EASTERN REGION TECHNICAL ATTACHMENT
NO. 93-11B
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A CASE STUDY IN SUPPORT OF WINDEX

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1. INTRODUCTION

On Saturday January 30, 1993, an area of significant snow squalls traversed upstate New York, Vermont, New Hampshire, Maine, and Massachusetts. These squalls developed in atmospheric conditions that appeared to offer little support for more than scattered flurries. Weak positive vorticity advection (PVA) was present at 500 mb, the Nested Grid Model (NGM) mean 1000 to 500 mb relative humidity (RH) field indicated a very limited moisture supply, and the 700 mb vertical velocities were strongly negative. Despite these nonconducive factors for snow squall development, snow squalls occurred with surface visibilities reduced to 1/4 mile or less at many locations. This included a near zero surface visibility at Concord, NH, and 1/4 mile visibility at Logan International Airport in Boston, MA.

The purpose of this paper is to show that the potential for snow squalls was clearly indicated by the forecast variables used in the Wintertime INstability inDEX (WINDEX), method of forecasting non-lake effect snow squalls (see accompanying Technical Attachment No. 93-11A). WINDEX uses the NGM low level temperature differences, boundary layer relative humidity, and an increase in the lifted index over a 12-hr period to produce a Wintertime Instability Index (Fig. 1). Examination of the NGM FOUS output revealed relatively high boundary layer moisture values (R1 > 50%), low level instability (T1-T5 > 10°C), and an increase in the lifted index, with a 12-hr change greater than 8 (indicating a change in air mass). These variables produced a WINDEX favorable for snow squall development. The NGM surface graphics also indicated the passage of an arctic trough across the region from Friday night through midday Saturday, which is a key factor in the development of snow squalls.

2. SYNOPSIS AND DISCUSSION

On January 29, 1993, the evening prior to snow squall development, the 0000 UTC NGM surface prognostic package indicated that an arctic surface trough would track southeast through upstate New York and New England during the period 0000 UTC through 1800 UTC January 30. An NGM 500 mb initial analysis indicated a vorticity maximum was located over extreme southeastern James Bay (Fig. 2). At the surface (Fig. 3), a distinct arctic trough was located from near 50°N and 75°W extending southwest across Lake Superior. The mean 1000 to 500 mb RH (Fig. 4), indicated two areas of 70% RH, the first located east of James Bay, and the second located over the northern Great Lakes. The NGM model boundary layer RH (Fig. 5), was similar to the mean 1000 to 500 mb RH, although the area of 70% RH was somewhat more extensive. The NGM 12-hr prog, valid 1200 UTC January 30, showed an eastward progression of these fields. The 12-hr 500 mb vorticity maximum (Fig. 6), was positioned near 47°N and 71°W, well to the north of New England. The mean 1000 to 500 mb RH (Fig. 7), showed a broad area of RH greater than 50%, but less than 70%, over New England. The area of 70% mean 1000 to 500 mb RH, initially east of James Bay, was predicted to track north of New England. Although the mean 1000 to 500 mb RH and 500 mb vorticity progs indicated little chance for snow squall development, the NGM surface and boundary layer forecast indicated otherwise. A distinct arctic surface trough was forecast to extend from near Bangor, ME (BGR), southwest to Glens Falls, NY (GFL) (Fig. 8). The NGM boundary layer RH for 1200 UTC January 30 (Fig. 9), indicated an area of greater than 70% RH over most of northern New England and the northern half of New York. A maxima of 90% to 100% boundary layer RH was positioned over western Maine, the northern half of New Hampshire, much of Vermont, and upstate New York.

It should be noted that WINDEX is intended to forecast convective snow events. Just as a forecaster would not expect thunderstorms to occur at every observation station ahead of an approaching cold front, snow squalls cannot be expected at every observation station in the winter. It is important to note that one of the main factors that a forecaster examines to predict thunderstorms, is an increase in low level RH values, or more specifically high surface dew points. WINDEX accentuates the importance of the boundary layer RH, and if used properly, is an excellent indicator of the moisture available near the surface to support shallow convection.

Based on WINDEX, a skilled meteorologist could see a number of forecast variables favorable for snow squall development with the receipt of the 0000 UTC January 30, 1993, NGM numerical guidance. An analysis of the NGM FOUS (Fig. 10) for 5 sites in the Northeast, indicated that all upstate New York and New England, with the exception of Connecticut, Rhode Island, and southeastern Massachusetts, would be favorable locations for the development of snow showers and squalls during the next 6 to 12 hours. The lower levels of the atmosphere were expected to be very unstable for mid-winter. The NGM T5 temperature, located near 800 mb, was forecast to be at least 10°C colder than T1, located around 980 mb, for all FOUS forecast points across New England. In some locations, T5 was forecast to be as much as 15°C colder than T1, approaching a nearly dry adiabatic lapse rate. A wind shift of 30° or more from a west or southwest direction to a northwest direction was also forecast for the boundary layer, and would be the focus for squall development initiated by strong surface convergence along the frontal trough. The 12-hr change in the NGM model lifted index was forecast to increase by at least 8°C and in some cases by as much as 13°C. This large change in the lifted index is indicative of a cold frontal passage (Petersen 1992), and a substantial change in air mass. In this case, it seemed that the main limiting factor for the southern propagation of the snow showers and squalls was the boundary layer RH. It should be noted that the boundary layer RH has often been observed by this author and Lundstedt (1993), to influence the southern extent for the potential for snow showers and squalls. For this case, the boundary layer RH decreased markedly over Southern New England.

3. RESULTS

The events that occurred during the pre-dawn hours through midday on January 30, 1993 confirmed what was indicated by WINDEX. Well before daybreak, snow showers and squalls were observed at Montreal and Sherbrooke, Quebec, Massena and Plattsburg, NY, and Burlington, VT. This line of squalls moved steadily to the southeast ahead of the arctic surface trough. Snow accumulations in upstate New York reached as much as 8 inches, and in the Green Mountains of Vermont ranged up to 4 inches before the squalls entered New Hampshire.

Shortly after daybreak, the squalls were observed at Lebanon, NH, and the ASOS test sites of Whitefield and Berlin, NH. By midmorning, squalls stretched from near Portland, ME, southwest to the New Hampshire coast, and into central Massachusetts. While Springfield, MA and Windsor Locks, CT only reported flurries in the area, the heavier squalls did affect north-central sections of Massachusetts eastward to the south shore of Boston.

4. CONCLUSION

Analysis of the contoured snowfall map (Fig. 11), and the surface aviation observations (Fig. 12), confirm that heavy snow squalls occurred on January 30, 1993. Aviation traffic was affected by visibility restrictions and snow on runways, resulting in air travel delays. It should be mentioned that the forecasts issued for some of the hardest hit areas of northern New England and upstate New York, indicated no snowfall of any consequence. For the most part, public and aviation forecasts were caught in a "NOWCAST" mode. This remained true even as the squalls were observed upstream. During this event, not every observing station across the area had visibility restrictions of 1/4 mile or less. However observations clearly show that the snow squalls occurred away from the climatologically favored mountainous areas, and extended to the east coast of Massachusetts.

In the future, through close monitoring of potential snow shower and snow squall events, and through analysis of this and other case studies supporting WINDEX, forecasters will hopefully develop confidence in using this tool for forecasting wintertime convection.

ACKNOWLEDGEMENTS

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REFERENCES

Lundstedt, W., 1993: WINDEX a method to forecast wintertime instability and non-lake effect snow squalls across northern New England. *Eastern Region Technical Attachment* No. 93-11A, NOAA/NWS, Bohemia, NY, 13 pp.

Petersen, R. A., 1992: Comparisons of LFM and NGM Lifted-Index calculations. *Weather and Forecasting*, 7, 536-541.

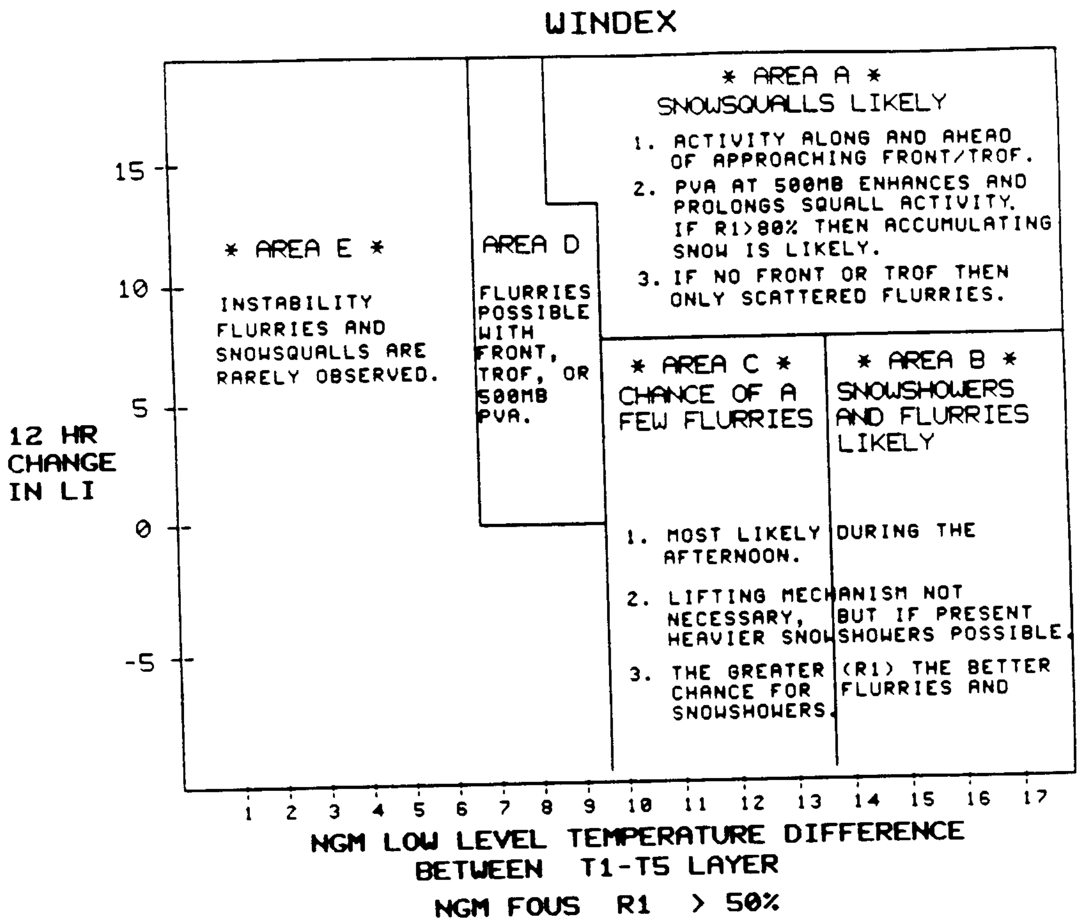

Figure 1. Graphical representation of WINDEX, from Lundstedt 1993.

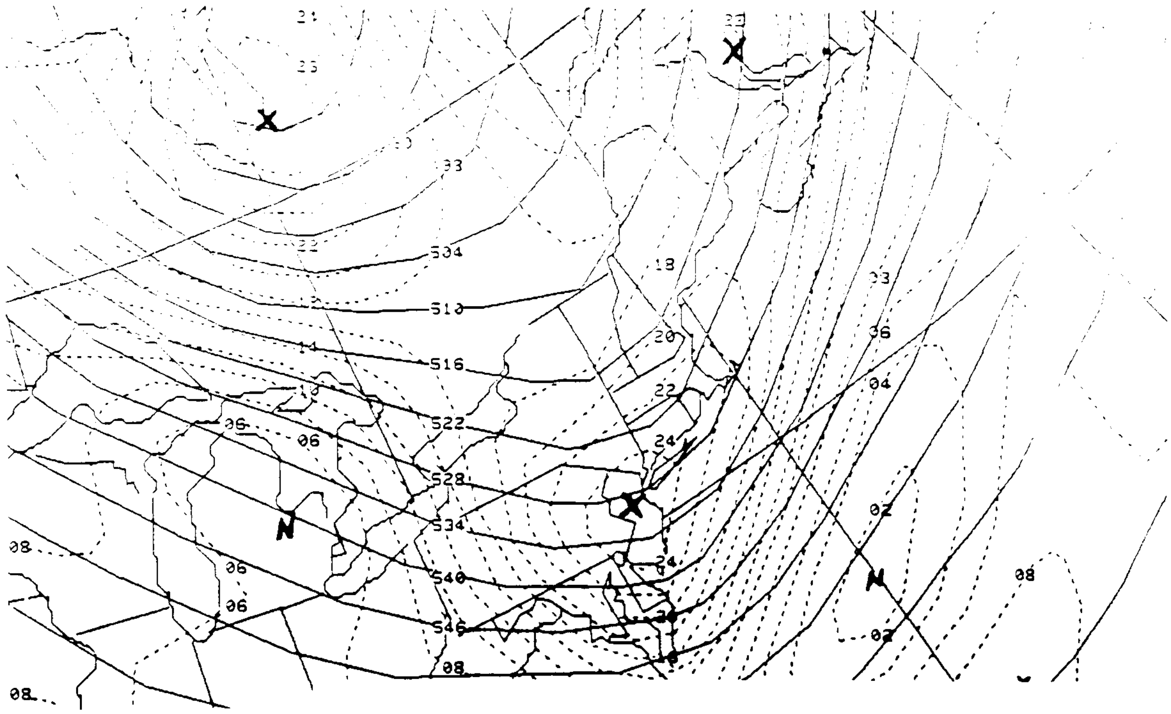

Figure 2. 0000 UTC January 30, 1993, NGM 500 mb Heights and Vorticity.

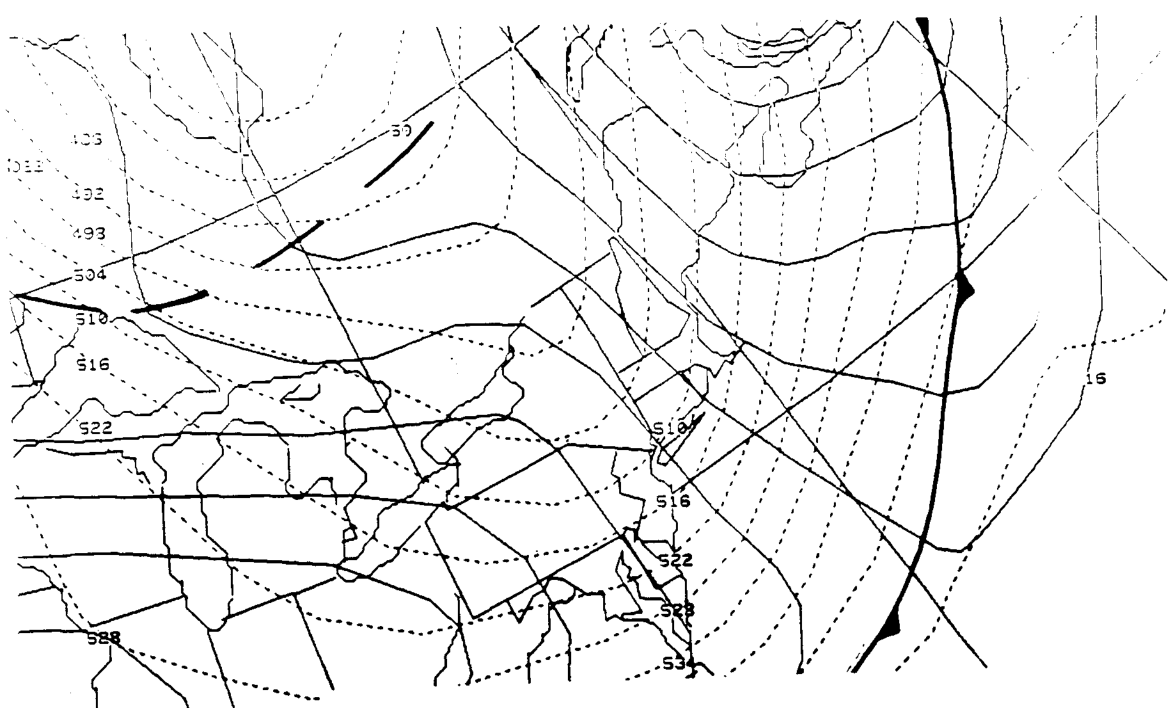

Figure 3. 0000 UTC January 30, 1993, NGM Mean Sea Level Pressure and 1000-500 mb Thickness.

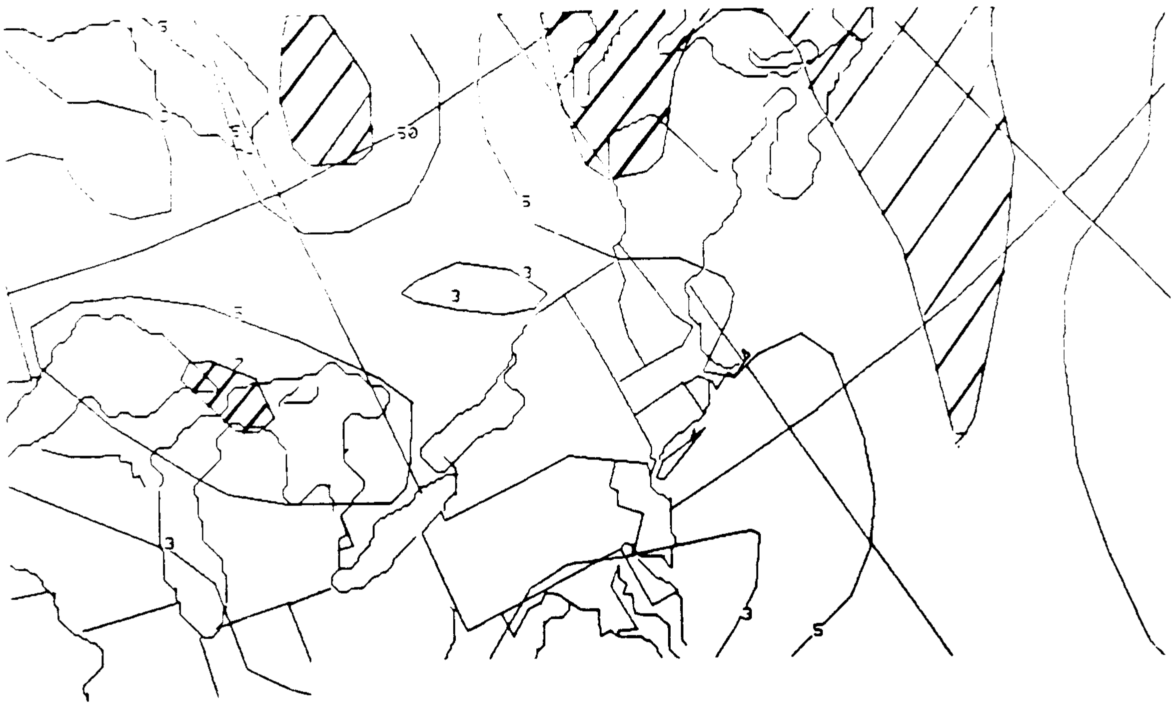

Figure 4. 0000 UTC January 30, 1993, NGM 1000-500 mb Mean Relative Humidity. Dashed areas denote RH > 70%.

Figure 5. 0000 UTC January 30, 1993, NGM Boundary Layer Relative Humidity. Dashed areas denote RH> 70%.

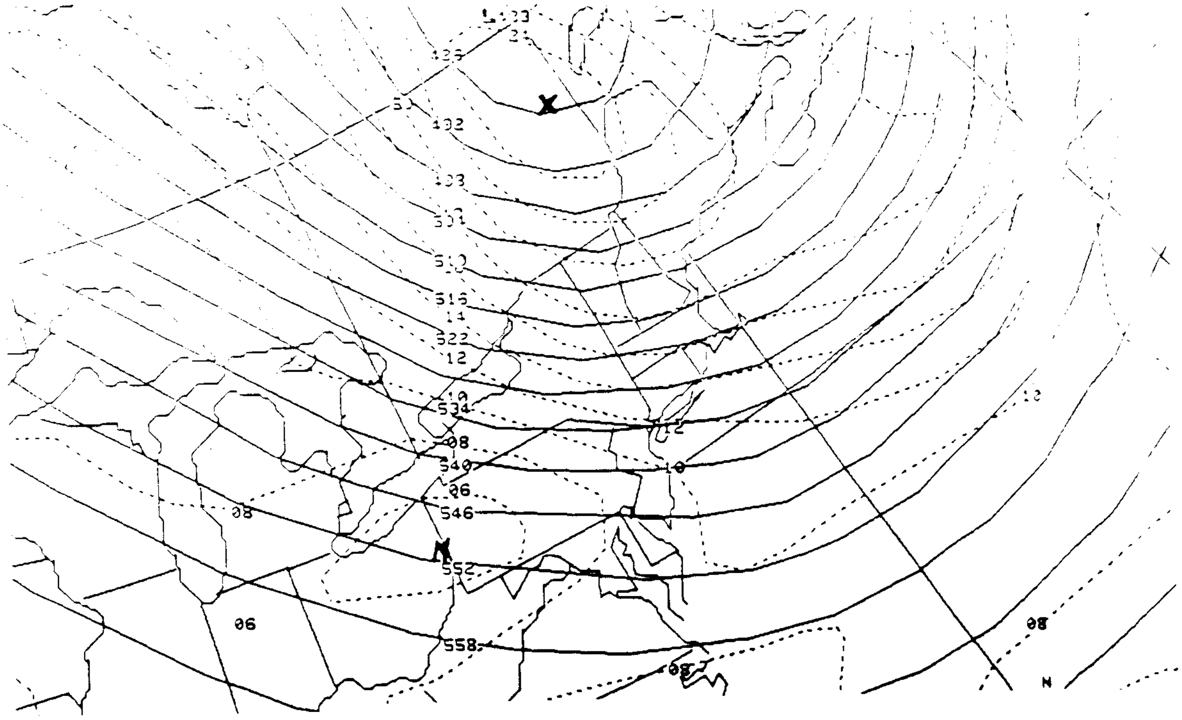

Figure 6. 1200 UTC January 30, 1993, NGM 500 mb Heights and Vorticity.

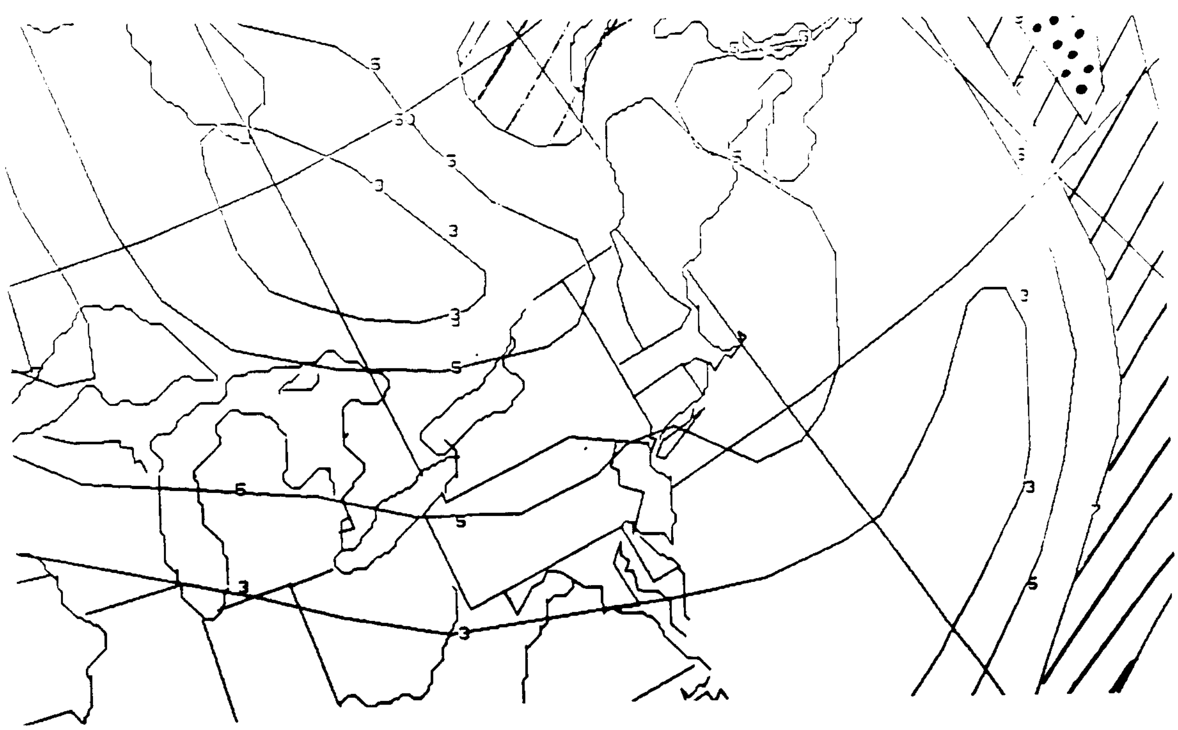

Figure 7. 1200 UTC January 30, 1993, NGM 1000-500 mb Mean Relative Humidity. Dotted area denotes RH > 90%.

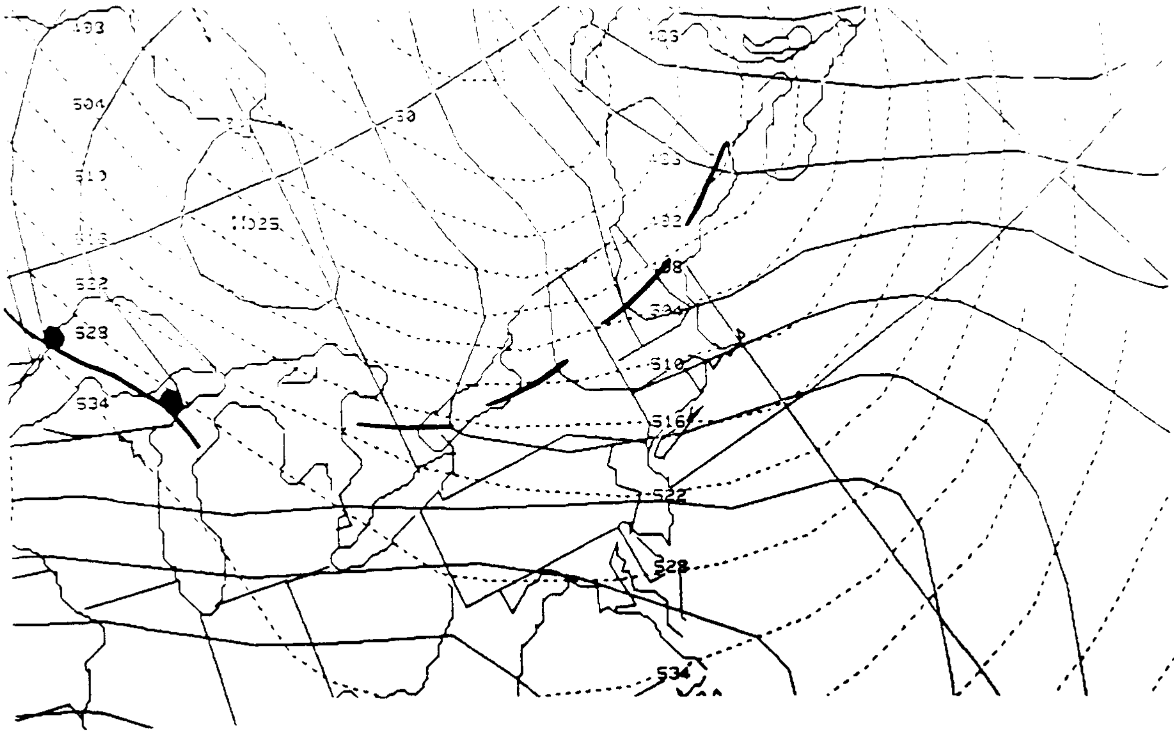

Figure 8. 1200 UTC January 30, 1993, NGM Mean Sea Level Pressure and 1000-500 mb Thickness.

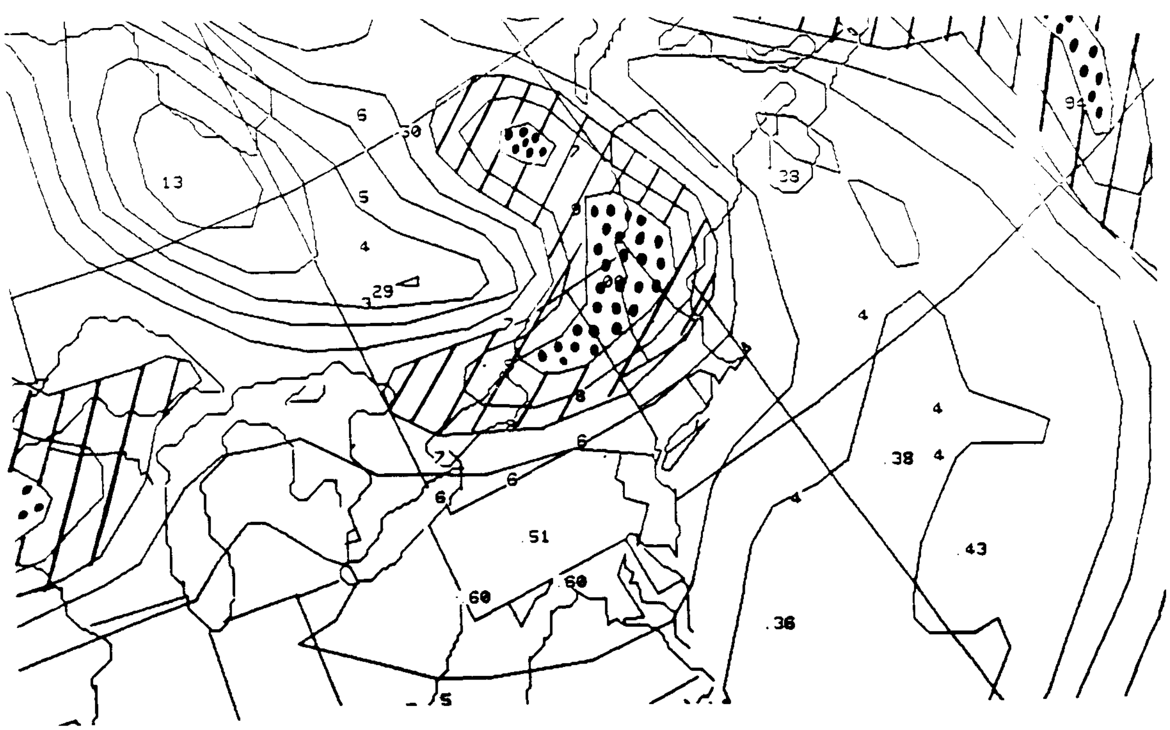

Figure 9. 1200 UTC January 30, 1993, NGM Boundary Layer Relative Humidity. Dotted areas denote RH > 90%.

TTPTTR1R2R3	VVVLI	PSDDFF	HHT1T3T5
ALB//424818	-4121	203028	01898277
06000606512	-7319	192726	06918479
12000755310	-4218	142824	10928678
18000544934	-2626	183113	13898282
24000557677	-0923	173112	16888283
30000869770	-0620	142205	21888687
36008979958	03017	061812	26898891
42007967829	00713	972308	25969187
48004968621	-1813	973214	22979182

TTPTTR1R2R3	VVVLI	PSDDFF	HHT1T3T5
BOS//435118	01618	143208	09948880
06000402512	-4321	192928	06908481
12000616005	01116	132628	08938780
18000523921	-0326	153119	10898381
24000324878	-0328	173218	11888182
30000417862	00723	163506	15868383
36000969966	01822	101411	20878686
42012979665	05119	011511	23948988
48003938623	-0614	970904	21979284

TTPTTR1R2R3	VVVLI	PSDDFF	HHT1T3T5
CON//424417	-0318	143028	05918579
06000503413	-6020	172827	03888278
12000805605	-2017	112723	04918576
18000362915	-2629	153117	05857880
24000324572	-1428	173218	08837781
30000417458	00423	163305	12828182
36001969963	01621	101511	17848485
42011959554	04219	021411	19908686
48004959331	-0815	981009	18948982

TTPTTR1R2R3	VVVLI	PSDDFF	HHT1T3T5
BTV//383412	-1819	182927	97868076
06000736613	-0617	162724	97868175
12003974504	-0523	153119	96837772
18000322715	-3430	193114	00807477
24000365468	-2625	183212	05807579
30000387861	00622	151905	12808182
36005979959	03918	071613	17838586
42008959738	02915	991608	17908782
48005969334	-0617	990402	17918780

TTPTTR1R2R3	VVVLI	PSDDFF	HHT1T3T5
PWM//474316	01515	113027	07928680
06000362213	-3120	152928	01878179
12000816107	-0157	102722	00908474
18000352407	-1530	143122	00827675
24000313453	-2030	173222	03827580
30000385752	00525	173212	07817880
36000639365	00422	111507	13838183
42009959963	04520	041315	16888384
48006949638	00317	001015	16928782

Figure 10. 0000 UTC January 30, 1993, NGM Numerical Guidance.

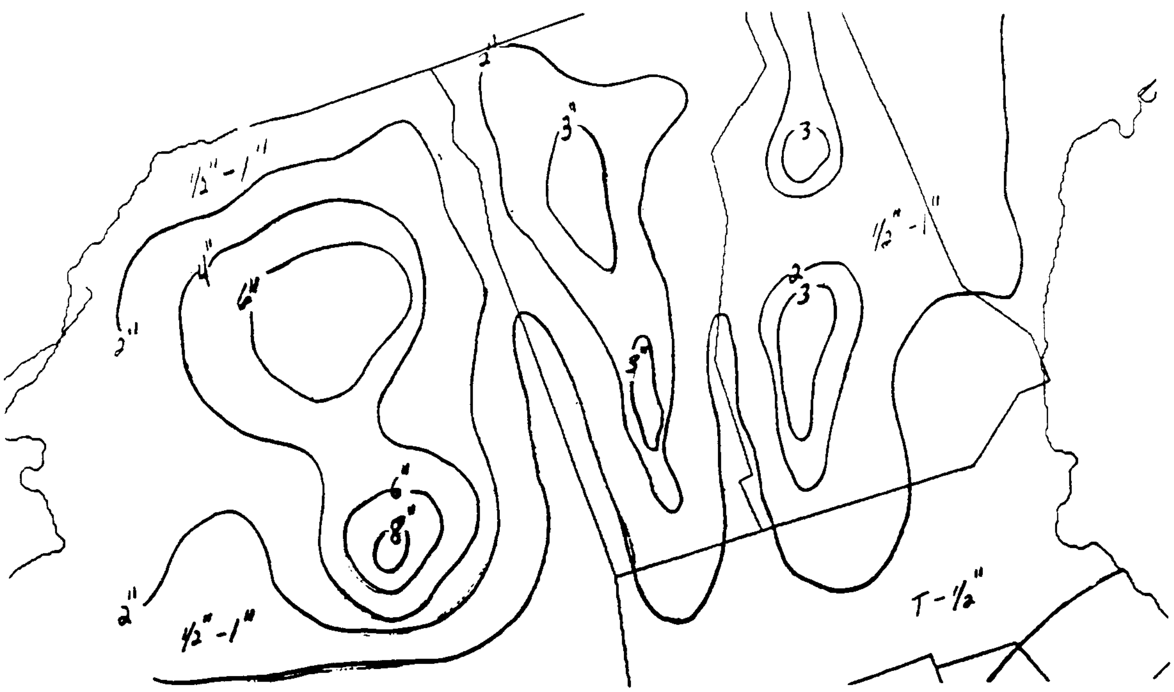

Figure 11. January 30, 1993, Contoured Observed Snow Depth.

LWM SP 1507 W1 X 1/8S+ 3512G25/987
LWM SP 1503 W9 X 1/2S 2917G25/987
BVY SA 1600 W4 X 1/2S 3415G25/992/ WND 25V01
BVY SP 1535 W4 X 1/2S 3415G25/992/ WND 27V01
BED SA 1545 E30 OVC 21/2 S- 27/10 3014G22/987
BOS SP 1621 -X M11 BKN 42 BKN 2SW- 3213G20/990/S2
BOS SP 1608 W11 X 1/4S+ 3116G36/991/R04RVR28V60+
BML TP 1116 A02 M21 OVC 13/4S- 101/02/-7/3016G25/975/ TEST PCPN 0000 $
YSC SA 1000 -X E25 OVC 11/2S- 109/-19/-23/2912/978/S4SC6
PBG SP 0825 W10 X 7/8S- 3212/993/RVR60+=
PBG SA 0755 M50 OVC 21/2S- 141/11/9/0000/994=
GFL SP 1215 COR W8 X 1/2SF 0208/996
ALB SP 1421 W11 X 3/4SW- 3121/004/R19VR60
ALB SP 1408 W11 X 11/2SW- 3115/003
5B5 TP 1357 A02 MM 3/4S-F 144/11/07/3215G23/990/ TEST PCPN 0000 WSHFT 1342
PRESRR FIBI
5B5 TP 1403 A02 MM 1.2SF 145/11/07/3316G21/991/ TEST PCPN 0000 WSHFT 1342
PRESRR
CON SP 1319 W2 X 1/4SW+ 3316/984/DRFTNG SNOW
CON SP 1312 W1 X 0SW+ 3317G31/984
CON SP 1310 W1 X 1/16SW+ 3317G31/984
CON SP 1304 W4 X 1/4SW+ 3318G28/984
LEB SA 1145 W5 X 3/4SW- 12/10/3609/983
MHT SP 1431 W2 X 3/4S- 3515G25/992
MHT SP 1416 W1 X 1/2SW 19/11/3515G25/990
PSM SP 1423 -X M10 OVC 1/2S 3611/987/RVR14 S6=
PSM SP 1408 W8 X 1/4S+ 3314/986/RVR20
AFN TP 1447 A02 CLR BLO 120 1/2SF 124/16/12/3507/982/ TEST $ FIBI
AFN TP 1443 A02 CLR BLO 120 1/4SF 121/18/14/3410/981/ TEST PCPN M $
BTV SA 0850 W0 X 1/8SW+BS 144/11/9/3511/993/SNOINCR 1/1/2/ 62003 90402
BTV SP 0847 W0 X 1/4SW+ 3410/993
MPV SA 1150 -X E35 OVC 2S-BS 137/0/-5/E3320G32/985/S3/30704 90406 00 20014
MPV SA 1050 -X E35 OVC 2S- 140/4/-2/E3315/983/S3
MVL 0930 A02 W6 X 1/2SF 124/05/02/3215/984 810 87-2700 330/15 / TEST PCPN 0000 $
MVL 0935 A02 W6 X 1/4SF 124/04/01/3118G24/984 810 87 -2800 330/18G24 / TEST $
VSF TP 1228 A02 W19 X 1S- 110 /18/11/2711/982/ TEST PSPN 0000 $ FIBI
VSF TP 1229 A02 W18X 3/4S- 112/17/11/2811/982/ TEST PCPN 0000 $

FIGURE 12. Surface Aviation Observations from January 30, 1993.