LAKE EFFECT SNOWS OF ROCHESTER AND BUFFALO, NEW YORK

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ABSTRACT

The closely spaced National Weather Service offices at Buffalo and Rochester, New York provide an opportunity to study station spacing on forecasting capability for the Great Lakes winter phenomenon of lake-effect snowfalls. Such snowfall episodes are presently undetectable in Rochester from Buffalo radar, with percentages of total accumulations being unpredictable by regression techniques varying between 24 and 79% over the winter season. Daily characterizations of snowfall attributable to "lake-effect" demonstrate the differing causative factors in each station's snowfall amounts.

1. INTRODUCTION

One area which commands much of the current effort in weather forecasting and research investigations is that of the mesoscale. Recent studies have focused particularly on thunderstorm phenomena. Another important phenomenon which affects large numbers of people in the Great Lakes region is winter lake-effect snowfalls (2). This is a frequently localized, potentially severe weather and life-threatening situation occurring to the lee of the Great Lakes over several months during the winter. This phenomenon provides a good opportunity to study the predictability of mesoscale activity based on the existing National Weather Service synoptic station spacing.

Lake-effect snow is produced during the winter months when cold air passes over the relatively warmer waters of the Great Lakes. The moisture added to the air produces low clouds and precipitation over land to the lee-side of the water bodies. This process usually requires at least 50 miles of passage over water before significant lake-effect snow is produced (3). These snowfalls usually occur after cold frontal passages when arctic air masses cross the lakes -- normally periods of predictably clearing weather under high pressure. Holroyd (4) noted that most significant lake-effect snowstorms around the eastern Great Lakes occurred when the temperature difference between the lake surface and the 850 mb level was 13 C° or more. These conditions are met on many occasions between November and March each year.

2. METHOD

The stations chosen for the study were the adjacent National Weather Service offices at Buffalo and Rochester, New York. Buffalo is a Forecast Office with responsibility for western New York and is equipped with a WSR-57, 10-cm radar. As noted by the Narrative Summaries in the Local Climatological Data for Buffalo and Rochester, the cities are affected by different weather controls. Buffalo is located 9 miles downwind of Lake Erie relative to the prevailing southwest wind direction. Rochester, on the other hand, is 7 miles south of Lake Ontario. Lake Erie frequently freezes over in winter shutting off the lake-effect mechanism. Lake Ontario almost always remains unfrozen in the winter.

Figure 1 shows the wind roses for Buffalo for the months November through March. Figure 2 shows the wind directions which allow the 50-mile or more passage over open water necessary for the major lake-effect snows near the two National Weather Service offices. The critical directions for Buffalo are SW to WSW (250° to 265°, relative to N), while Rochester's are WNW to ENE (295° to 70°). Thus, Rochester may be subjected to snow from wind directions over a fan-shaped approach covering 125° of arc while Buffalo is affected by an approach of only about 35°. Over a snow season the amounts at both cities are similar, due to a higher frequency of southwesterly winds at Buffalo that offsets their smaller angle of vulnerability and shorter period of open waters. Table 1 shows the percentage of time during the winter period (December - March) when winds are from the respective directions as derived from the wind roses. (Of course, with some strong winds, lake-effect bands may reach far enough to involve both cities at the same time.) The viewpoint taken for the following discussion will be that of the predictability of snow in Rochester from Buffalo, as that is the Forecast Office site.

3. RESULTS

Lake-effect snow should be detectable on radar. However, typical radar beam characteristics show minimum detectable echo top heights to be around 3000 feet at 50 nautical mile range, increasing to 9000 feet at 100 nautical mile range (6). Lake-effect clouds have typically been observed from a 5-cm commercial weather radar operated by WOKR-TV, Channel 13 in Rochester to have tops at 9000 to 10,000 feet over the lake, decreasing to 5000 to 7000 feet on landfall. Simultaneous observations by the Buffalo radar of the clouds approaching Rochester from the west track such clouds only as far as 30 miles to the west of Rochester. Then they disappear below the beam (7). Also, light snow (the majority of lake-effect) is much less effectively detected by 10-cm radars, such as Buffalo's, than by the commercial type in use at WOKR.

If such snow is not detected by radar and is due to local wind conditions and proximity to open lake surfaces, could Buffalo predict Rochester's amounts based on local accumulations? Correlating Rochester snowfall amounts against Buffalo amounts for December, January, February and seasonal total for the period 1941-42 through 1979-80 yielded percentages of predictability. The percentages given in Table 2 show the percent of total variation in Rochester amounts that can be explained by a linear relationship based on Buffalo snowfall.

Only in the case of February total snowfall can the Rochester total be predicted with more than half of the monthly variation accounted for. And even here, 24% of a monthly average 22.8 inches is 5 to 6 inches of unpredictable snowfall. With past values in February of to 65 inches, almost 16 inches could be unpredicted. December values could yield 79% of the average 19 inches, or 15 inches, unpredicted. Again, the maximum in a December of 44 inches would give an unforeseen 35-inch accumulation. This amount could occur early in the season before residents and travelers are psychologically prepared for it.

The previous comments applied to total monthly and seasonal amounts. These include contributions due to passing frontal storms as well. A more pertinent study is the daily snowfall values for the months of December, January, February and March for five winters, 1976-77 to 1980-81. "Lake-effect snow" was considered to be beyond an arbitrary threshold of one inch accumulation, chosen as an amount indicative of possible social, economic or safety consequence. Further, a difference between the two stations of at least one inch with the wind direction in the predetermined range at the station of heaviest accumulation was required. Certainly lake-effect snows make up a much larger number of all snow days than these arbitrary criteria indicate. Thus, these total days will be conservation estimates. Table 3 shows the number of such "lake-effect" episodes in the past five winters.

The results clearly show the heavy snow accumulations in Buffalo during the two severe winters, 1976-77 and 1977-78. The remaining year totals parallel the milder winters that followed. The figures also demonstrate the cessation of lake-effect snows in Buffalo in February and March as Lake Erie freezes. Finally, the decrease of lake-effect snows in both cities in March is evident as air temperatures rise above lake temperatures, also ceasing lake-effect snow production. These trends seem to indicate the arbitrary "lake-effect" snow definition is essentially valid if overly conservative. Overall, the values demonstrate that significant snowfall episodes are affecting each city at different times as would be expected by the differing mechanisms.

4. CONCLUSIONS

Rochester is a major metropolitan area of New York State that is subject to a unique winter phenomenon, lake-effect snow. These snow episodes, sometimes highly localized, can have a significant impact on area transportation, economy and safety. This type of snow is currently undetectable from Buffalo and occurs under a different set of circumstances from that for Buffalo. Long distance forecasting based on local observations in Buffalo would be a complicated, if even possible, procedure. On a real-time basis, the Buffalo radar would not help in detecting these episodes.

Such a localized weather phenomenon affecting large numbers of people needs a system of observing sites closely spaced. Even the present spacing of National Weather Service offices around the shores of Lake Ontario can prove too sparse as motorists are fond of reminding everyone after they have experienced an unexpected "chance of flurries" several inches deep.

Table 1. Percent of time wind direction is in decisive interval for each station during the winter season.

Directions	PERCENT OF TIME Dec	Jan	Feb	Mar	Aug
BUF: SW - WSW	21	21	26	24	23
ROC: WNW - ENE	30	33	31	39	33

Table 2. Percentage of variation of Rochester snowfall attributable to linear prediction from Buffalo.

PERCENTAGE EXPLAINED Dec	Jan	Feb	Season
21	44	76	34

Table 3. Number of defined "lake-effect" snow episodes at Buffalo and Rochester during five recent winters.

Winter	NUMBER OF LAKE-EFFECT SNOW EPISODES Dec		Jan		Feb		Mar		Total	
	BUF	ROC	BUF	ROC	BUF	ROC	BUF	ROC	BUF	ROC
1976-77	5	2	21	2	2	0	1	1	29	5
1977-78	6	2	3	6	3	4	0	1	12	13
1978-79	0	2	4	3	0	3	0	1	4	9
1979-80	0	1	1	1	0	4	0	4	1	10
1980-81	1	5	0	7	0	0	1	0	2	12

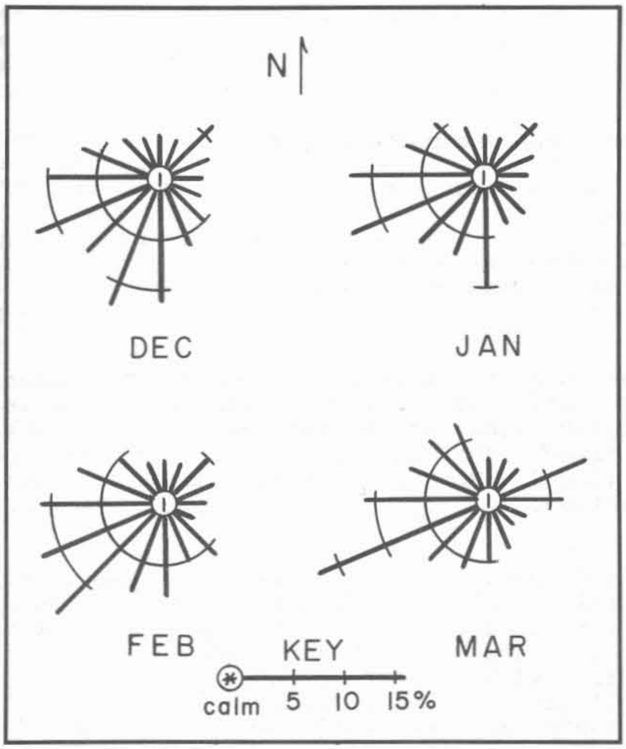

Figure 1. Wind roses at Buffalo, New York, for the months of December, January, February and March. Each succeeding concentric circle denotes 5% of the hours when the wind was from that compass direction. The number in the center denotes the percent of time the wind was calm, (5).

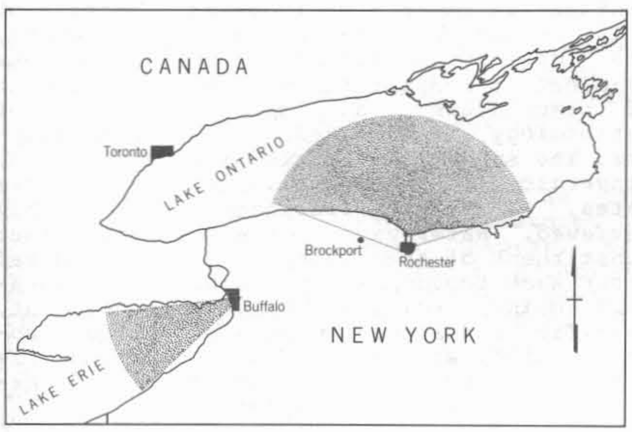

Figure 2. Interval of wind directions that may produce lake-effect snowfall at Buffalo and Rochester, New York.

REFERENCES AND FOOTNOTES

1. Robert S. Weinbeck has been Assistant Professor of Meteorology in the Department of the Earth Sciences at SUNY Brockport for the last four years. His research interests include mesoscale lake-effect studies and solar-terrestrial influences.

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