SYNOPTIC PATTERNS ASSOCIATED WITH HEAVY SPRING SNOWFALLS IN SOUTHWESTERN ALBERTA 1/

612-76

By

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Introduction

Most residents of southern Alberta have learned to expect snow in the spring months of April and May, or even June. However, the ferocity of the storms and the total amount of precipitation is often surprising, especially if these storms occur after a prolonged period of fine weather. An analysis of spring (April to June) rainstorms in Alberta, dating back to the turn of the century indicates that over half occurred in the southwestern parts of the province or along the foothills, south of Calgary. Likewise, the incidence of heavy spring snowstorms is much higher in southwestern Alberta and along the foothills than in the remainder of the province.

Topography

Alberta is often referred to as lying in the rain shadow of the Rocky Mountains, thereby implying that the mountains are responsible for "less" precipitation in the province. As Reinelt (1968) points out, this notion is misleading and indeed, in some instances, the opposite may be true. The important thing to realize is that topography influences precipitation, often in a complex manner, and a proper understanding of the precipitation regime of southwestern Alberta requires some knowledge of the remarkable topography. The Rocky Mountain chain forming the western boundary of the province south of latitude 54N is paralleled on the east by a series of lesser ranges or hills. In the southwestern corner of the province, however, these "front" ranges are absent and in the Waterton Park area the transition from prairie to mountains is fairly abrupt. As a matter of fact, this feature of the landscape, "where the mountains meet the prairies," is sometimes referred to as the theme of Waterton Park. Topographic profiles through Waterton and Lake Louise are depicted in Figs. 2 and 3. It can be noted from Fig. 2 that Waterton is open to the prairies on the east. Lake Louise, on the other hand, is tucked away in the mountains and is separated from the prairies by several mountain ranges. Thus, the Waterton area is open directly to easterly upslope winds, but in the case of Lake Louise, east winds from the prairies can enter only by way of passes, and the major upslope effects would occur much further east.

Precipitation Regime

Annual precipitation regimes vary considerably over the province. In the south, the curve shows a pronounced peak in June with total summer precipitation often double the winter precipitation. The high mountains of Banff and Jasper Parks, on the other hand, show a reversal of this pattern with winter precipitation about double the summer amount. Snowfall variations in the province are indeed complex, both time wise and spatially, and several distinct regimes can be identified.

The wide variation in snowfall patterns between the prairie and alpine environments is depicted in Fig. 5. The Medicine Hat curve is fairly typical of the prairie environment. The curve is fairly flat, almost symmetrical, with no well-defined peaks. Average monthly snowfall is less than 10 inches (25 cm).

Lake Louise, on the other hand, has a remarkably different regime. Not only is the total snowfall vastly greater than that of Medicine Hat, but there is a well-defined peak in mid-winter. The Waterton Park HQ curve, showing about the same order of magnitude of total snowfall as Lake Louise (about 200 inches - 510 cm) also has the mid-winter peak, but in contrast shows a well-defined secondary peak in April. With the exception of Cape Dyer, NWT, Waterton Park HQ has the highest annual snowfall of any Canadian station east of the Rocky Mountains.

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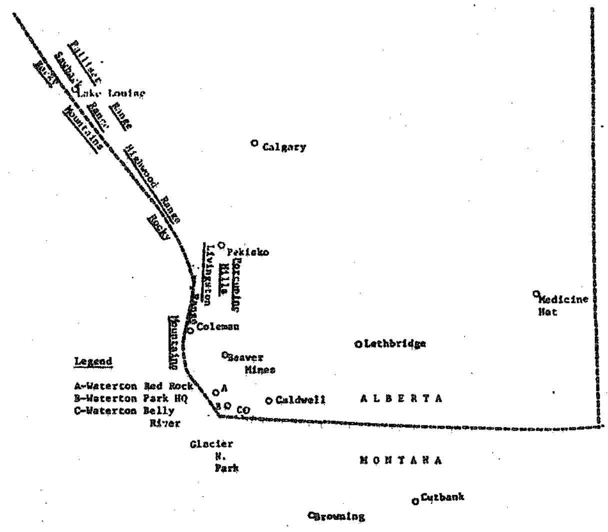


Fig. 1. Map of Southern Alberta

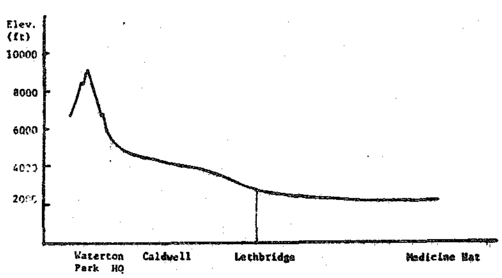


Figure 2. Topographic Profile through Waterton Park

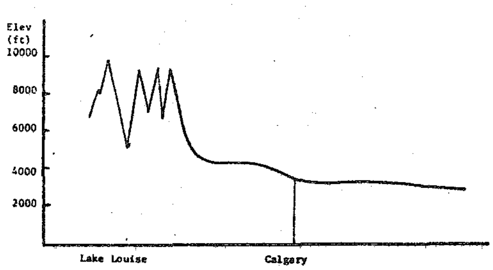


Figure 3. Topographic Profile through Lake Louise

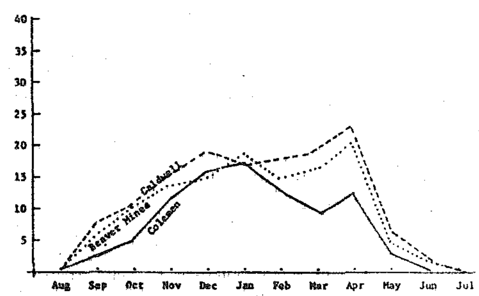


Figure 4. Mean Snowfall (inches)

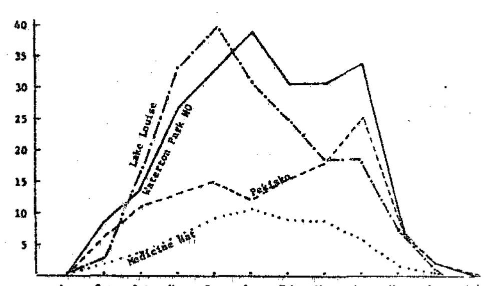


Figure 5. Mean Snowfall (inches)

The striking feature of the Pekisko curve is the definite maximum in April. Further analysis indicates that other foothill stations show this same feature (Fig. 4). It should be noted that these analyses are based on the same data set, that is stations having 25 years record or longer in the period 1941-1970.

The April maximum or secondary maximum is most pronounced in the Waterton area of southwestern Alberta (and likely northeastern portions of Glacier Park). It also extends northward in a narrow band along the Porcupine Hills and along the eastern slopes of the most easterly mountain ranges northward to about latitude 52N. This feature may appear to be an anomaly, but it integrates into the general precipitation regime fairly smoothly for most of southwestern Alberta.

Synoptic Patterns

The crux of the matter is that southwestern Alberta is subject to high precipitation events in spring. In particular, heavy snowfalls have occurred in April. Several questions can be considered in relation to these events:

1. What is the synoptic pattern giving rise to such storms?
2. Is there a similarity between the patterns giving heavy snowfall and those giving heavy rain?
3. Why is April subject to more extreme snowfall events as opposed to March or May?
4. Why is the southwestern portion of the province subject to a greater frequency of the high precipitation events?
5. One would expect an orderly seasonal progression northward along the eastern ranges of these extreme events. This does not appear to be the case. Why?

A. Heavy Snow in April.

The synoptic events and the economic impact associated with the twin storms of April 1967 have been described by Janz and Treffry (1968). The pertinent maps delineating the main synoptic features are reproduced in Fig. 6. The following should be noted in these charts:

a. 500mb. - The main low is situated over Washington and Oregon with a minor trough (extending to southern Montana), rotating anti-clockwise around it. This situation gives rise to a warm moist southeasterly flow over southwestern Alberta. The lowest temperature in the main low centre is -35°C with the temperature over the storm area about -23°C.

b. Surface chart - The main low pressure area is located in Wyoming. An easterly upslope condition exists in southern Alberta with moderate northerly winds and heavy snow in the southwest corner and in northern Montana. Temperatures in western Alberta are below freezing but eastern areas nearer the Arctic front are above freezing.

c. The total snowfall charts - The basic snowfall pattern in both storms was essentially the same. Note the heaviest amounts in the Waterton area and the lighter amounts in those areas protected from easterly upslope by outer mountain ranges or hills (i.e. the area north of Coleman). The heavy snowfall area extends northward in a relatively narrow band along the slopes of the eastern ranges. Total snowfall in the Waterton area is in excess of 80 inches (200 cm).

d. A reconstruction of the vertical temperature profile indicates that an upslope "lift" of only about 2000 ft (680 m) was sufficient to produce a sufficiently deep layer, below freezing so that precipitation was in the form of snow.

e. Storm No. 1 and Storm No. 2 were separated by about 10 days. However, 10 days after Storm No. 2, a third storm hit the area bringing another 10 to 20 inches (45 cm). The total snowfall over a 24-day period was thus around 100 inches (250 cm) in Waterton Park. The water equivalent of this snow is not available but it was likely well in excess of the average.

B. Floods in June.

The synoptic features associated with a severe storm that caused extensive flooding in southern Alberta and northern Montana is described by R. A. Dightman in Warner (1973). The 500 mb charts and the surface chart of the mid-period of the storm are reproduced in Fig. 7. The similarities between the April 1967 situation and the 1964 flood situation are rather striking.

a. 500 mb - It will be noted that the main 500 mb centre is in approximately the same location, i.e. western Washington and Oregon. A smaller secondary low is located in southern Idaho. A moist southeasterly flow is directed toward southwestern Alberta. The temperature over southwestern Alberta, however, is some 10°C higher than that of the mid-period of the snow situation in 1967.

b. Surface Chart - The main low is somewhat further east, but a flat trough persists westward across Wyoming. It will be noted that the Arctic front is in almost the same location. There is a strong upslope flow over southern Alberta due to the southward thrust of cooler air to the north.

c. Precipitation - This storm caused extensive flooding in Montana and southwestern Alberta. Damage estimates range as high as 55 million dollars in Montana and about 1 million in Alberta. Total precipitation estimates are upwards of 15 inches (380 mm) along the eastern slopes of the mountains west of Browning. The Waterton Park area received almost 10 inches (250 mm).

d. A reconstruction of the vertical temperature profile in the Waterton area indicates that temperatures aloft were high enough so that upslope "lift" did not cool the lower atmosphere below the freezing point. Thus the precipitation, possibly even at the mountain peaks, was in the form of rain.

e. Other aspects of 1964 storm. - Table 1 shows the precipitation events at Belly River station (Waterton Park) in spring of 1964. Heavy precipitation events produced at least 15 inches (380 mm) water equivalent prior to the extreme event with about 10 inches (250 mm) which precipitated the severe flood. Another interesting note is that on April 5, 1964, Red Rock Canyon, a station in Waterton Park reported 34.4 inches of snow in a 24-hour period. This is the highest 24-hour snowfall reported in Alberta, and appears to be the highest 24-hour snowfall recorded in Canada between the Rocky Mountains and the Niagara Peninsula of Ontario.

Table 1.

Spring Precipitation Events - Belly River (Waterton Park) - 1964

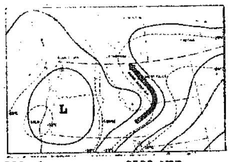
Event	Date	Precipitation	Form
Storm #1	April 4 - 6	40 inches (100 cm)	snow
Storm #2	April 20 - 23	40 inches (100 cm)	snow
Storm #3	May 9 - 11	7 inches (180 mm) (wev)	snow, rain
Storm #4	June 6 - 8	9.9 inches (250 mm)	rain

f. A comparison of the synoptic situations associated with storms 1, 2, and 3 of spring 1964 with the patterns of the June storm and the 1967 snow storms shows that many of the essential features are similar. The main 500 mb centre moved through the northwestern USA producing moist southeasterly flow over southwestern Alberta, the surface low moved through eastern Montana, and there was a "deep upslope" circulation extending from the surface to well above 10,000 feet over southwestern Alberta.

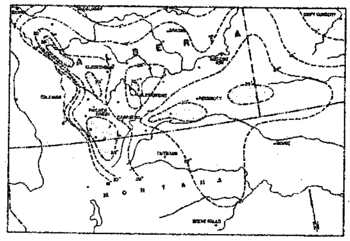
g. Waterton Park experienced another devastating flood in mid-June 1975. As in most other high precipitation events affecting the area, deep upslope contributed substantially to the total precipitation.

C. Other Syntopic Considerations.

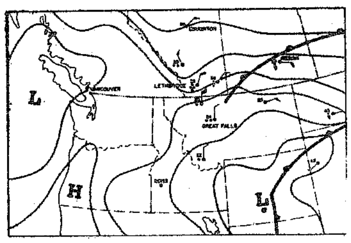
Climatologically two synoptic features probably contribute to the April maximum snowfall. During April the storm track had advanced sufficiently far north to permit



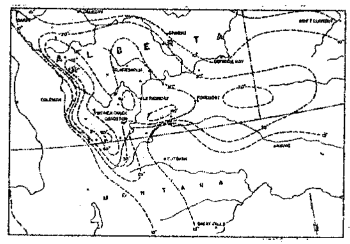
500 mb contours. 0500 MST,
28 April 1967



Total Snowfall, Storm No. 1, 17-20 April 1967

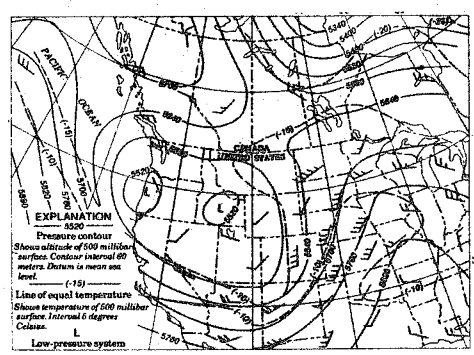


Surface chart, 0500 MST, 28 April 1967

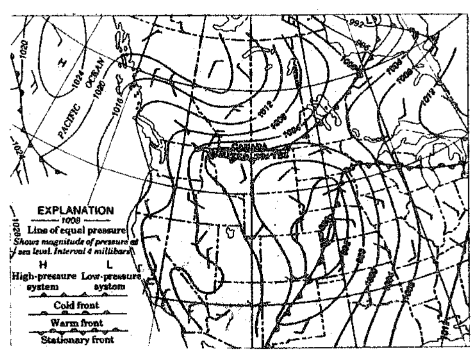


Total Snowfall, Storm No. 2, April 27-30 1967

Figure 6. Charts pertaining to twin storms of April 1967. (Reprinted from Weatherwise, Vol 21, No 2)



500 mb contours. 0500 MST , 8 June 1964



Surface chart. 0500 MST, 8 June 1964.

Figure 7. Charts pertaining to June flood, 1964. (Reprinted from Warner, 1973)

the 500 mb low pressure areas to migrate across the northwestern USA. At the same time, there is still a cold air supply over the Territories and northern Alberta to provide the necessary cold upslope in lower levels. The question as to why the southwestern corner of Alberta is favoured for heavy spring precipitation events is undoubtedly related to the fact that the favoured spring storm track is often through the northwestern USA. One might expect a seasonal northward migration. This does not appear to be the case. The reason for this requires more study but a theory favoured by some experienced meteorologists in Alberta, is that the northward progression of the storm track is a discontinuous phenomenon rather than a continuous phenomenon as one might expect. Certainly many of the late spring storms that have given copious precipitation are of the "cold low" variety - a phenomenon somewhat different from the situations described in this paper.

If one accepts a snowfall rate of 12 inches (30 cm) or greater per day as a heavy snowfall, a 25-year record from Waterton HQ shows eight such events in April and 1 in May. Caldwell has had 11 heavy snowstorms in April, three in May and one in June over a 55-year period. At least nine spring rainstorms in which total storm rainfall exceeded five inches (130 mm) have been reported from the Waterton area since 1908.

Conclusions

1. Many of the heavy spring precipitation events affecting southwestern Alberta have had similar synoptic patterns. However, there are other patterns which have also produced heavy precipitation in the same area.

2. Since upslope plays a major role in the patterns described in this paper, topography determines the main precipitation patterns.

3. The lack of "protective" ranges or hills in the southwestern corner of Alberta permits greater easterly upslope lift over short distances resulting in copious precipitation.

4. April is the month of highest mean monthly snowfall along the eastern slopes of the mountains from west of Calgary to Glacier Park. Mountain stations from Banff to Waterton Park tend to show a secondary maximum in April.

5. Heavy spring precipitation events in southwestern parts of the province are not necessarily annual events. However, in some springs, several storms have followed in relatively close succession.

ACKNOWLEDGMENTS

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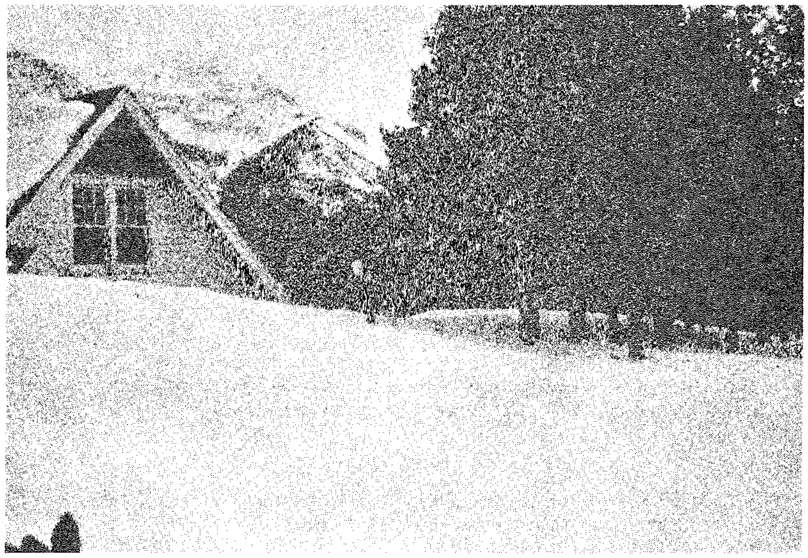

Waterton townsite, April 1967. Muledeer is standing on 14 feet of snow.

Waterton townsite. Snowclearing late April 1967.

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