NATIONAL WEATHER DIGEST
severe weather

SEVERE WEATHER BREAKOUT OF 23 JULY 1978 OVER MAINE AND NEW HAMPSHIRE

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ABSTRACT

During the afternoon of 23 July 1978, several squall lines swept through Maine and New Hampshire in advance of a strong cold front which passed through the region during the late afternoon and evening. Widespread severe thunderstorm activity occurred. This paper presents analysis of these storms. It includes a discussion of their cause, and a report on actions taken by the Portland, Maine, Weather Service Forecast Office (WSFO) and Concord, New Hampshire, and Caribou, Maine, Weather Service Offices (WSO's). In addition, a complete report of storm damage is presented.

1. INTRODUCTION

During the afternoon of 23 July 1978, several squall lines swept through Maine and New Hampshire in advance of a strong front which passed through the region during the late afternoon and evening. The severe thunderstorm outlook, issued for the day by the National Severe Storms Forecast Center (NSSFC), made no mention of the possibility of severe thunderstorms over Maine and New Hampshire. However, by midmorning, forecasters at WSFO Portland were ready for the upcoming storms because the station checklist (1) indicated a strong potential for severe weather over a large portion of Maine and New Hampshire. At 1655 GMT, NSSFC issued a Severe Thunderstorm Watch for New Hampshire and all but extreme northern Maine. At 1845 GMT, strong thunderstorms, accompanied by hail, hit the Rangeley Lakes Region of Maine causing power outages. For the rest of the afternoon and early evening, Maine and New Hampshire were battered by the most widespread severe thunderstorm activity in the nine-year history of WSFO Portland. Severe thunderstorms hit five counties in Maine and one in New Hampshire. Numerous mini-tornadoes were reported. Many other counties had strong thunderstorms, some of which were possibly severe.

Appendix A shows a summary of the statements issued by WSFO Portland and WSO's Concord and Caribou and the reasons for their issuance. Appendix B lists the damage reports from around the two-state area and Figure 24 shows the location of these reports as well as where the strongest radar echoes were reported. The verification of these statements was discussed in a previous paper written by the author. This paper will describe, in detail, the dynamics which produced such a large severe weather outbreak.

2. SYNOPTIC, MESO, AND MICRO SCALE INGREDIENTS LEADING TO THE SEVERE WEATHER OUTBREAK.

A. SURFACE

At 1200 GMT, a low pressure system was located just north of Maniwaki, Quebec. A cold front extended southwest through Ontario, just to the east of Lake Huron. The northeast-southwest orientation of the cold front is conducive to severe weather outbreaks in Maine and New

Hampshire. A warm front extended southeast through central Maine. The warm front moved to northern Maine by 1500 GMT and then became stationary. The low moved east passing through extreme northeast Maine by late afternoon. The cold front moved east at about 9.3m/s (18kt) between 1200 GMT and 1800 GMT. Its eastward speed increased to between 12.9m/s (25kt) and 15.4m/s (30kt) after 1800 GMT. The front entered extreme northwest Maine at about 1900 GMT and passed off the Maine and New Hampshire coast at about 0300 GMT on July 24. Figure 1 shows a three-hour progression of this system. Dewpoint temperatures ahead of this system ranged from 18C to 24C, and surface temperatures over Maine and New Hampshire soared to the 32C to 38C range over all but extreme northern Maine where considerable cloud cover kept temperatures between 27C and 32C.

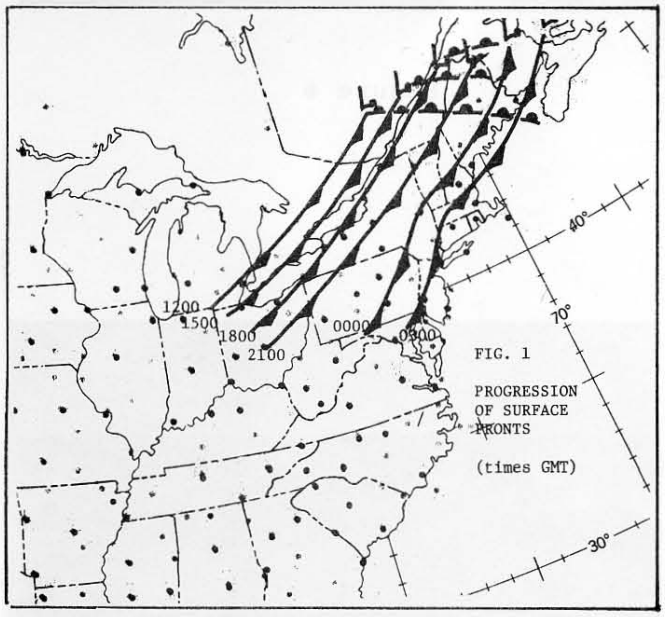


Figure 1

B. SATELLITE

The 1230 GMT satellite picture (Figure 2) and surface observations indicated that all but extreme northern New Hampshire and the northern third of Maine began the morning with clear skies. Also, considerable convective activity had already developed with the system. Clear-cloudy borders, which are conducive to severe thunderstorm development, stretched through southern Quebec and into northern Maine. Thunderstorm activity intensified north of Lake Ontario by 1430 GMT (Figure 3). The initial line of intense thunderstorms then spread rapidly east along the clear-cloudy border through southern Quebec, finally reaching northwest Maine by 1700 GMT. Subsequent squall lines developed ahead of the front and moved through Maine and New Hampshire during the afternoon. Figures 3 through 11 show the progress of those squall lines as depicted by satellite.

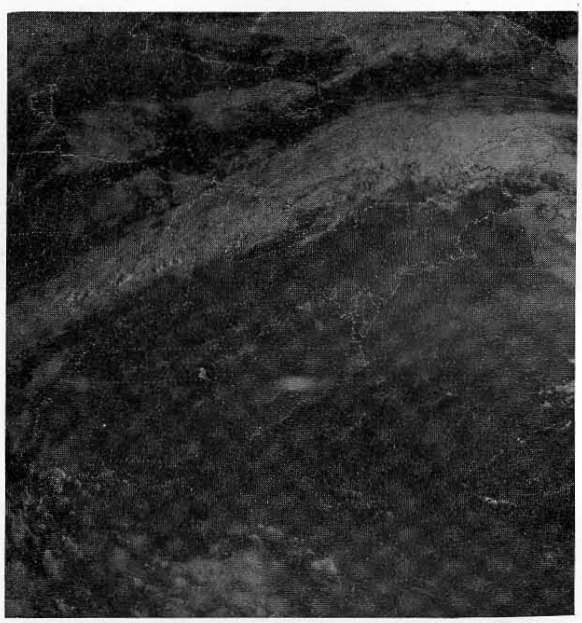
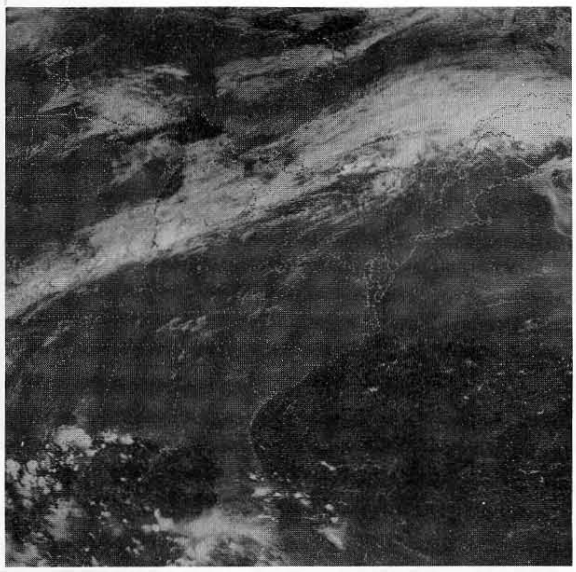


Figure 2



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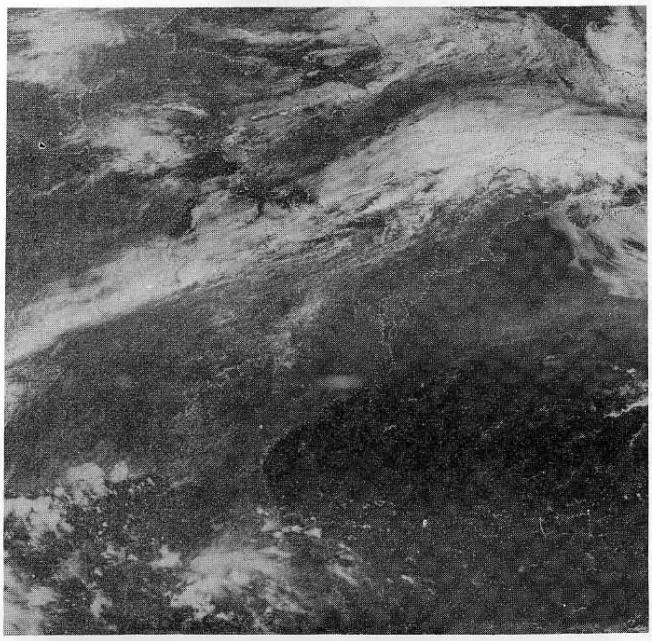

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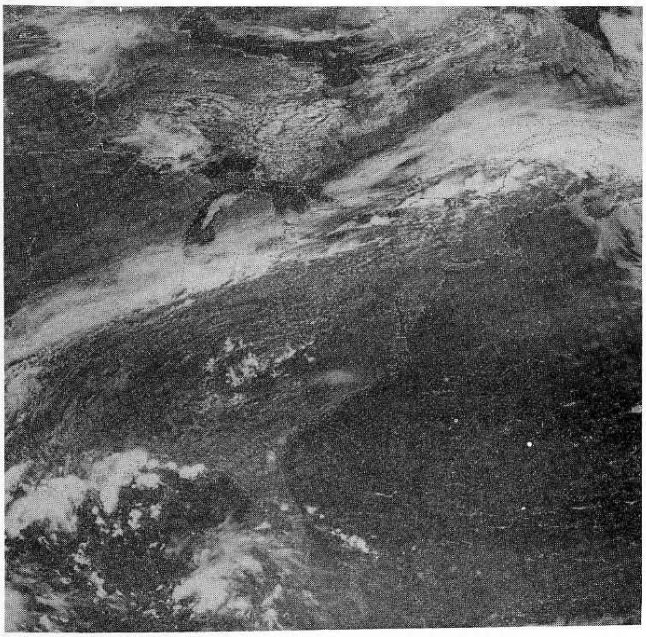

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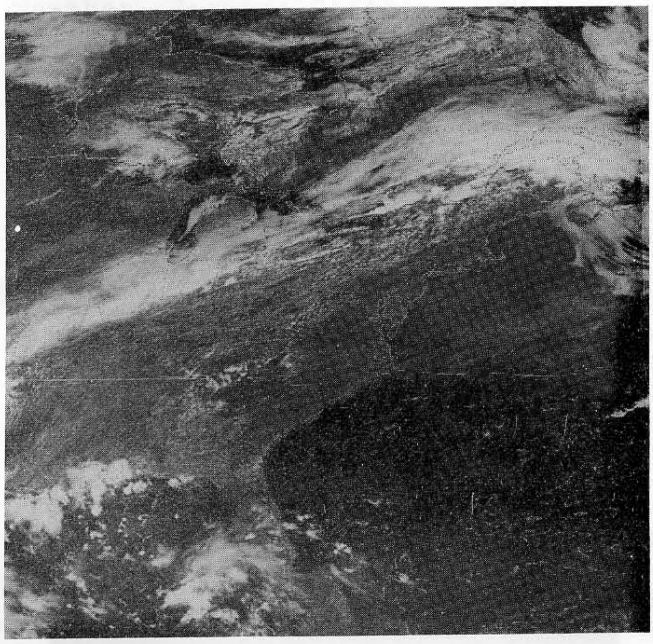

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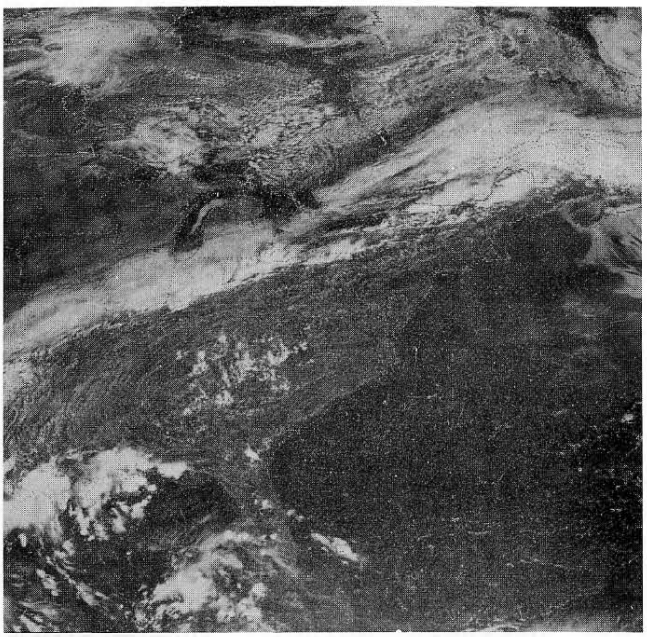

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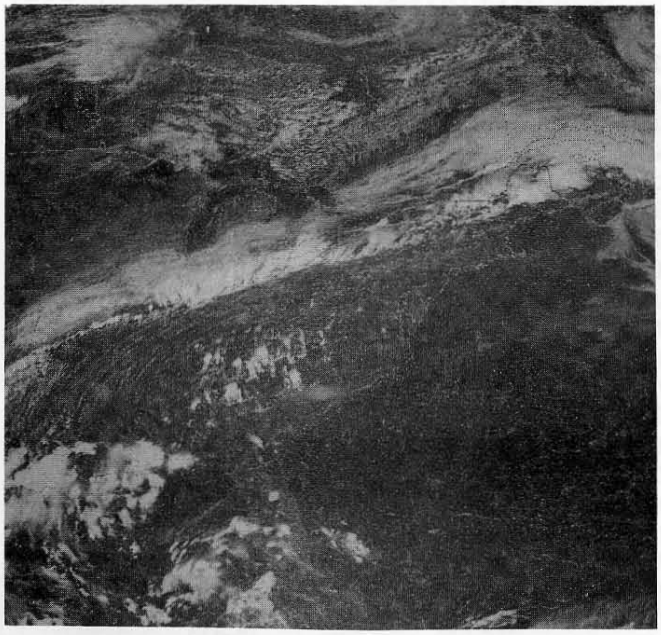

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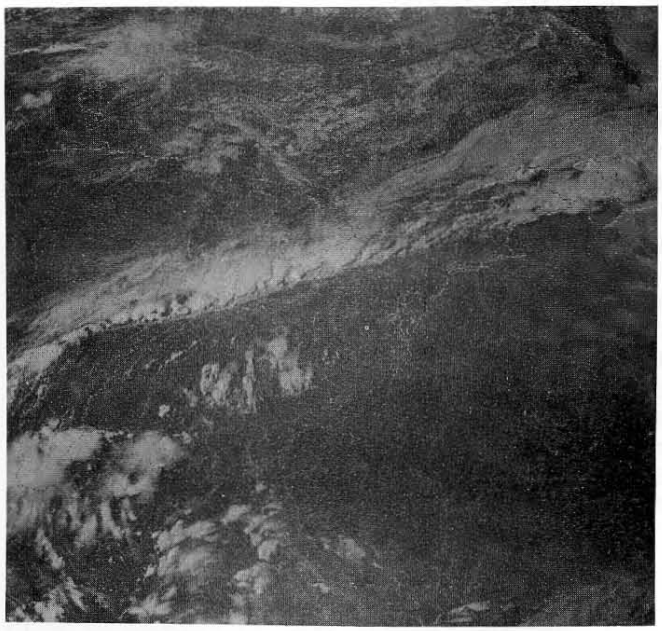

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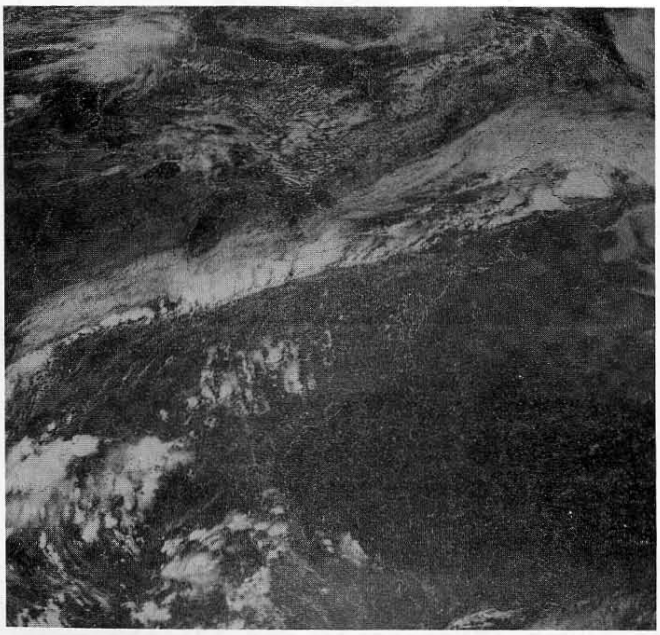

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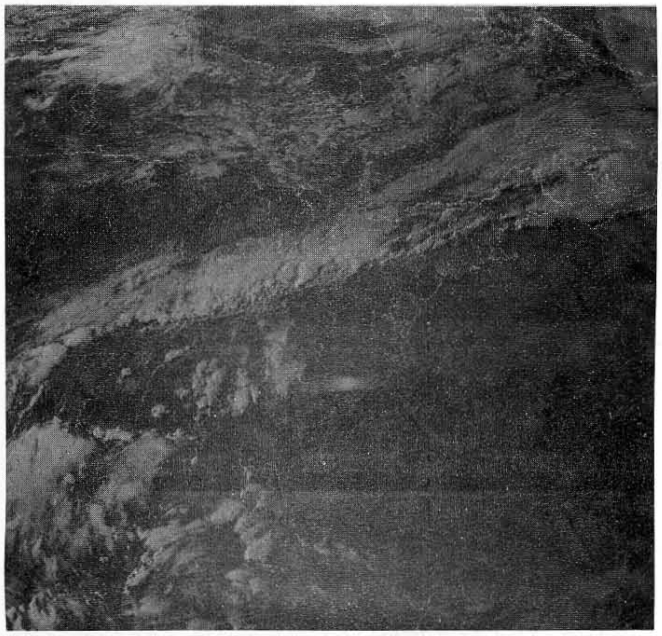
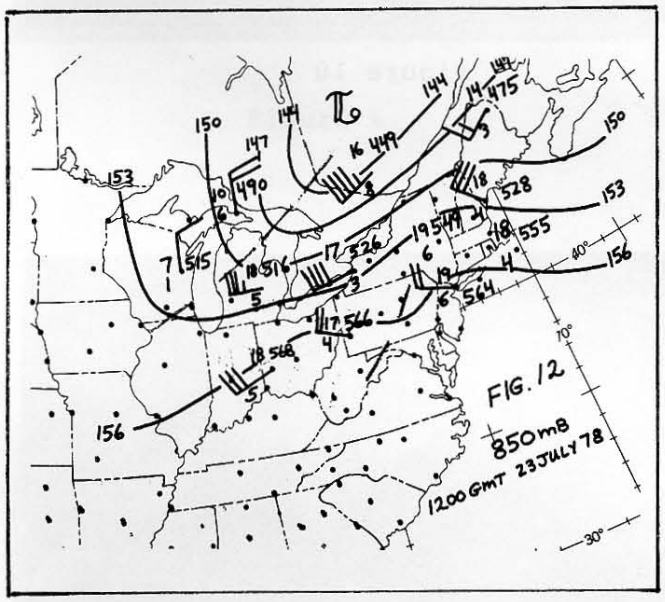


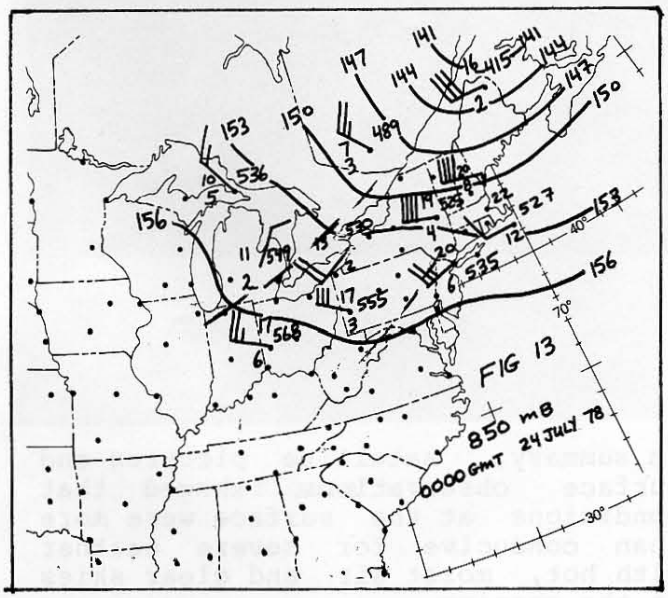
Figure 11

In summary, satellite pictures and surface observations showed that conditions at the surface were more than conducive for severe weather with hot, moist air and clear skies in the morning.

C. 850 MILLIBARS

At 850mb (Figures 12 and 13) all key parameters showed a strong potential for severe weather. An abundance of moisture was present with dewpoint temperatures in excess of 10C. A low Level (850mb) jet of 20.6m/s (40 kt) passed through the area that was hardest hit by severe weather. There was warm advection during the day over New Hampshire and most of southern Maine. The maximum temperature ridge (over eastern New York state) was just to the west of the maximum moisture ridge (over New England) at 1200 GMT and moved into New England during the day.

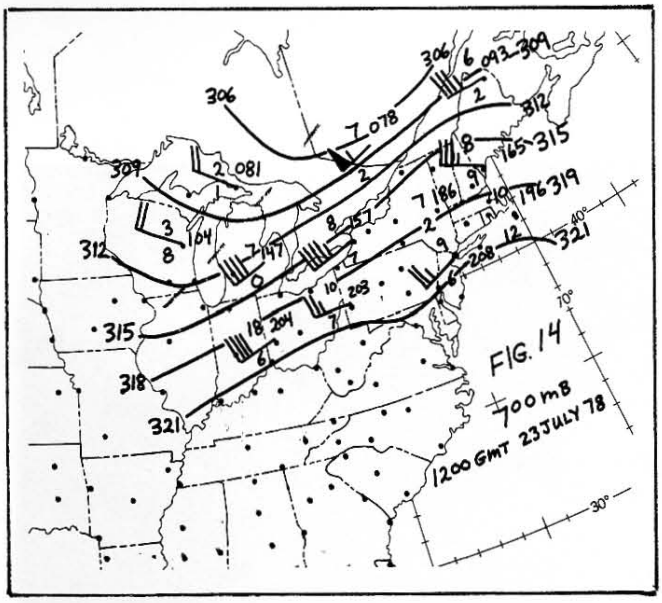




D. 700 MILLIBARS

The main feature at 700mb (Figures 14 and 15) when severe weather potential is examined is whether a dry line will pass through the area in question. The influx of dry air at 700mb combined with hot, moist air in low levels (850mb and below) makes the atmosphere more convectively unstable as the day progresses. In this case, there was actually an addition of moisture at 700mb; however, close examination of the 1200 GMT soundings for 23 July at Portland, Maine, and Albany, New York, (Figures 22 and 23) indicated sharp drying above 650mb. With the atmosphere being as warm as it was that day, this would certainly suffice in meeting the "convective instability" criteria.

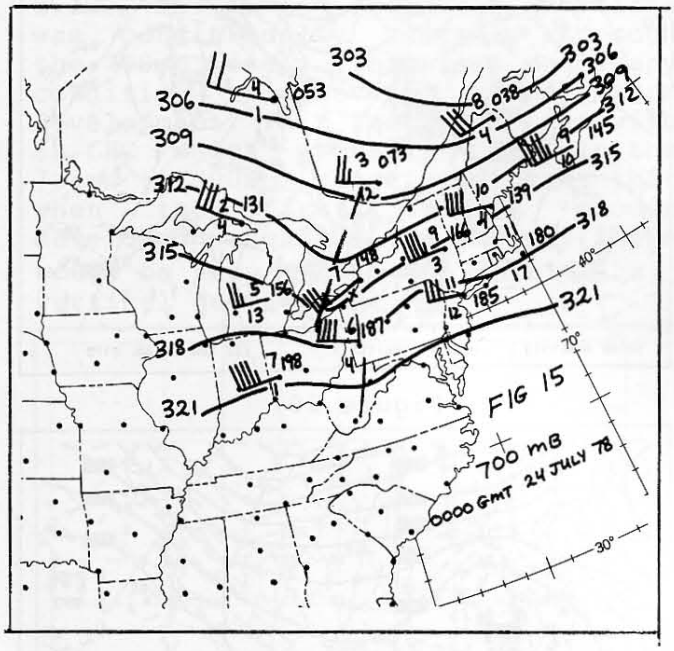
Severe weather has also been found to break out over an area of little or no temperature change at 700mb. This area was present over New York state at 1200 GMT and moved over New England during the day.

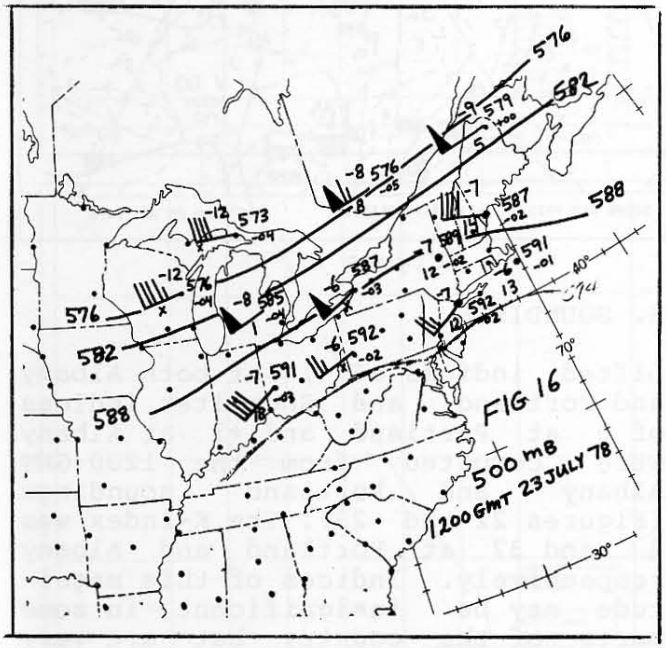


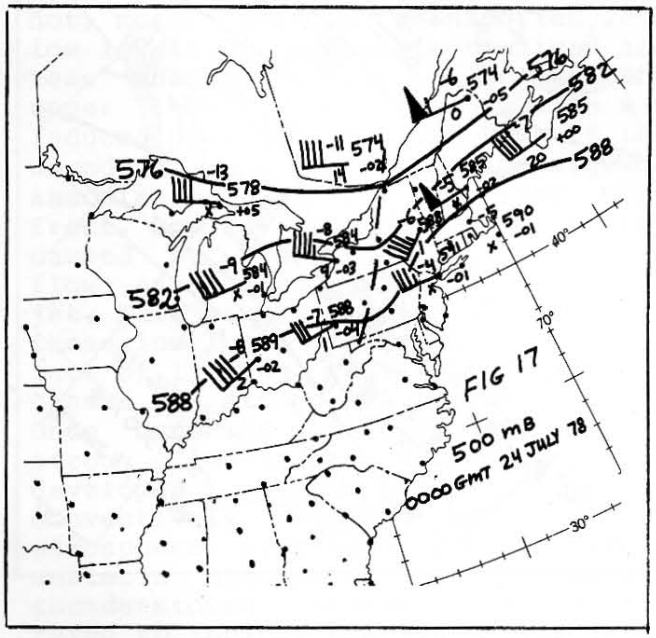
E. 500 MILLIBARS

At 500mb (Figures 16 and 17) the most noteworthy feature is the 25.7m/s (50 kt) jet moving into the threat area. Other parameters at 500mb such as horizontal wind shear and 500mb height falls are not positive indicators in this case.

Ideally, one would want cold advection at 500mb to coincide with low level heating to destabilize the atmosphere further. This condition is not quite met in this case. However, the magnitude of warm advection at 500mb (1C) between 1200 GMT and 0000 GMT is less than at 700mb or 850mb (2C), thus some destabilization of the middle atmosphere does take place during the day.

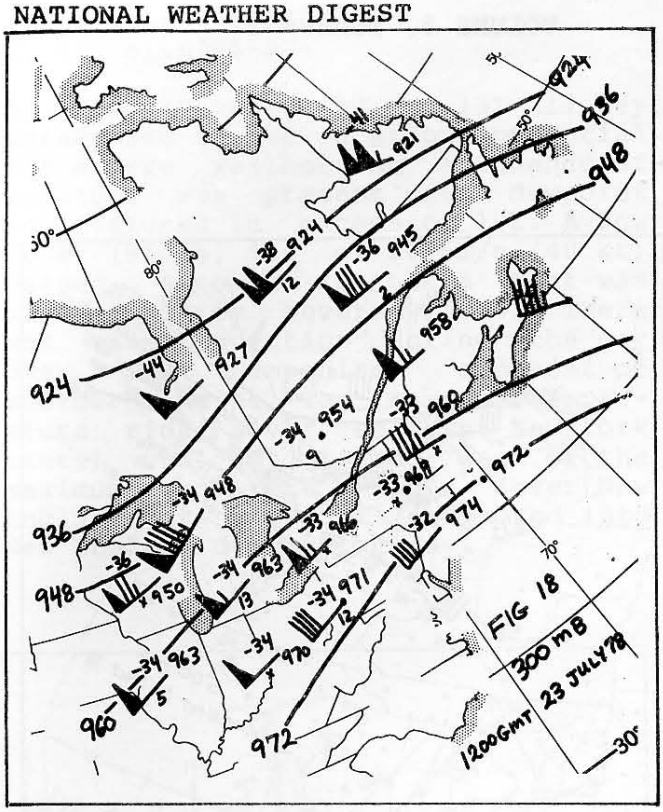


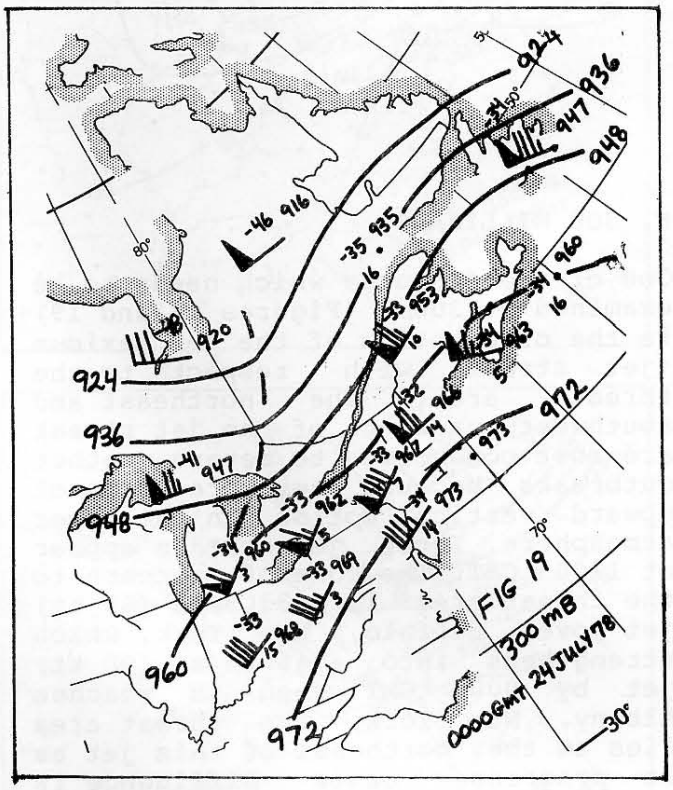




F. 300 MILLIBARS

One of the features which needs to be examined at 300mb (Figures 18 and 19) is the orientation of the jet maximum (jet streak) with respect to the threat area. The northeast and southwest quadrants of the jet streak are most conducive to severe weather outbreaks because they are areas of upward vertical motion in the upper atmosphere. Three jet streaks appear at 1200 GMT. The one of concern to the threat area is a 33.5m/s (65 kt) jet over Buffalo, New York, which strengthens into a 46.3m/s (90 kt) jet by 0000 GMT when it reaches Albany, New York. The threat area lies to the northeast of this jet as it progresses east. Diffluence is also a key factor at this level since it indicates the evidence of the presence of an approaching positive vorticity center aloft. An area of weak diffluence over the threat area at 1200 GMT moves off the coast by 0000 GMT.





G. VORTICITY

Strong Positive Vorticity Advection (PVA) was lacking in this severe weather case. This is indicated by the initial 500mb height/vorticity charts on the Limited Fine Mesh (LFM) model for 1200 GMT and 0000 GMT (Figures 20 and 21). The weak difffluence at 300mb and small 500mb height falls also indicates this. Strong PVA does pass through Quebec and northern Maine, while weak PVA overspreads New Hampshire and western Maine during the day.

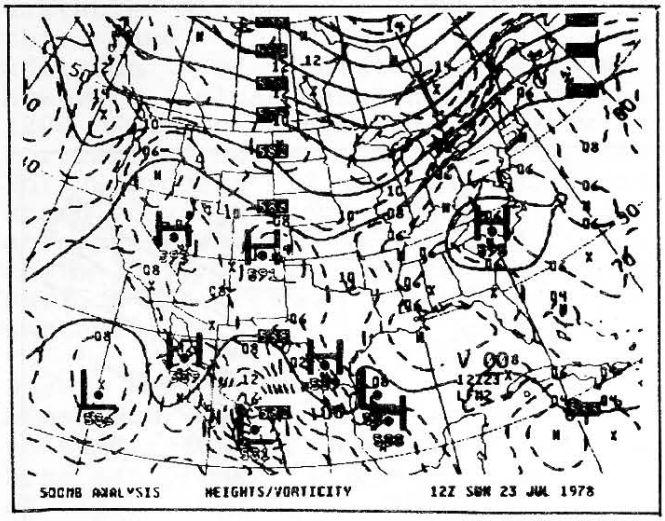


Figure 20

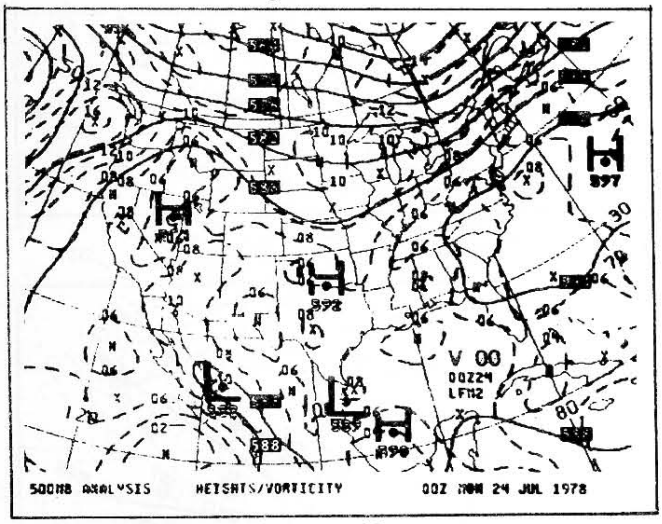


Figure 21

H. SOUNDINGS

Lifted indices of -1 at both Albany and Portland, and Showalter indices of 0 at Portland and +1 at Albany were computed from the 1200 GMT Albany and Portland soundings (Figures 22 and 23). The K-index was 3[illegible] and 37 at Portland and Albany respectively. Indices of this magnitude may be insignificant in some parts of the country but are very significant in the northeast in determining atmospheric instability.

In addition, strong heating at the surface and less heating at upper levels lead to the destabilization of the sounding. As previously mentioned, the sounding was convectively unstable above 650mb due to sharp drying above that level. The Level of Free Convection (LFC) was approximately 780mb at Albany at 1200 GMT. Although there was no LFC at Portland at 1200 GMT, one most likely developed during the day, considering the changes that occurred in the soundings. With the exception of small layers between 1010mb and 992mb, and 850mb and 810mb, Portland was conditionally unstable through the 700mb level. This is a necessary condition for severe thunderstorm development. This fact, combined with an LFC which probably fell in the 700mb to 800mb range, indicates that when the first cumulus clouds developed ahead of the front, there would be very little to inhibit their vertical development.

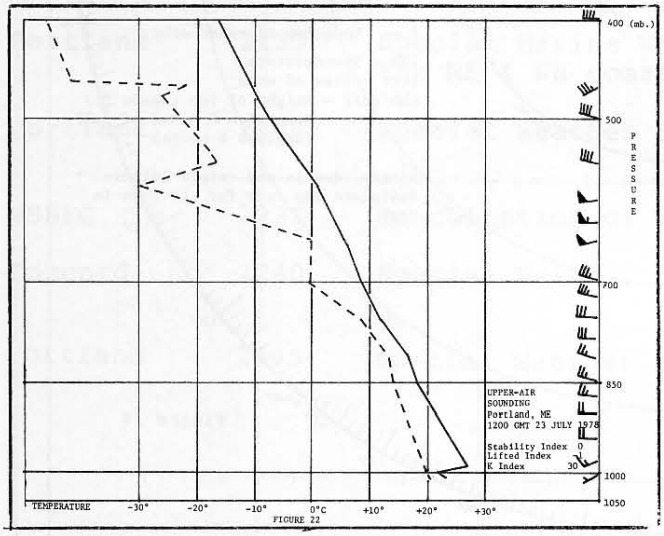


FIGURE 22

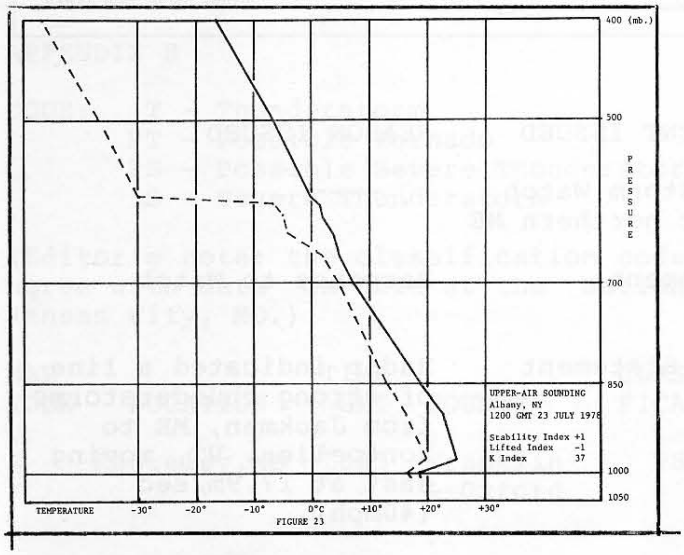


FIGURE 23

3. SUMMARY

This severe weather outbreak was induced mostly by low level dynamics. The atmosphere became less stable in the convective, conditional, and absolute sense during the day, as hot, moist air was transported into low levels while dry air remained and less heating occurred in mid and upper levels. Vertical motion was induced by the destabilization of the sounding and surface convergence associated with the strong cold front. Low level convergence was also caused by the strong ageostrophic flow associated with the low level jet. This strong lifting, provided by these low level features, offset the lack of lifting that would have been caused by strong PVA or diffluence. Once cumulus development began, strong low-level vertical motion developed these clouds into the convectively unstable region of the atmosphere. Lifting of a convectively unstable atmosphere leads to severe thunderstorms because there is nothing to inhibit cumulus development.

Winds at mid and upper levels increased during the day, thus aiding in the development of the severe thunderstorms.

Seldom do severe weather outbreaks of this magnitude occur over Maine and New Hampshire, but it is hoped that those reading this paper have learned what conditions cause them to do so.

ACKNOWLEDGEMENT

The author wishes to express his appreciation to Mr. James A. Volkommer, Meteorologist In Charge at WSFO Portland, Maine, and Mr. Fred Zuckerberg, Regional Meteorologist, for offering advice and criticism in the writing of this paper.

REFERENCE

(1) A severe weather checklist was developed by the author in the spring of 1977. It was being prepared for publication at the same time that this paper was written.

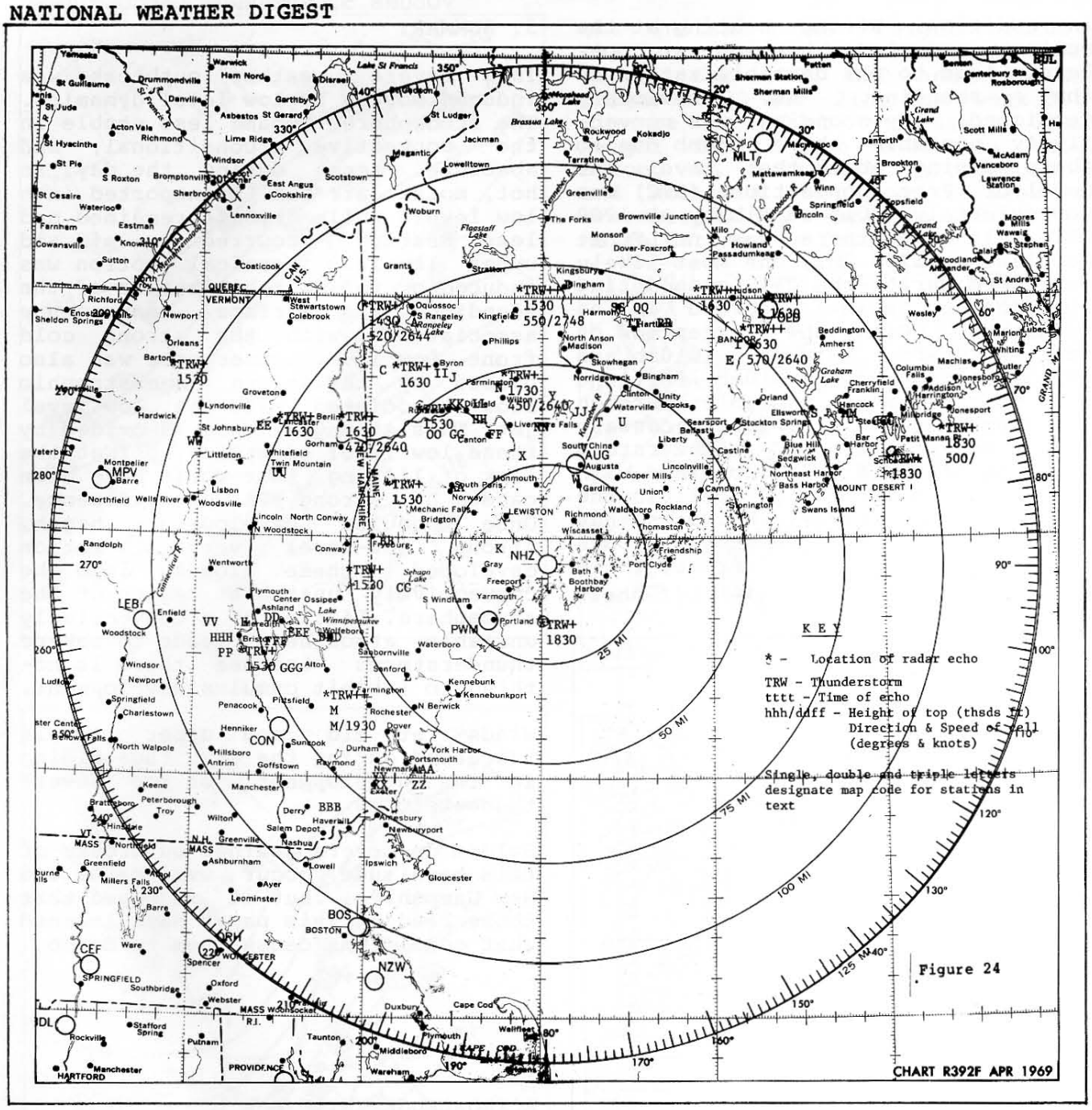


Figure 24

APPENDIX A

STATION	TIME/GMT	TYPE OF STATEMENT ISSUED	REASON ISSUED
NSSFC	1655	Severe Thuunderstorm Watch for NH & all but northern ME	----
Portland & Caribou	1715	Redefining statement	Response to Watch
Portland	1800	Special Weather Statement	Radar indicated a line of strong thunderstorms from Jackman, ME to Montpelier, VT, moving east at 17.9m/sec (40mph).

Concord	1920	Severe Thunderstorm Warning for Grafton, Sullivan, Merrimack, Belknap, Carroll, Cheshire, Hillsboro, Rockingham, & Stratford Counties	Radar indicated a line of thunderstorms, some of which were severe, from Berlin, NH, to Lebanon, NH, moving east-southeast at 22.4m/sec (50mph).
Portland	1930	Special Weather Statement	Radar indicated very strong thunderstorms from Caribou to Houlton, southwest through the Moosehead & Rangeley Lakes Reg., then into NH, moving east at 17.9m/sec (40mph).
Portland	2030	Severe Thunderstorm Warning southern Penobscot, Hancock, & Washington Counties	Severe thunderstorm reported at Bangor,ME. Radar indicated storm was moving east at 20.1m/sec (45mph). Bangor was hit with pea-size hail and heavy rain.
Portland	2130	Special Marine Warning for the ME & NH coast	Strong thunderstorms approaching the coast
Portland	2200	Special Weather Statement	Summary of thunderstorm situation
NSSFC	2235	Cancellation of Watch	
Concord	2240	Special Weather Statement	Summary of thunderstorm situation
Portland	2245	Special Weather Statement	Response to Watch cancellation

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APPENDIX B

CODE: T - Thunderstorm
PT - Possible Tornado
PS - Possible Severe Thunderstorm
S - Severe Thunderstorm

(Editor's note: the classification code is the author's, and may or may not agree with data on file at the National Severe Storms Forecast Center in Kansas City, MO.)

MAP CODE	LOCATION	TIME GMT	COUNTY	CLASSIFICATION	DAMAGE REPORT
A	Rangeley,ME	1845	Franklin & Oxford	PS	Power outages. Pilot reported hail.

B	Houlton, ME	1920	Aroostook	T	Heavy thunderstorms with power outage and trees down. Lightning struck police station.
C	Andover, ME	1930	Oxford	S	Trees, powerlines, and corn-fields knocked down. 1" hail
D	Bingham, ME	1945	Somerset	PS	Heavy thunderstorms with strong winds and downpours.
E	Hamden, ME	2000	Penobscot	T	Heavy rain and power outages.
F	Island Falls, ME	2000	Aroostook	PT	Numerous thunderstorms. Possible tornado. Trees up-rooted. Strong blasts of wind.
G	Kingfield, ME	2000	Franklin	PT	Mini-tornado reported 91.4m (100 yds) by 30.48m (100 ft) in size. Damaged trees and gardens.
H	New Hamp-ton, NH	2030	Belknap	PT	Mini-tornado reported. Rows of trees knocked down. Powerlines down. Tremendous downpours.
I	Bangor, ME	2030 to 2100	Penobscot	PS	Trees, poles, and wires down. Pea-size hail. Heavy rains caused washouts. Power out. One-half hour rainfall of 3.81cm (1.5"). Winds 17.9m/sec (40mph) at Bangor FSS and unconfirmed wind reports of 31.3m/sec (70mph) in Bangor area.
J	Peru, ME	2100	Oxford	S	Heavy rain. Wind estimated to be at least 22.4m/sec (50mph) by a WSFO Portland forecaster who called in the report. Trees uprooted. People near Worthy Pond saw two waterspouts.
K	New Glou-cester, ME	2100	Cumberland	T	Man struck by lightning.
L	Sanford, ME	2120	York	T	House hit by lightning.
M	Concord, NH	2135	Merrimack	T	Wind gusts to 20.6m/sec (40kts) at Concord WSO.
N	Farmington, ME	2200	Franklin	T	Limbs down.
O	Lincoln, ME	M	Penobscot	PS	Trees down. Heavy rain. Strong wind.
P	W. Enfield, ME	M	Penobscot	PS	Trees down. Heavy rain. Strong wind.

Q	Milford, ME	M	Penobscot	PS	Trees down. Heavy rain. Strong wind.
R	Bradley, ME	M	Penobscot	PS	Trees down. Heavy rain. Strong wind.
S	N. Ells-worth, ME	M	Hancock	PS	Trees down. Heavy rain. Strong wind.
T	Vassalboro, ME	M	Kennebec	T	Rain and wind damage.
U	China, ME	M	Kennebec	T	Rain and wind damage.
V	Sydney, ME	M	Kennebec	T	Rain and wind damage.
W	Hallowell, ME	M	Kennebec	T	Rain and wind damage.
X	Fayette, ME	M	Kennebec	T	Rain and wind damage.
Y	Rome, ME	M	Kennebec	T	Rain and wind damage.
Z	Lewiston,ME	M	Androscoggin	T	Rain and wind damage.
AA	Paris, ME	M	Oxford	T	Heavy downpours and small hail.
BB	Lovell, ME	M	Oxford	T	Heavy downpours and small hail.
CC	Cornish, ME	M	Cumberland	T	Heavy downpours and small hail.
DD	Meredith, NH	M	Belknap	T	Wind damage.
EE	Lancaster,NH	M	Coos	T	Boat tipped over. Uncon-firmed drowning.
FF	Canton, ME	M	Oxford	PS	Strong winds damaged one roof. Trees, limbs, poles, and wires down.
GG	Hanover, ME	M	Oxford	T	Some hail. Lightning strikes. Poles, wires and trees down.
HH	Roxbury, ME	M	Oxford	S	Golfball size hail.
II	Ellis Pond, ME	M	Oxford	S	Marble size hail.
JJ	Belgrade, ME	M	Sagadahoc	T	House fire caused by light-ning.
KK	Rumford, ME	M	Oxford	T	Poles, wires, and trees down. Some hail.
LL	Dixfield, ME	M	Oxford	T	Poles, wires, and trees down. Some hail.

MM	Hancock, ME	M	Hancock	T	Fire caused by lightning.
NN	Mt. Vernon, ME	M	Sagadahoc	PT	Noise on Echo Lake sounded like air passing through a tunnel. Trees down. Motorboat flipped over. Possible tornado.
OO	Newry, ME	M	Oxford	S	Wind 26.8m/sec (60mph). Rainfall 2.03cm (.8").
PP	Bristol, NH	M	Grafton	T	Cloudburst. Strong winds.
QQ	Dexter, ME	M	Penobscot	T	Trees and powerlines down due to high winds.
RR	Corinna, ME	M	Penobscot	T	Trees and powerlines down due to high winds.
SS	Ripley, ME	M	Somerset	T	Trees and powerlines down due to high winds.
TT	St. Albans, ME	M	Somerset	T	Trees and powerlines down due to high winds.
UU	Twin Mountains, NH	M	Coos	T	Heavy downpours.
VV	Bridgewater, NH	M	Grafton	T	Trees and powerlines down. Forest fire.
WW	St. Johnsbury, VT	M	--	T	Housefire.
XX	Exeter, NH	M	Rockingham	T	Electricity out.
YY	Stratham,NH	M	Rockingham	T	Electricity out.
ZZ	N. Hampton, NH	M	Rockingham	T	Electricity out.
AAA	Greenland,NH	M	Rockingham	T	Electricity out.
BBB	Danville,NH	M	Rockingham	T	Electricity out.
CCC	W. Sullivan, ME	M	Hancock	PT	Unconfirmed tornado.
DDD	Wolfeboro,NH	M	Carroll	T	Numerous boating accidents on Lake Winnipesaukee near Wolfeboro.
EEE	Gilford, NH	M	Belknap	T	Powerlines down.
FFF	Lakeport,NH	M	Belknap	T	Powerlines down.
GGG	Laconia, NH	M	Belknap	T	Monument struck by lightning.
HHH	Alexandria, NH	M	Belknap	T	Trees and powerlines down. Small woods fire.