SNOW STUDY

WHEN SNOW SQUALLS BECOME NO SQUALLS

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ABSTRACT

A late winter lake effect snow storm developed along the western shore of Lake Michigan on 9-10 March, 1983. An arctic air outbreak across warmer waters created adiabatic and super-adiabatic lapse rates in the boundary layer. Less than 24 hours after the snow squalls began, an influx of warmer air shut off the convective instability. The case is discussed from an operational forecasting viewpoint, with attention focused on subtle changes in key parameters that led to the quick end of the snow.

1. INTRODUCTION

The Great Lakes exert a major influence on the local climate of the upper Midwest. In summer the cooler waters hold lakeshore temperatures 10 to 15 degrees below inland readings, and the lake breeze modifies the boundary layer over land. This modification can also take place in winter on the lee of the Great Lakes (2) resulting in lake effect snows.

The months of November and December are favorable periods for significant lake snow squalls. Water temperatures are still relatively warm from the summer heating, and surges of arctic air stream southward across the upper Midwest. The synoptic condition favorable for lake effect squalls is well documented in the literature (2,3,4,5,6,7). The synoptic situation varies considerably from this in the late winter and early spring as arctic outbreaks begin to give way to warmer air masses.

On Wednesday, 9 March, 1983, cold air began pushing across the western Great Lakes in the wake of a departing storm system. The lee (western) shore of Lake Michigan appeared to be in a position to receive lake effect snow in excess of 5 inches. Although this is a dusting compared to early and mid-winter squalls, it could cause travel problems and catch people unprepared in early March. In Milwaukee the snow began early on the 9th, but quickly ended after leaving a little more than 3 inches of snowfall at Mitchell Field with lesser amounts away from the lake.

2. SYNOPTIC FEATURES

The week prior to 9 March, 1983, was unseasonably mild for Milwaukee and most of the upper Midwest. Mitchell Field reached record highs on 3 March (72°F), 6 March (64°F), and 7 March (59°F). The warmth was brought northward by winds at the surface and aloft ahead of a cut-off low in the central Plains. The low began to lift out and move east so that by the morning of 9 March a surface cyclone (1003 mb) was located near Sault St. Marie, MI (Figure 1). Cyclonic curvature of the wind field at the surface and 850 mb (Figure 2) aided in the development of light snow across Wisconsin, northern Michigan, eastern Minnesota, eastern Iowa and northern Illinois.

3. THE FIRST 24 HOURS

Table 1 lists the FOUS output from 12Z 9 March. Thickness of the 1000-500 mb layer was projected to drop from 5350 meters to 5290 meters in 24 hours, and the boundary layer temperature was predicted to cool from 274°K (1°C) to 258°K (-15°C) in the same time period. These progs looked reasonable in light of the cold air advection that often takes place on the back side of a surface cyclone. Boundary layer winds were forecasted from a direction of 010° to 020° at nearly 30 knots over the next 36 hours. For Milwaukee this wind direction would allow for maximum fetch of cold air over Lake Michigan. The average water temperature for Lake Michigan near Milwaukee on 9 March is 3°C (37°F). If boundary layer temperatures were to drop to -15°C by 12Z 10 March, an 18 degree water-to-air temperature difference would be favorable for super-adiabatic lapse rates and lake effect squalls (8).

The evolution of surface conditions at Milwaukee is represented by the data in Table 2. A surface trough extending south-southwest from the low passed through southeast Wisconsin between 16Z and 17Z 9 March. Temperature and dew point began dropping with the passage of the trough, and visibility remained below 2 miles in light snow, fog, and haze through 01Z 10 March. A wedge of 850 mb temperatures below -10°C can be seen pushing southward over Wisconsin and Illinois at 00Z 10 March (Figure 2). Conditions appeared favorable for a continuation of snow in the Milwaukee metropolitan area, and forecasts mentioned heavier snow amounts near the lake.

4. THE LAST 24 HOURS

Although the surface cyclone over northern Michigan was weakening, it remained nearly stationary from 12Z 9 March to 00Z 10 March. Between 00Z and 12Z 10 March the surface and upper air low shifted dramatically southward (Figures 1 and 2) to a position over the Ohio Valley. A surface high and upper air ridge building eastward north of Lake Superior combined with the weak cyclone to pull warmer air back into the Great Lakes region.

In Milwaukee it is not often that warm air advection takes place under northerly flow, but the 850 mb isotherms (Figure 2) indicate the push of warmer air over Wisconsin from 00Z 10 March to 00Z 11 March. The nearest upper air sounding to Milwaukee is taken at Green Bay. The four soundings recorded from 12Z 9 March to 00Z 11 March (Figure 3) graphically illustrate the rapid cold air advection in the surface-850 mb layer and the subsequent warming that follows. The peak cold air advection in the boundary layer occurred between 12Z 9 March and 00Z 10 March, resulting in a super-adiabatic lapse rate in the lowest 44 mb at 00Z 10 March. This time period represented Milwaukee's most persistent snowfall, with 1.8 inches falling between 12Z and 18Z 9 March. Visibility remained below 2 miles from 14Z 9 March to 01Z 10 March.

From 12Z 10 March to 06Z 11 March surface winds at Milwaukee remained northerly and boundary layer winds continued from the northeast, but warm air advection raised the 850 mb temperature 8°C in 24 hours. The snow at Milwaukee ended at 17Z 10 March and surface visibilities improved to 7 miles. The surface temperature warmed from 23°F at 10Z 10 March to 28°F at 19Z 10 March, while the temperature-dew point spread grew from 4°F at 12Z 10 March to 7°F at 22Z 10 March.

		Boundary Layer Winds (knots)	1000-500 mb Thickness (meters)	Boundary Layer Temp (°K)
9 Mar	12Z	330°/14	1035	274
	18Z	330°/14	1034	273
10 Mar	00Z	010°/28	1032	266
	06Z	010°/33	1029	260
	12Z	020°/29	1029	258
	18Z	010°/29	1030	257
11 Mar	00Z	020°/26	1031	259
	06Z	010°/25	1032	261
	12Z	010°/24	1033	264

Table 1. FOUS data from 1200Z 9 March, 1983, with parameter forecasts valid every 6 hours for 48 hours.

5. SUMMARY AND CONCLUSION

For the first 24 hours of this lake effect snow event, Mitchell Field recorded 3 inches of snowfall. Other weather observers in southeast Wisconsin recorded lesser amounts (Figure 4), although locations closest to the lake received the most snow. During the early part of the storm, a typical lake effect snow situation was occurring in Milwaukee. Cold air advection in the boundary layer pushed over the warmer water of Lake Michigan creating adiabatic or super-adiabatic lapse rates below 850 mb. The snow squalls ended as fast as they developed when warm air advected into the western Great lakes. Boundary layer lapse rates were modified to the extent of shutting down the convective instability necessary to create the snow squalls.

From an operational forecasting viewpoint this case study brings up an interesting point. Even though the initial conditions may point to the development and persistence of lake squalls, a subtle change in one of the key parameters can quickly end the snow. In the case of Milwaukee's 9-10 March snowfall, movement of the surface cyclone from northern Michigan to the Ohio Valley caused warm air to enter the western Great Lakes and stabilize the lower atmosphere. Even though boundary layer winds remained northeast with a long fetch over Lake Michigan's open water, the water-to-air temperature was reduced enough to dissipate the snow activity in the lee of the lake.

	Time (GMT)	Visibility (miles)	Weather	Wind (knots)
9 Mar	12	10	S-	250°/11
	13	2½	S-HF	260°/11
	14	2	S-HF	250°/10
	15	7/8	S-HF	240°/10
	16	7/8	S-HF	250°/8
	17	7/8	S-HF	350°/10
	18	1	S-HF	330°/16
	19	1	S-HF	350°/17
	20	1	S-HF	340°/15
	21	1¼	S-HF	340°/14
	22	2	S-HF	350°/12
	23	1½	S-HF	350°/11
10 Mar	00	1½	S-HF	320°/11
	01	1½	S-HF	330°/14
	02	3	S-	350°/14
	03	3	S-	350°/16
	04	5	S-	340°/14
	05	2	S-	340°/16
	06	5	S-	340°/14

07	10	S-	350°/16
08	10	S-	350°/14
09	10	S-	350 /14
10	10	S-	350°/14
11	10	S-	350°/16
12	6	S-	340°/15
13	1	S-F	330°/16
14	3	S-F	350°/15
15	4	S-F	340°/15
16	5	S-H	350°/17
17	7		360°/18
18	7		010°/17
19	7		360°/13
20	7		350°/16
21	7		350°/16
22	7		340°/15
23	7		360°/15
11 Mar 00	7		350°/16
01	8		350°/16
02	10		330°/14
03	12		350°/16

Table 2. Surface observations at Mitchell Field.

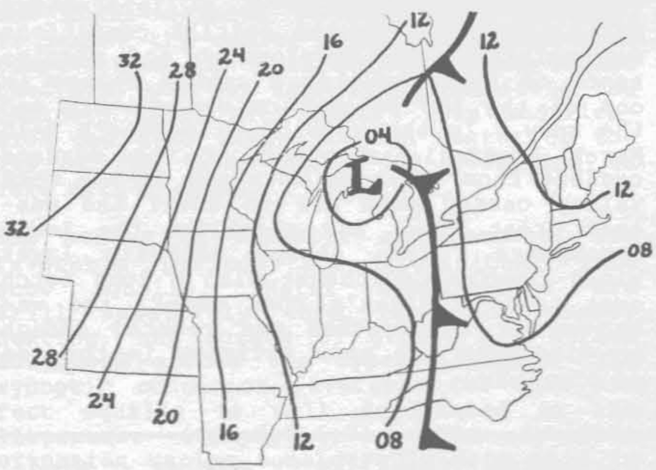

Figure 1a. Mean sea level pressure, 1200Z 9 March, 1983

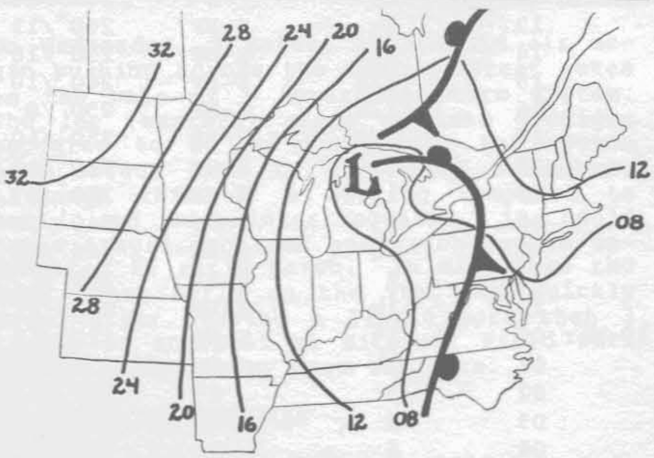

Figure 1b. Mean sea level pressure, 0000Z 10 March, 1983

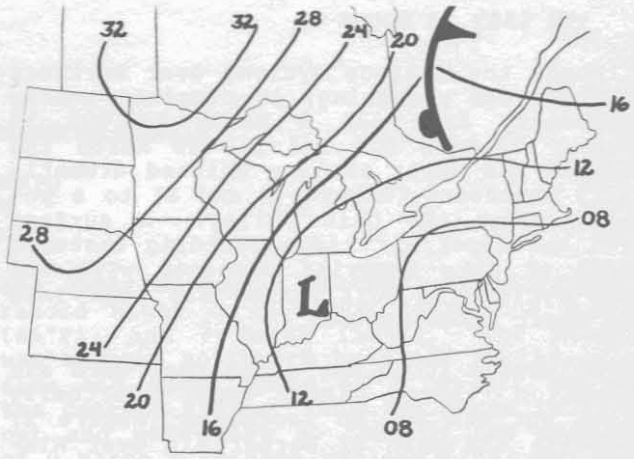

Figure 1c. Mean sea level pressure, 1200Z 10 March, 1983

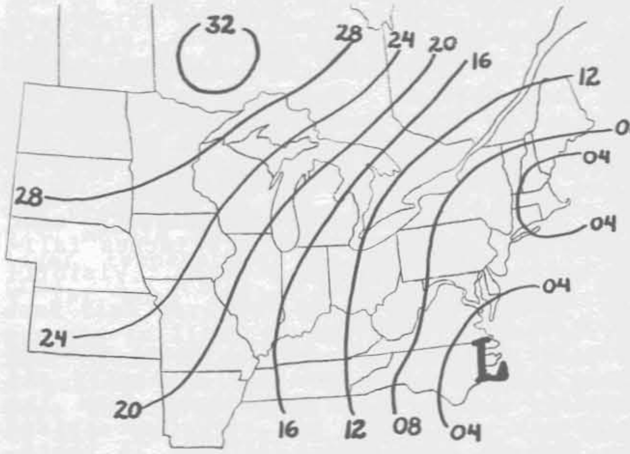

Figure 1d. Mean sea level pressure, 0000Z 11 March, 1983

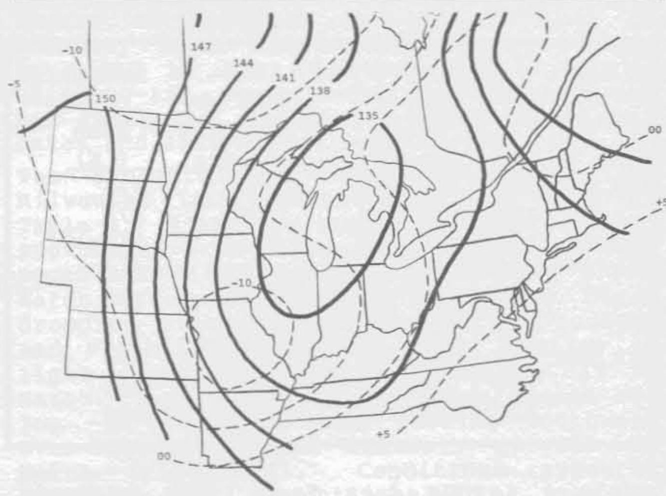

Figure 2a. 850 mb heights/isotherms, 1200Z 9 March, 1983

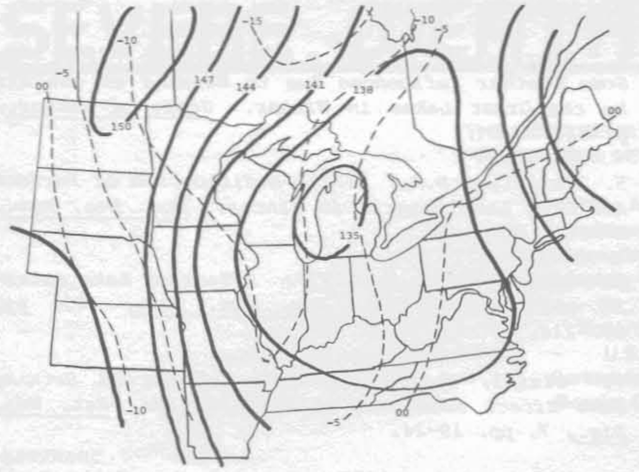

Figure 2b. 850 mb heights/isotherms, 0000Z 10 March, 1983

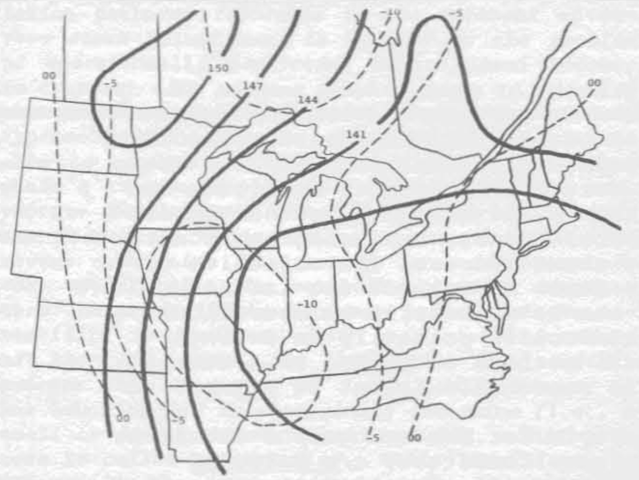

Figure 2c. 850 mb heights/isotherms, 1200Z 10 March, 1983

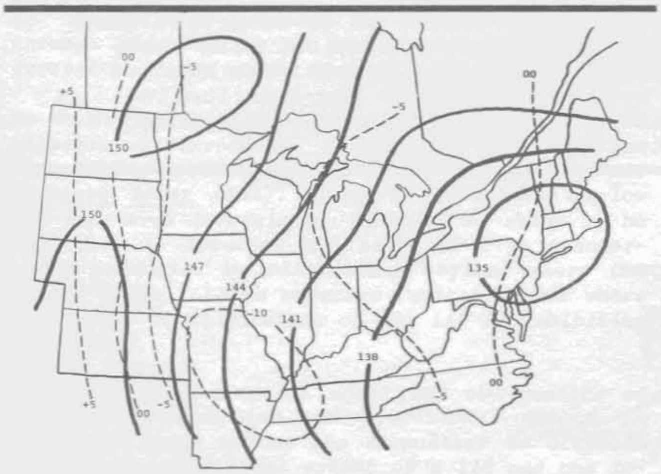

Figure 2d. 850 mb heights/isotherms, 0000Z 11 March, 1983

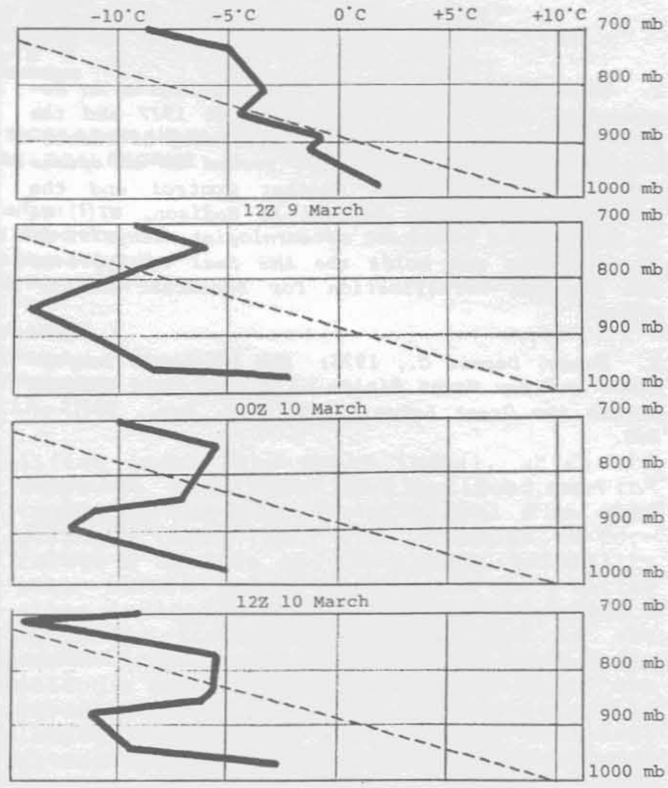

Figure 3. Upper air soundings from Green Bay for the surface to 700 mb layer. Dashed diagonal line is the 283°K isentrope.

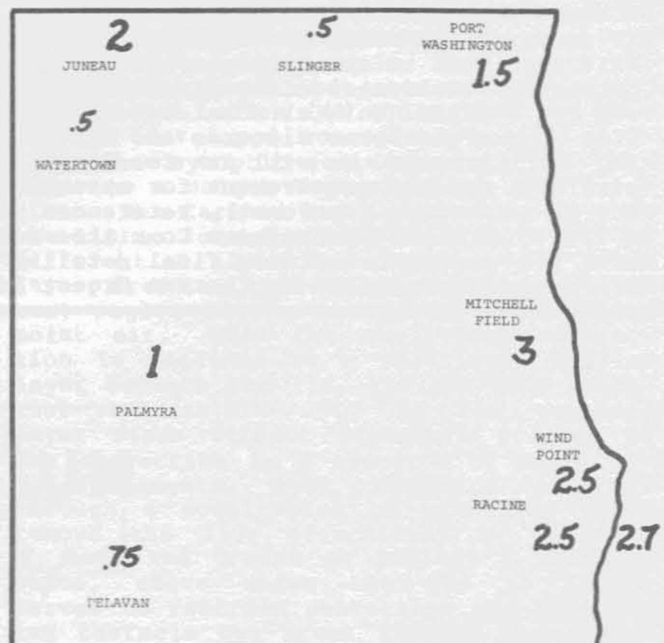

Figure 4. Southeast Wisconsin snowfall (inches) for the 24 hour period ending 1200Z 10 March, 1983.

FOOTNOTES AND REFERENCES

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2. Baker, Dennis G., 1976: The Mesoscale Temperature and Dew Point Fields of a Very Cold Airflow Across the Great Lakes. Mon. Wea. Rev., 104, p. 860.

3. Peace, R.L. and R.B. Sykes, 1966: Mesoscale Study of a Lake Effect Snow Storm. Mon. Wea. Rev., 94, pp. 495-507.

4. Petterssen, S. and P.A. Calabrese, 1959: On Some Weather Influences Due to Warming of the Air by the Great Lakes in Winter. Jour. of Meteor., p. 646.

5. Phillips, D.W., 1972: Modification of Surface Air Over Lake Ontario in Winter. Mon. Wea. Rev., 100, p. 662.

6. Wilson, James W., 1977: Effect of Lake Ontario on Precipitation. Mon. Wea. Rev., 105, pp. 207-214.

7. Niziol, Thomas A., 1982: A Record Setting Lake Effect Snowstorm at Buffalo, NY. Nat. Wea. Dig., 7, pp. 19-24.

8. Wiggin, B.L., 1950: Great Snows of the Great Lakes. Weatherwise, 3, pp. 123-126.

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