

# Case Study

## A RECORD SETTING LAKE EFFECT SNOWSTORM AT BUFFALO, NY

by  
Thomas A. Niziol (1)  
National Weather Service  
Buffalo International Airport  
Buffalo, NY

### ABSTRACT

*On January 10-11, 1982 a very strong, localized Lake Effect snowstorm occurred over Buffalo, NY. In a 24 hour period just over two feet of snowfall was recorded at the Buffalo airport. During the storm the heaviest activity was confined to a narrow band, five to ten miles wide, affecting a large percent of the population in the city and adjacent suburbs. The purpose of this paper is to present the meteorological conditions responsible for the storm. A synopsis of the large scale weather pattern is presented, and some important observations about the meso-scale features of the snow band are discussed.*

### 1. INTRODUCTION

Residents of Buffalo, NY develop an increased awareness of the local weather during the late fall and winter months, and for a good reason. The localized snowstorms that form off the eastern end of Lake Erie during this period have been known to bring the entire area to a standstill in a very short time. On the afternoon of Sunday, January 10th, 1982 one such snowstorm occurred.

A band of Lake Effect snow squalls formed that morning, in traditional fashion, well south of the city. The band of snow intensified as it moved north, over the city and adjacent suburbs during the afternoon, centering itself over the Buffalo airport. Heavy snowfall whipped up by the strong winds paralyzed the area. By the afternoon of the next day, 28.3 inches of fluffy snow had fallen at the Buffalo airport. Although greater amounts of snow fell during previous storms, a new 24 hour record for snowfall was set on this date at the Buffalo airport.

### 2. LAKE EFFECT REVIEW

It has been long established that certain meteorological conditions are responsible for the formation and life cycle of Lake Effect storms. These conditions were summarized by Wiggin (2). And two of the most important factors are listed below:

- 1) A strong flow of arctic air across the relatively warm lakes creating lee shore lapse rates that are adiabatic or greater to 5000 feet.
- 2) Wind trajectories that circulate the air across a long fetch of the warm lakes.

Certain synoptic features show up time after time to produce these conditions and were summarized by Hill in his literature review of Lake Effect weather (3). These include:

- 1) A strong flow of arctic air over the lower Great Lakes behind a low pressure system that has moved into eastern Canada.
- 2) The southward extension of the parent low in the form of a trough over the Great Lakes.
- 3) A trough aloft over the eastern U.S. or Canada that frequently stagnates or broadens to the west.

These synoptic features were all present to some degree during January 10-11, 1982, creating meteorological conditions that were highly favorable for Lake Effect snow.

### 3. BUFFALO'S LOCATION FOR LAKE EFFECT

The city of Buffalo is in a prime location for Lake Effect weather, located at the eastern end of 220 mile long Lake Erie. The history of Lake Effect storms over Buffalo indicates that the prevailing west-southwest winds generally position most Lake Effect activity south of Buffalo. When the winds back to the southwest, the squalls migrate north, over the city and adjacent suburbs. A southwest trajectory produces the longest fetch over Lake Erie, and the potential for heavy Lake Effect activity. Previous studies suggest that the winds above the gradient layer, generally between two thousand and seven thousand feet determine the band orientation and location (4). A general rule of thumb at the Buffalo weather office implies that a wind direction of 240° to 250° at the 850 mb. level will position Lake Effect activity over Buffalo.

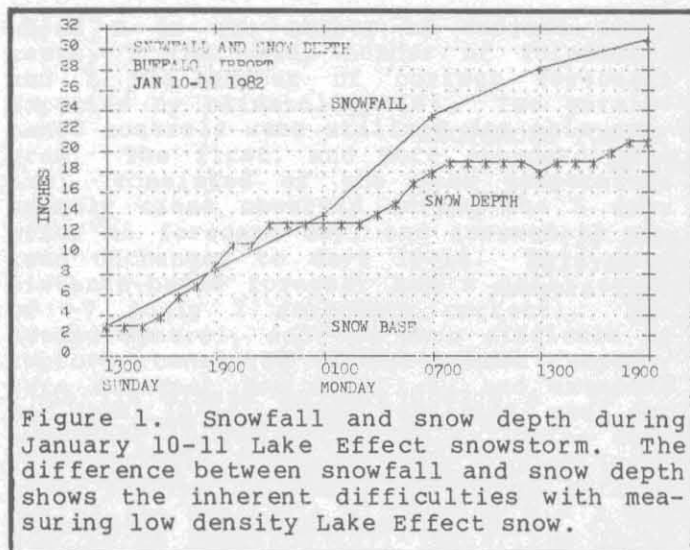


Figure 1. Snowfall and snow depth during January 10-11 Lake Effect snowstorm. The difference between snowfall and snow depth shows the inherent difficulties with measuring low density Lake Effect snow.

It has been shown in the past that the most productive Lake Effect snowstorms occur during late November or early December (5). Lake Erie usually freezes over by January, ending Lake Effect activity. An unusual aspect of this storm was the fact that due to a somewhat mild November and December, the lake was relatively ice free this late in the season. The potential for a Lake Effect snowstorm was excellent if an arctic airmass moved across the lake.

4. SYNOPTIC FEATURES OF THE STORM

The synoptic conditions responsible for the storm were close to textbook. During the days before the storm, the upper air pattern over North America set up to push a very cold, deep pool of arctic air into the Lower Great Lakes region. Figure 2a shows the polar vortex at the 500-mb level responsible for the arctic outbreak.

Conditions at lower levels of the atmosphere were similar. The low center at the 700 mb and 850 mb level dug southward, developing a broad trough across the Lower Great Lakes Region (Figures 2b and 2c). The vertical stacking of the storm is apparent at these levels. Lack of vertical wind shear has been shown to enhance the precipitation frequency of convective cells, and in this case, allowed a well organized longitudinal band.

Mean sea level pressure is shown at 12 hour intervals in Figure 3. The low center pushed southward developing a strong gradient over the lakes. Consequently, from the surface up to the 700 mb level, a cyclonically curved southwest to northeast flow existed over the longest fetch of Lake Erie.

5. OBSERVATIONS OF STORM MESO-FEATURES

Table 1 is a summary of the observations

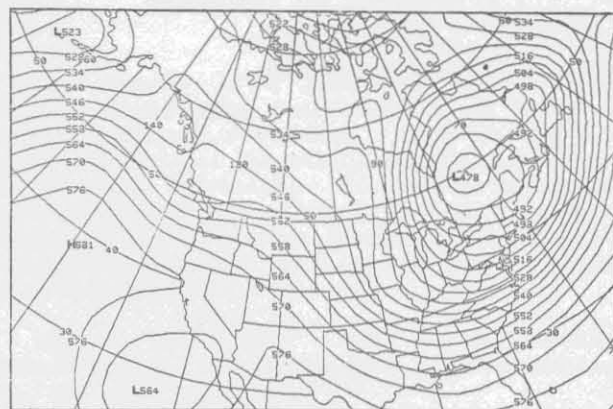


Figure 2a. 500 mb heights over North America, 1900 EST Sunday, January 10, 1982.

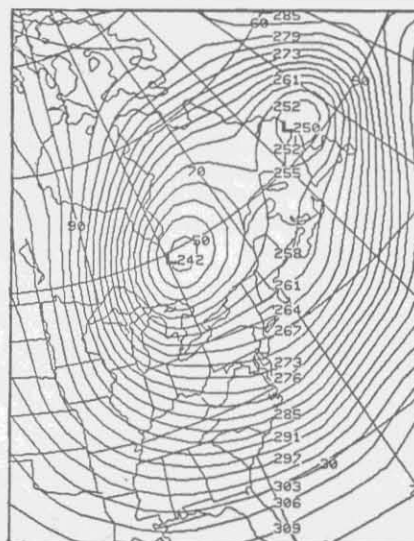


Figure 2b. 700 mb heights over North America, 1900 EST Sunday, January 10, 1982.

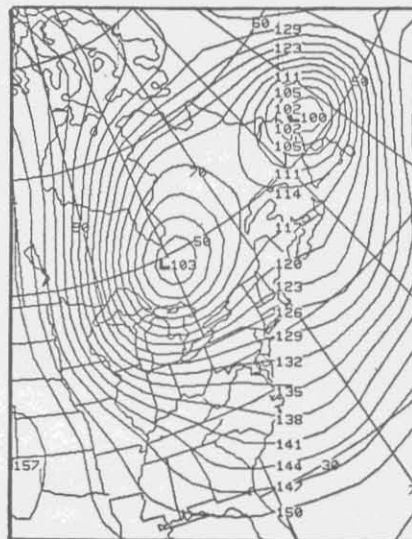


Figure 2c. 850 mb heights over North America, 1900 EST Sunday, January 10, 1982.

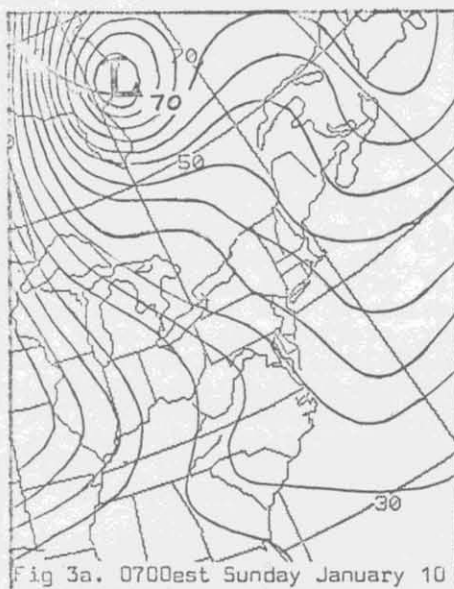


Fig 3a. 0700est Sunday January 10

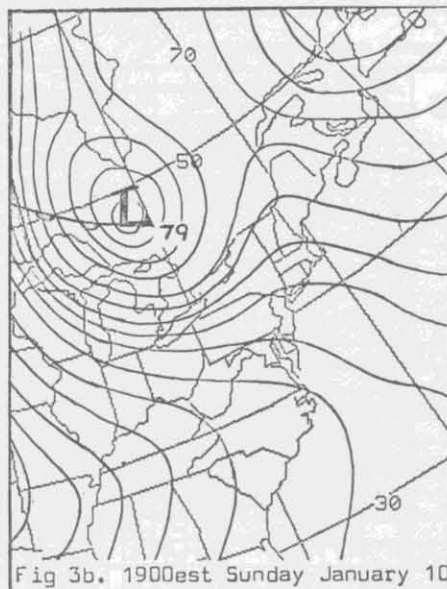


Fig 3b. 1900est Sunday January 10

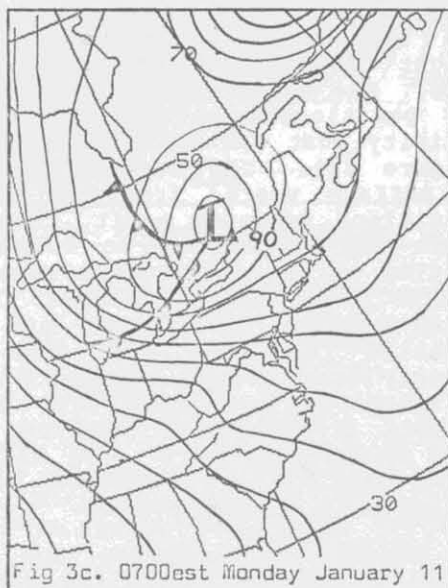


Fig 3c. 0700est Monday January 11

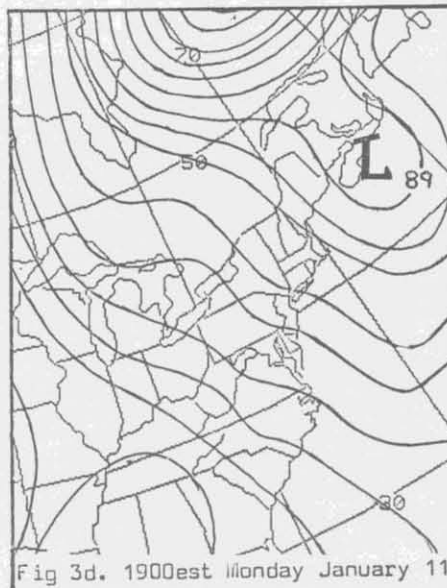


Fig 3d. 1900est Monday January 11

Figure 3. Mean sea level pressure with isobaric interval of 4 mb during January 10-11, 1982.

taken at the Buffalo airport during the storm. These observations, coupled with overlays from the National Weather Service radar at Buffalo, provide some interesting observations about the meso-structure of the storm.

Figure 3a shows the location of the surface low at 0700 EST Sunday, January 10th. The Buffalo sounding at the time indicated a very cold influx of arctic air into the region, and the wind direction up to 7000 feet was generally out of the northwest (Table 1a).

During the morning an organized band of lake squalls developed and began to migrate north toward the city. The northern

edge of the snow band moved into the city by mid-afternoon. At this time, the heaviest snow was falling south of the Buffalo airport, but airport visibility had already dropped to 1/4 to 1/2 mile in moderate snow and blowing snow. This is apparent from the 1530 EST radar overlay, which indicates precipitation contours in the form of snow off the eastern end of Lake Erie (Figure 4a). As the heaviest activity moved over the airport, the surface wind direction shifted from 280° to 250°, then 220°. At Niagara Falls, 14 miles to the northwest of Buffalo, the wind direction remained at 260°. Apparently, the windshift at Buffalo signalled the passing of the convergence zone, located somewhere beneath the northern edge of the heaviest

MP1-10A (4-75)		U.S. DEPARTMENT OF COMMERCE ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION WEATHER BUREAU										
SURFACE WEATHER OBSERVATIONS												
TYPE	TIME (LST)	SKY AND CEILING (Hundreds of Feet)	VISIBILITY (Statute Miles)		WEATHER AND OBSTRUCTIONS TO VISION	SEA LEVEL PRES. (Hpa.)	TEMP. (C)	DEW PT. (C)	WIND			ALTIM. ETER SET- TING (Inch.)
			SURFACE	TOWER					DIREC- TION (Deg.)	SPEED (Kts.)	CHAR- ACTER	
(1)	(2)	(3)	(4)	(4a)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
SA	1250	12sect 85sect	7			055	3	-10	26	26/34	964	
SP	1348	-x e28hkn	4		bs				27	29/37	961	
SA	1350	-x m17ovc	2		bs	044	2	-9	27	25/35	961	
SP	1413	-x m15bkn	4		bs				28	29/32	958	
SP	1430	-x m12bkn	2		bs				28	27/33	957	
SP	1435	-x m12ovc	1/2v		s-bs				28	22/33	957	
SP	1442	w5x	1/4v		sbs				28	23/31	957	
RS	1450	w6x	1/4v		sbs	020	2	-5	28	23/29	956	
RS	1550	w6x	1/4v		sbs	020	3	-2	27	25/30	953	
SP	1605	-x m5bkn	1/4v		sbs				25	26/37	952	
SP	1620	w4x	1/8		s+bs				22	20/37	953	
SP	1630	w2x	1/16		s+bs				22	25/31	951	
SA	1650	w2x	1/16		s+bs	009	0	-3	23	27/33	950	
RS	1750	w0x	0		s+bs	005	0	-5	22	28/38	949	
SA	1850	w0x	0		s+bs	996	-1	-6	22	30/37	946	
SA	1950	w0x	0		s+bs	988	-3	-8	22	26/31	946	
CA	2050	w0x	0		s+bs	986	-4	-8	22	30/40	943	
SA	2152	w0x	0		s+bs	994	-2	-4	25	24/30	945	
SA	2254	w0x	1/16		sbs	990	-1	-5	29	26/36	944	
SA	2350	w0x	1/16		sbs	985	-3	-6	26	30/38	943	
SA	0051	w0x	1/16		sbs	974	-3	-5	27	26/32	940	
SP	0107	w0x	1/4		sbs				28	22/38	939	
RS	0150	w0x	0		s+bs	973	-2	-3	23	16/33	940	
SA	0250	w0x	0		s+bs	974	-2	-6	22	25/33	940	
SA	0350	w0x	0		s+bs	966	-3	-6	21	25/38	938	
SA	0450	w0x	0		s+bs	966	-2	-5	22	30/40	938	
SA	0550	w0x	0		s+bs	974	0	-3	21	29/42	940	
SA	0651	w0x	0		s+bs	981	2	-1	22	26/33	942	
SA	0750	w0x	1/16		s+bs	985	5	2	26	25/34	943	
SA	0850	w0x	1/16		s+bs	991	9	9	28	37/39	943	
SA	0950	w1x	1/16		s+bs	998	8	7	26	42/36	947	
SP	1010	w3x	3/16		sbs				27	25/35	951	
SP	1042	-x e6ovc	1/4		s-bs				27	25/31	952	
CA	1051	-x e6ovc	1/4		s-bs	014	10	10	26	24/30	952	
SP	1129	-x e6bkn	1/4		s-bs				27	22/29	954	
SA	1151	6sect e10ovc	1		s-bs	021	11	10	27	22	954	
RS	1250	-x 5sect e10ovc	1/2		s-bs	025	12	11	27	20/29	955	

Table 1. Surface Observations taken at Buffalo airport during January 10-11, 1982.

DATE	TIME (EST)	LAKE TEMP(C)	SFC	WINDS(KTS.)/TEMP(C)		
				850mb	700mb	
JAN 10	0700	0	320° 16/-20	300° 36/-28	280° 42/-37	
	1900	0	220° 23/-18	250° 50/-24	275° 63/-34	
Jan 11	0700	0	210° 29/-18	250° 65/-22	295° 57/-30	
	1300	0	310° 14/-12	290° 27/-20	300° 55/-28	

Table 1a. Sounding data taken at Buffalo during January 10-11, 1982. Wind direction, wind speed and temperature are shown at three significant levels. Average Lake Erie water temperature is also shown.

snow. This is a very marked meso-scale feature of the snowband and has been analyzed in past Lake Effect episodes (6). The wind direction at Buffalo and Niagara, along with the radar overlay, would position the convergence zone just north of the Buffalo airport.

As evening approached, the band intensified, and remained nearly stationary over the Buffalo airport. The surface low center continued to dig southward, developing a very strong southwest flow up the length of Lake Erie (Figure 3b). The strong wind speeds observed throughout the cloud layer resulted in longitudinal stretching of the snow band, producing Lake Effect snow as far inland as Rochester. The temperature of the airmass was still extremely cold (Table 1a). The orientation of the snow band in the 1930 EST radar overlay was in good agreement with the 850 mb wind direction. The sounding indicated a direction of 250° at this level, roughly parallel to the snow band. The surface wind direction at Buffalo and Niagara continued to indicate a convergence zone operating beneath the band.

These conditions existed for the most part until Monday morning. There was a brief period though, at the Buffalo airport when conditions improved very slightly. This was apparently in response to a very slight southward migration of the snow band. The radar overlay at 2330 EST Sunday positioned the axis of the heaviest activity just south of the Buffalo airport (Figure 4c). The surface wind direction at Buffalo veered from 220° to 270° and conditions improved a bit. The wind shift again may have been in response to the passing of the convergence zone, this time to the south of the airport. Soon afterwards however, heavy snow and zero visibilities returned. The 0330 EST radar overlay from Monday morning showed heaviest activity centered over the Buffalo airport (Figure 4d). Surface wind direction backed to 220°. The wind direction at Niagara Falls remained at 250° to 260° during this entire episode.

By Monday morning, the low center was speeding rapidly toward the east coast and a trailing warm front was circulating down toward the lower Great Lakes (Figure 3c). The sounding at 0700 EST Monday indicated very little warming of the airmass. The wind direction at the 700 mb level had shifted to the northwest, but wind directions below that level had shown little change. The 0730 EST radar overlay indicated two bands of snow (Figure 4e). The heaviest part of the Buffalo snow band had migrated south of the Buffalo airport, and the surface wind direction at Buffalo soon shifted to 250°. Sky conditions and visibility gradually improved as the warm front passed across the area.

By 1030 EST Monday morning, the radar overlay showed quite a change in the orientation of the snow bands (Figure 4f). The Buffalo band was rotating into an east-west axis, and the axis of the snow band off Lake Ontario was actually northwest-southeast. The upper trough gradual-

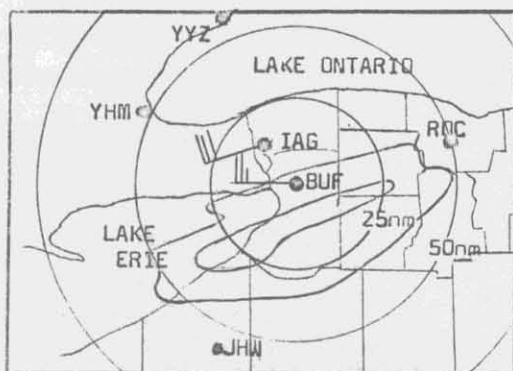


Fig 4a. 1530est Sunday January 10

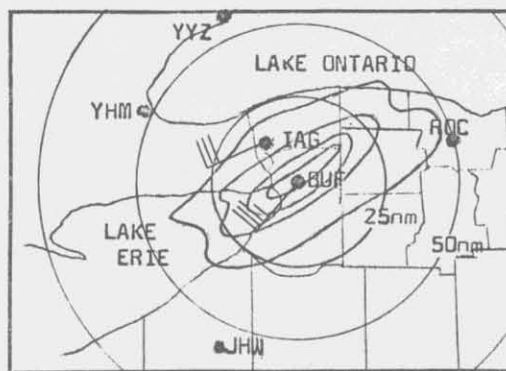


Fig 4b. 1930est Sunday January 10

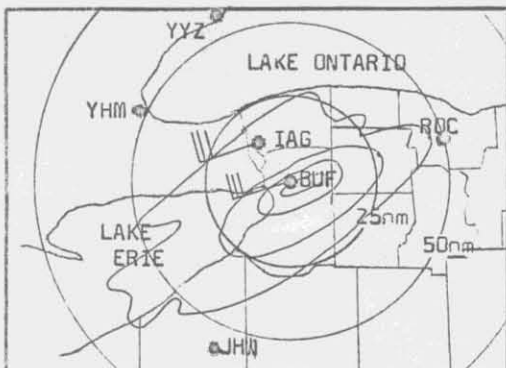


Fig 4c. 2330est Sunday January 10

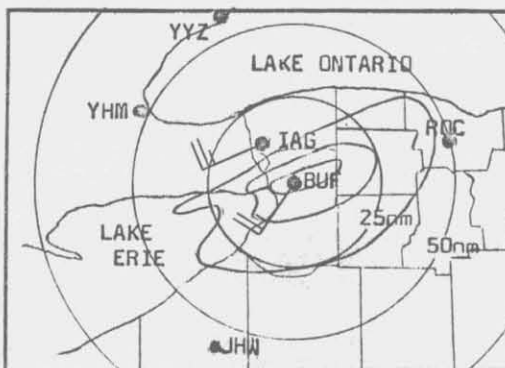


Fig 4d. 0330est Monday January 11

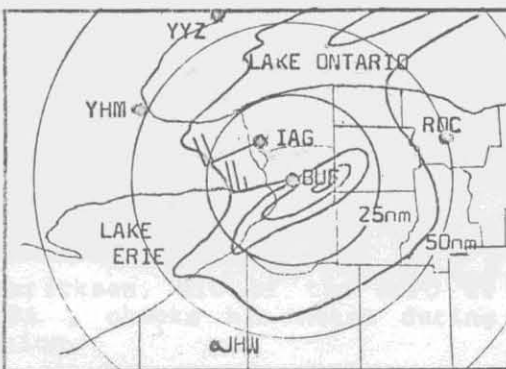


Fig 4e. 0730est Monday January 11

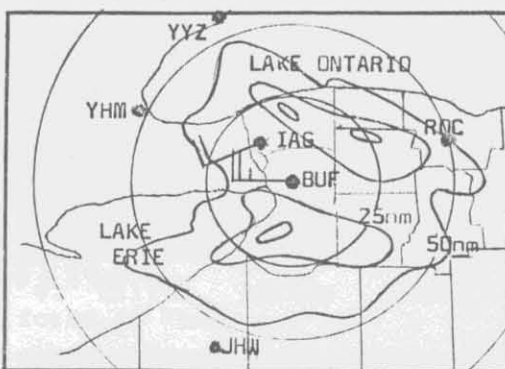


Fig 4f. 1030est Monday January 11

Figure 4. Overlays from the NWS-57 radar at Buffalo, NY. Contours are not standard VIP levels, but rather correspond to increased signal attenuation in linear mode. This method was developed at Buffalo to determine snowfall intensity, mainly in the form of squalls from Lake Effect snowstorms.

ly passed through the area by midday, shifting the winds in the cloud layer, and therefore the axis of the snow bands.

Conditions generally improved during Monday afternoon, although Lake Effect snow continued over the traditional snow belts south of the city. The arctic airmass remained over the lower Great Lakes region through Monday night, and combined with northwest winds, continued to produce Lake Effect snow to the south and east of Lake Ontario.

## 6. STORM SUMMARY

Snow depth reports from the local A.M.S. snow spotter network indicated that the greatest snow amounts were confined to a narrow band around the Buffalo airport. The airport, as well as most schools and businesses around western New York were closed that day. Although the airport totaled 28.3 inches of snowfall, settling and wind blown packing of the low density Lake Effect snow compacted the depth to 18 inches (Figure 1).. The storm began over

the traditional snowbelts south of the city and eventually migrated back to that area, producing a secondary snowfall maximum.

This snowstorm was compared by many people to the infamous "Blizzard of '77", still fresh in the memories of Western New Yorkers. Fortunately, the brunt of the January 10-11 storm lasted about 18 hours, whereas the '77 blizzard raged for four days. Because the snowstorm occurred Sunday afternoon and Sunday night, a large percent of the population was safe at home, rather than stranded at school or work. In addition, the Buffalo office of the National Weather Service had issued a winter storm warning for Buffalo and vicinity about 10 hours before the storm struck . . . . early Sunday morning.

7. CONCLUSIONS

This paper has served to document a classic Lake Effect snowstorm over Buffalo, New York. In general, the basic conditions necessary for the development of Lake Effect snow were met: a) the waters of Lake Erie were relatively ice free; b) an extremely cold arctic airmass circulated down acrosss the lake, and c) the accompanying wind trajectories were relatively constant, out of the southwest for an extended period of time. Although it is a very delicate task to achieve a balance of these conditions in nature, they do occur often enough to keep the residents of Buffalo on guard during the winter months.

The waters of Lake Erie will continue to spawn localized snowstorms along its lee shore in the future, but the knowledge gained from each episode will contribute to a better understanding of the processes involved in a Lake Effect storm.

REFERENCES AND FOOTNOTES

1. Tom Niziol is a meteorologist intern at WSFO Buffalo, NY. Previously, he worked in atmospheric research for Calspan Corporation. His main interest in operational meteorology is Lake Effect weather.
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