysis with fronts (right) (from NOAA's National Centers for Environmental Prediction Hydrometeorological Prediction Center).



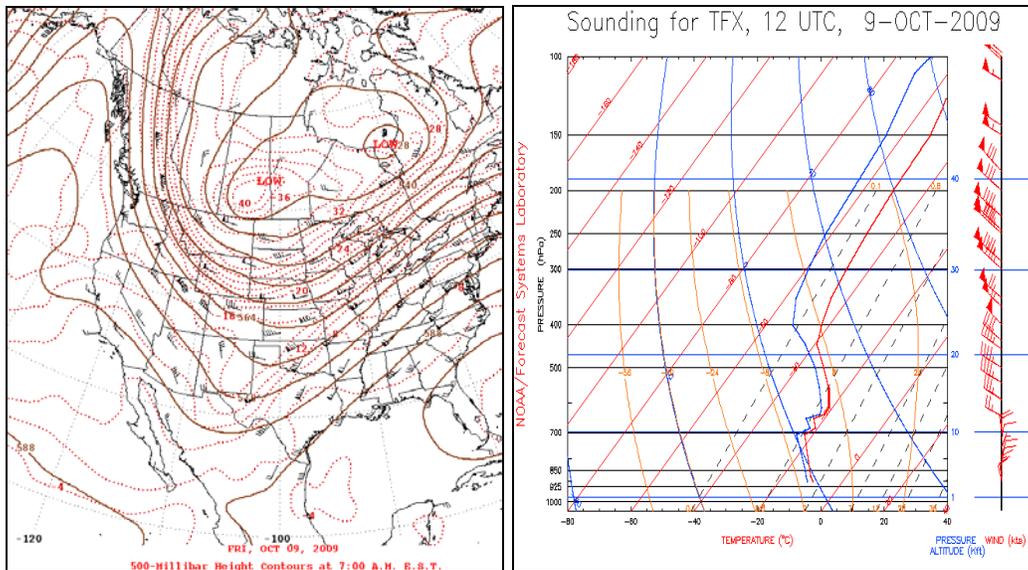
**Fig. 2.** Daily temperature departures from normal at Great Falls, MT. Note the above normal temperatures of September, which came to an abrupt halt in October. Temperatures during the first 13 days of October averaged 17°F below normal at Great Falls.



**Fig. 3. Mean Sea level pressure and frontal analysis 0000 UTC 9 October (left) and 1200 UTC 9 October (right).**

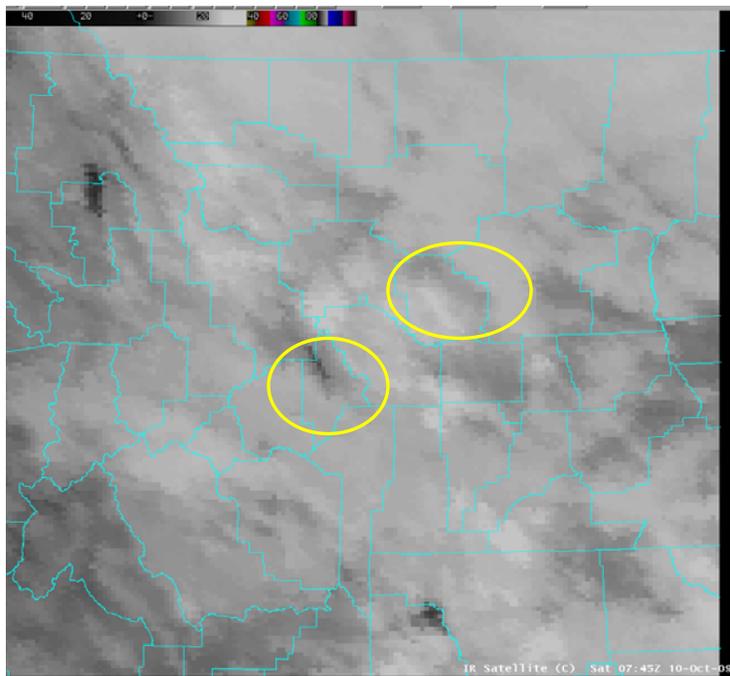
**9 OCTOBER 2009.** By the morning of 9 October, the cold air mass had settled across the area (Fig. 3), with the depth of the air mass notable by the below zero (F) temperatures reported at several locations, including Porphory Peak, at 8200 feet MSL (in the Little Belt Mountains). The morning radiosonde at Great Falls indicated that the air mass extended through 10,000 feet MSL (Fig. 4). Cold temperatures prevailed as the air mass spread over the area. High temperatures on 9 October remained in the upper teens and 20s (F). After a period of brief clearing on the morning of 10 October (Fig. 5), some locations recorded temperatures as low as  $-16^{\circ}\text{F}$  – unprecedented for Montana for so early in the season.

**10-12 OCTOBER 2009.** Surface high pressure remained strongly in control on 10 and 11 October (Fig. 6). The sea level pressure value of 1037.4-hPa at Great Falls was one of the highest sea-level pressure values in October since 1998. Maximum temperatures remained in the 20s (F) again on 10 and 11 October, with low temperatures in the single digits. The deep cold air mass produced near record-breaking cold through a large depth of the atmosphere. At Great Falls, the 500-hPa temperature of  $-34.3^{\circ}\text{C}$  at 1200 UTC 9 October (Fig. 7) was one of the coldest values in October. The coldest is  $-36.1^{\circ}\text{C}$ , measured on 28 October 1971. Skies cleared across southwest Montana on the afternoon of 11 October, and by sunrise on 12 October across the rest of southwest and north central Montana. Some sub-zero (F) temperatures readings occurred again on the morning of 12 October. This was the last day of below freezing temperatures at

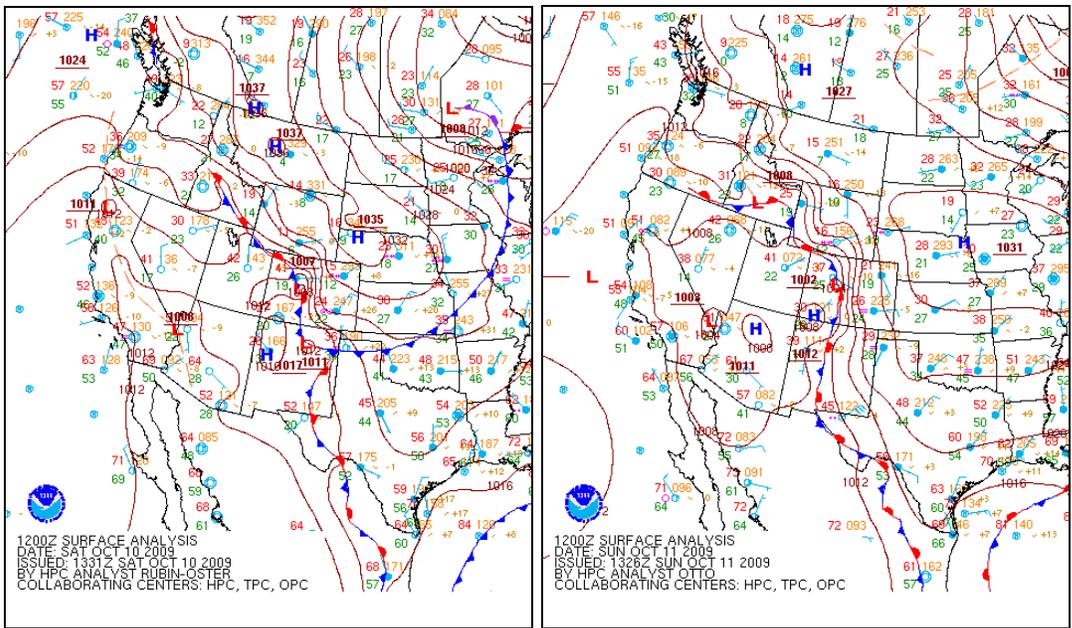


**Fig. 4. 500-hPa height contours at 1200 UTC October 9 2009 (left). Upper air radiosonde is from Great Falls (right). Note the depth of the cold air on the sounding, through 700-hPa (sounding courtesy NOAA's Forecast Systems Laboratory).**

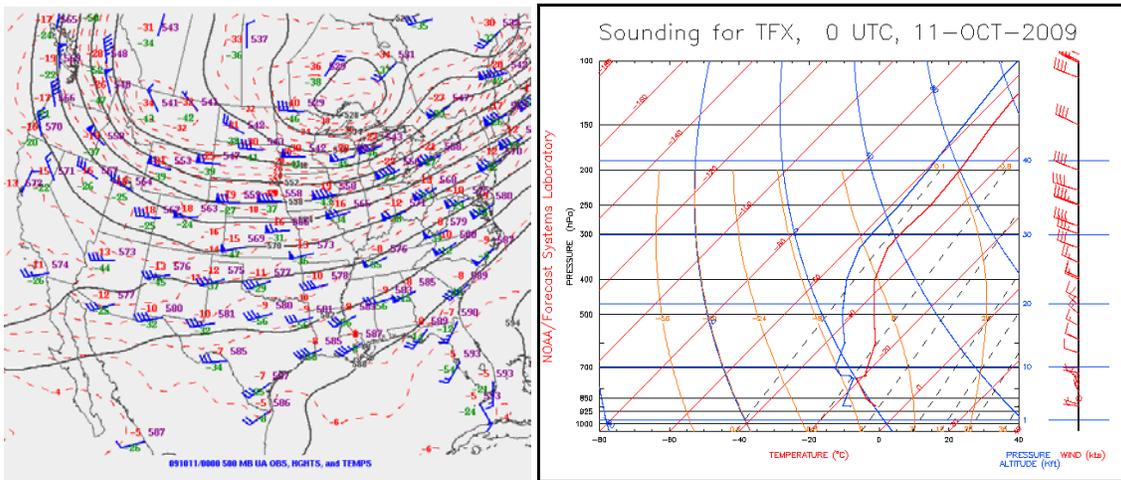
most locations. A map of the lowest temperatures recorded during this period shows that the coldest temperatures occurred from the northern Rocky Mountain Front, through the mountains of central Montana (Fig. 8). After four days of sub-freezing temperatures in early October, a slow warm-up finally began.



**Fig. 5. Infrared satellite imagery 0745Z 10 October 2009. Some small breaks in the clouds occurred in central Montana during the overnight hours. These breaks can be seen in central Montana, in the areas with the yellow circles.**



**Fig. 6. Mean Sea level pressure and frontal analysis 1200 UTC 10 October (left), and 1200 UTC 11 October (right).**



**Fig. 7. 0000 UTC 11 October 2009 500-hPa pattern (left) and upper air sounding at Great Falls (right).**

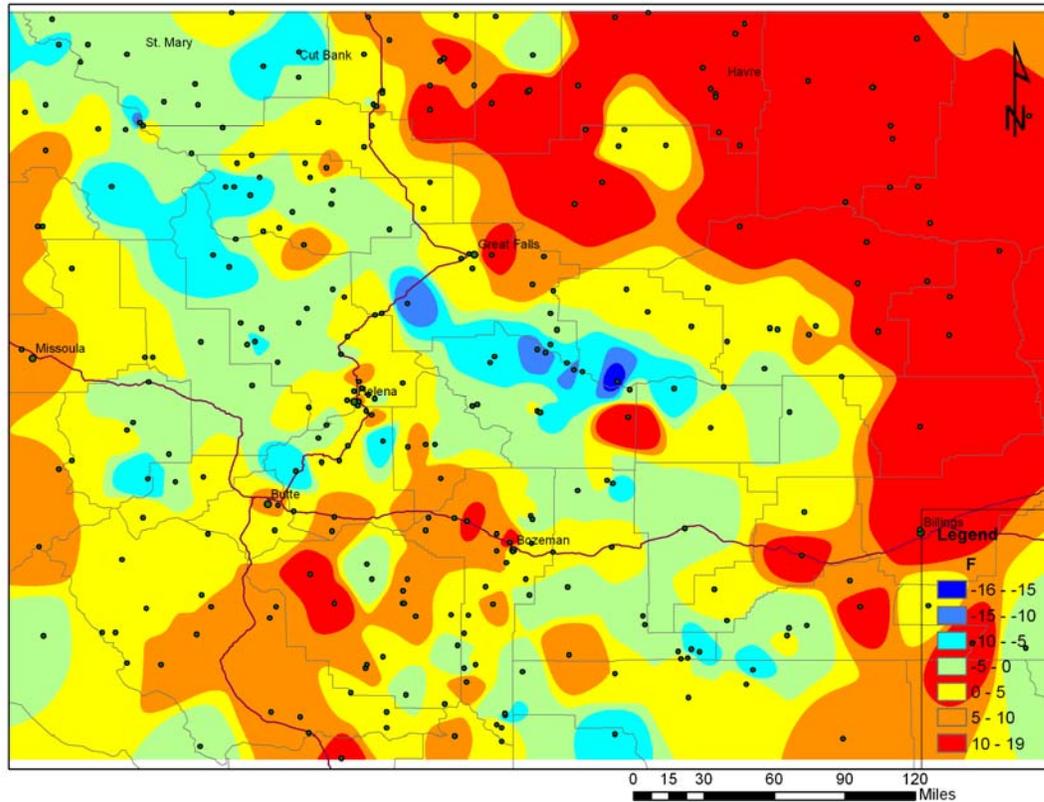


Fig. 8. Lowest temperatures (F) recorded during the period from 9-12 October 2009.

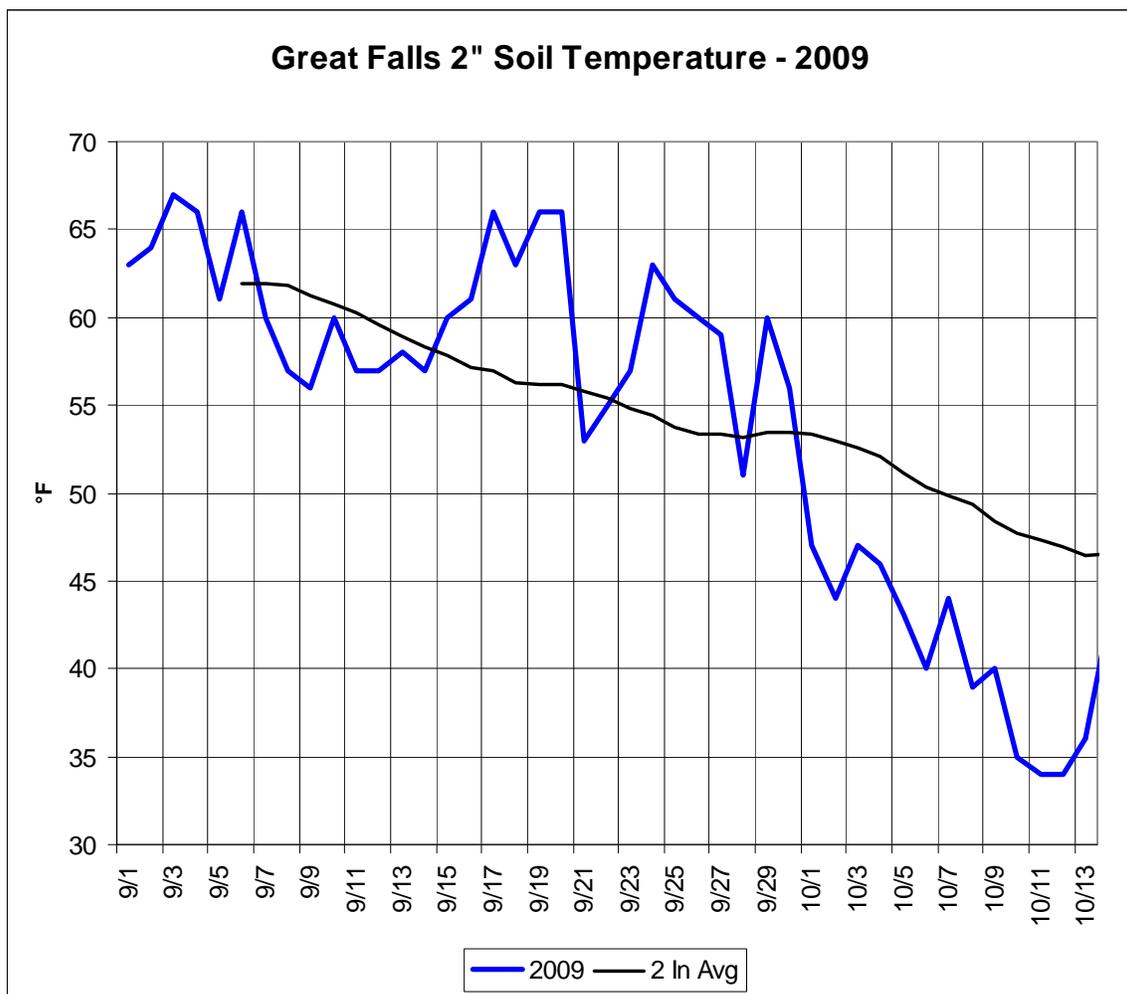
**DISCUSSION AND SUMMARY.** This was a record event on many avenues. For early October, this period tied the record for the greatest number of consecutive days of sub-freezing temperatures. The four-day period from 9-12 October 2009 tied the record for early October at Great Falls of four days set in October 1957. This did not set an October record, as lengthy cold periods have occurred in late October as recently as October 1991. In 1991, there was a six-day period of sub-freezing temperatures which extended into November. (Not all of the new records are shown in Table 1.) Some records, established in the early 1880s, were exceeded during this event.

The coldest temperatures in the state during this period also set daily statewide records. The low temperature of -16°F at Utica 22SW (southwest Judith Basin County) exceeded the previous record of -12°F at Whiskey Creek SNOTEL (Snowpack Telemetry – US Department of Agriculture National Resource Conservation Service) on 10 October. On 11 October, the value of -13°F at Polebridge (Flathead County) exceeded the previous record of -4°F at Black Bear SNOTEL.

Several impacts were associated with this event. From the snowfall that accompanied the cold front on the evening of 8 October, roads iced over rapidly by the next morning. This caused some problems with the morning drive on 9 October. Not surprising, the shallowest soil temperatures cooled rapidly with the outbreak of cold air. The two-inch soil temperature plot at Great Falls shows the rapid decline in soil temperatures from September through early October (Fig. 9). With sufficient solar insolation during the

cloudy day, roads mostly melted off during the daylight hours. Cold temperatures had an impact on crops still in the ground. As the soil froze to shallow depths, seed potatoes and sugar beets, not yet harvested, suffered freeze damage. The State of Montana requested a federal disaster declaration to address these agricultural issues.

Additionally, the autumn tree foliage had been turning at this time. In many areas, this was one of the best autumns in years for fall-color. This cold period froze the leaves, and days later, the foliage turned to a dingy brown. A potentially serious problem was the sudden browning of needles on young coniferous trees (Fig. 10). Many of these trees were harmed in the late spring cold of April 2007, and now suffered freeze damage before their fall dormancy. The coming months will determine whether these trees survive.



**Fig. 9. Two-inch soil temperature plot at Great Falls from 1 September through 15 October 2009 (blue line). The black line is the average two-inch soil temperature for 2003-2008.**



**Fig. 10.** Frozen needles on young conifers as damaged from the cold of early October 2009.

**ACKNOWLEDGMENTS.** The author would like to thank the following for their archives of weather resources: NOAA’s National Centers for Environmental Prediction National Hydrometeorological Center, NOAA’s Storm Prediction Center and NOAA’s Forecast Systems Laboratory.

**Table 1. A non-exhaustive listing of record established during this cold period. This table mainly shows the records established at larger cities in southwest and north central Montana, along with a few other notable records. In addition to this sampling, many more locations established similar temperature records across the area.**

**Earliest Maximum temperature at or below 20°F**

| <b>Location</b> | <b>Date</b> | <b>Old Record Date</b> |
|-----------------|-------------|------------------------|
| Cut Bank        | Oct 10      | Oct 16 1930            |
| Great Falls     | Oct 10      | Oct 18 1905            |
| Lewistown       | Oct 10      | Oct 17 1930            |

**Earliest temperature at or below 5°F**

| <b>Location</b> | <b>Date</b> | <b>Old Record Date</b> |
|-----------------|-------------|------------------------|
| Great Falls     | Oct 10      | Oct 19 1905            |

### Earliest Minimum temperatures at or below 0°F

| Location | Date   | Old Record Date |
|----------|--------|-----------------|
| Choteau  | Oct 10 | Oct 24 1919     |
| Stanford | Oct 10 | Oct 29 1991     |

### October 9

| Location    | Record              |      | Old record | Date |
|-------------|---------------------|------|------------|------|
| Cut Bank    | Daily cool Max Temp | 19   | 30         | 1932 |
| Dillon      | Daily cool Max Temp | 35   | 35         | 1985 |
| Great Falls | Daily cool Max Temp | 22   | 25         | 1919 |
| Havre       | Daily cool Max Temp | 25   | 29         | 1919 |
| Lewistown   | Daily cool Max Temp | 22   | 27         | 1919 |
| Big Sky     | Daily Max Snowfall  | 4.0" | 2.5"       | 2006 |
| Wisdom      | Daily Max Snowfall  | 1.0" | 0.5"       | 1932 |

### October 10

| Location      | Record              |    | Old record | Date |
|---------------|---------------------|----|------------|------|
| Choteau       | Daily cold Min Temp | -4 | 18         | 1977 |
| Cut Bank      | Daily cold Min Temp | 1  | 10         | 1977 |
| Dillon        | Daily cold Min Temp | 8  | 15         | 1987 |
| Great Falls   | Daily cold Min Temp | 4  | 14         | 1919 |
| Helena        | Daily cold Min Temp | 9  | 15         | 1987 |
| Lewistown     | Daily cold Min Temp | 11 | 12         | 1987 |
| Rogers Pass   | Daily cold Min Temp | -2 | 12         | 1977 |
| Stanford      | Daily cold Min Temp | 0  | 10         | 1987 |
| White Sulphur | Daily cold Min Temp | -1 | 8          | 1919 |
| Belgrade/BZN  | Daily cool Max Temp | 30 | 39         | 1946 |
| Cut Bank      | Daily cool Max Temp | 20 | 26         | 1972 |
| Dillon        | Daily cool Max Temp | 26 | 33         | 2008 |
| Great Falls   | Daily cool Max Temp | 20 | 34         | 1959 |
| Havre         | Daily cool Max Temp | 28 | 29         | 1959 |
| Helena        | Daily cool Max Temp | 25 | 36         | 1959 |
| Lewistown     | Daily cool Max Temp | 17 | 28         | 1959 |
| Valier        | Daily cool Max Temp | 18 | 38         | 1919 |
| Wisdom        | Daily cool Max Temp | 29 | 36         | 1949 |

## October 11

| Location      | Record              |    | Old record | Date |
|---------------|---------------------|----|------------|------|
| Belgrade/BZN  | Daily cold Min Temp | 14 | 15         | 1987 |
| Bozeman MSU   | Daily cold Min Temp | 11 | 20         | 1973 |
| Cascade 20SE  | Daily cold Min Temp | -2 | 15         | 1969 |
| Dillon        | Daily cold Min Temp | 12 | 17         | 1986 |
| Great Falls   | Daily cold Min Temp | 10 | 21         | 1969 |
| Helena        | Daily cold Min Temp | 14 | 17         | 1881 |
| Lewistown     | Daily cold Min Temp | 5  | 18         | 1969 |
| Wisdom        | Daily cold Min Temp | 2  | 2          | 1987 |
| Belgrade/BZN  | Daily cool Max Temp | 27 | 29         | 1985 |
| Cut Bank      | Daily cool Max Temp | 20 | 28         | 1972 |
| Dillon        | Daily cool Max Temp | 26 | 29         | 2008 |
| Great Falls   | Daily cool Max Temp | 23 | 30         | 1969 |
| Helena        | Daily cool Max Temp | 26 | 30         | 1899 |
| Lewistown     | Daily cool Max Temp | 20 | 27         | 1969 |
| Martinsdale   | Daily cool Max Temp | 18 | 32         | 2008 |
| White Sulphur | Daily cool Max Temp | 19 | 32         | 2008 |
| Wisdom        | Daily cool Max Temp | 28 | 28         | 2008 |

## October 12

| Location     | Record              |    | Old record | Date |
|--------------|---------------------|----|------------|------|
| Belgrade/BZN | Daily cold Min Temp | 9  | 17         | 1986 |
| Bozeman MSU  | Daily cold Min Temp | 11 | 18         | 1969 |
| Cut Bank     | Daily cold Min Temp | -3 | 6          | 2002 |
| Dillon       | Daily cold Min Temp | 12 | 14         | 2008 |
| Great Falls  | Daily cold Min Temp | 13 | 16         | 2002 |
| Helena       | Daily cold Min Temp | 8  | 14         | 1881 |
| Lewistown    | Daily cold Min Temp | 7  | 18         | 1969 |
| Wisdom       | Daily cold Min Temp | 2  | 4          | 2002 |
| Cut Bank     | Daily cool Max Temp | 29 | 30         | 1969 |