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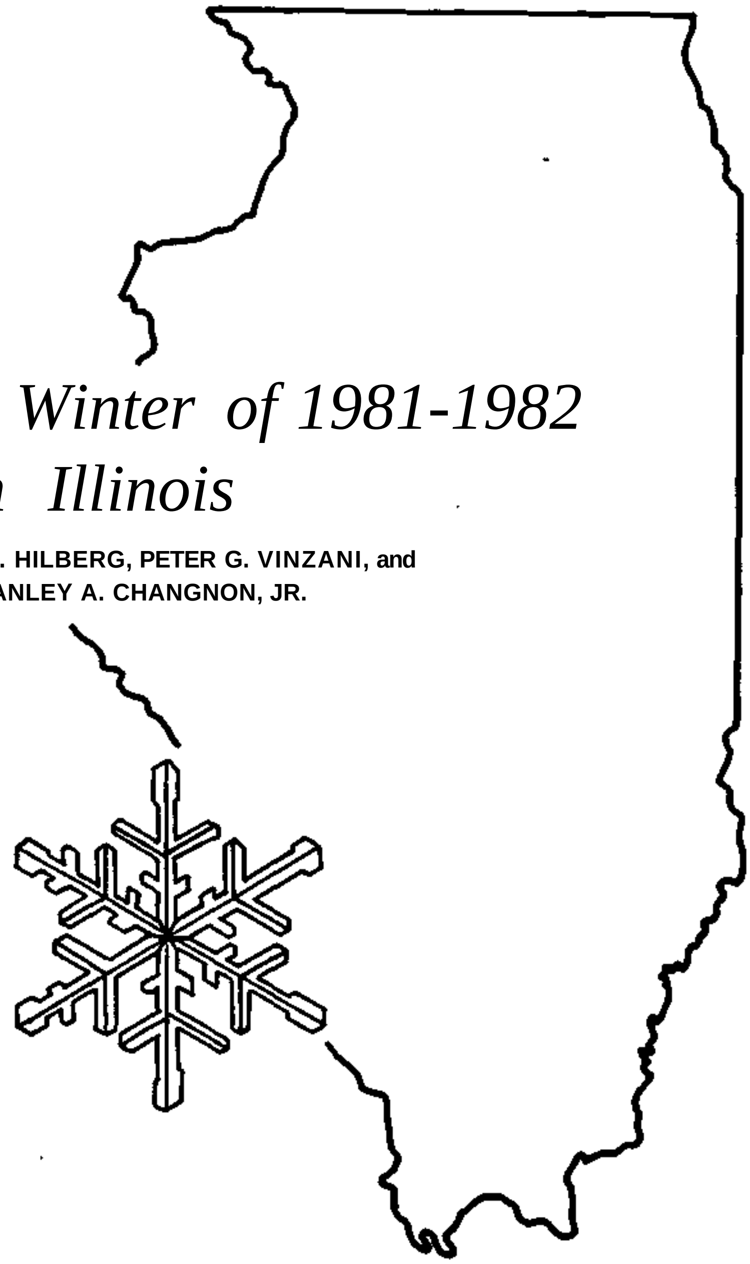
REPORT OF INVESTIGATION 104

STATE OF ILLINOIS

ILLINOIS DEPARTMENT OF ENERGY AND NATURAL RESOURCES

The Severe Winter of 1981-1982 in Illinois

by STEVEN D. HILBERG, PETER G. VINZANI, and
STANLEY A. CHANGNON, JR.



ILLINOIS STATE WATER SURVEY

CHAMPAIGN

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Reference: Hilberg, Steven D., Peter G. Vinzani, and Stanley A. Changnon, Jr. The Severe Winter of 1981-1982 in Illinois. Illinois State Water Survey, Champaign, Report of Investigation 104, 1983.

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STATE WATER SURVEY DIVISION
STANLEY A. CHANGNON, JR., M.S., Chief

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THE SEVERE WINTER OF 1981-1982 IN ILLINOIS

by Steven D. Hilberg, Peter G. Vinzani, and Stanley A. Changnon, Jr.

ABSTRACT

The winter of 1981-1982 was Illinois' fourth severe winter in six years and the second most severe on record. Eighteen severe winter storms equalled the record number set in the winter of 1977-1978. The winter was unusually long, lasting from late November through early April. This report examines the climatology of the winter in regard to storm characteristics, snowfall, and temperature and contains a general synoptic analysis of each storm. Mean upper atmospheric circulation patterns of this and three previous severe winters are compared. Impacts of the severe storms and the winter in general are discussed in terms of transportation, utilities, public health, government, agriculture, and the environment.

The winter of 1981-1982 had the greatest impact in central and southern Illinois. Up to 20 inches of snow and blizzard-like conditions in south central Illinois during the storm of 29-31 January led to it being classified as the most damaging of the winter. The storms and cold of the winter were responsible for 34 deaths and at least 550 injuries statewide. Transportation and energy usage and costs were most affected by the winter weather. Serious agricultural damage resulted from the severe cold, and both the snow and cold had detrimental effects on wildlife.

INTRODUCTION

One continuing objective of the climatological research program of the State Water Survey is the study of severe climatic events and anomalies such as droughts, severe winters, dust storms, and floods. These studies describe the actual weather conditions during the event, evaluate the events climatically, identify the meteorological causes, and assess the impacts on the people, commerce, and institutions of Illinois.

The ultimate goal of such studies is to provide assessment information for five general purposes and user groups: 1) to measure the event for those who have been impacted by it and wish to assess the magnitude of the events causing a specific impact (such as homeowners and insurance firms); 2) to provide information useful in future decisions of policymakers; 3) to furnish data and information relevant to future designs of structures and planning of activities; 4) to understand causation so as to improve future climate forecasting; and 5) to gain a better understanding of the climate of Illinois.

As part of this continuing program, a climatological study of severe winter storms during the 1900-1960 period was performed (Changnon, 1969). The advent of extremely severe winters in 1976-1977, 1977-1978, and 1978-1979 led to a series of investigations of them (Changnon and Changnon, 1978; Changnon et al., 1980). These assessments concluded that the winter of 1977-1978 was the worst of the 20th Century in Illinois, and that of 1978-1979 was the second worst. Other severe winters of the century included 1911-1912 (third ranked), 1917-1918 (fourth ranked), 1903-1904 (fifth), 1959-1960 (sixth), and 1976-1977 (seventh).

The winter of 1981-1982 became another in the recent series of extreme winters in Illinois. It marked the fourth severe winter during the 6-year period that began in 1976, a unique climatic circumstance in itself. No other series of bad winters is evident in the past 100 years. The winter of 1981-1982 was notable for five reasons.

1) It had 18 severe storms, tying 1977-1978 for the record one-season high.
2) The winter season was extremely long, lasting from late November to mid-April.
3) The lowest daily temperatures of the century in Illinois occurred in January 1982.
4) Costs related to excessive energy consumption and to damages to roads and highways exceeded $1 billion, with great delays in travel and serious spring flooding.
5) Lives of 34 persons were lost, the fourth largest number in this century.

The record-tying number of winter storms, large number of severe ice storms (table 1), extremely low temperatures, and massive impacts collectively led to the classification of the 1981-1982 winter as the second worst winter of the 20th Century, replacing 1978-1979. Hence, in the past six years (1977-1982) Illinois has experienced its first, second, and third worst winters of the 20th Century.

Although the 1981-1982 winter was severe statewide, the greatest impact of the storms and the snowfall occurred in the central and southern sections. Record single-storm snowfalls and winter total snowfalls were recorded at many stations in the south central and central sections. The extremely low statewide temperatures, particularly in January, helped bring on the excessive use of heating fuels for everyone in Illinois and the exceptionally high cost of fuel.

The studies of the other recent severe winters (Changnon and Changnon, 1978) noted that there were two basic types of severe winters. One type is based on the occurrence of extremely cold periods of 1 to 2 months duration, either with or without excessive snowfall. The winter of 1976-1977 was typical of this type of winter. The other basic type of severe winter in Illinois has severe ice storms and heavy snowfalls occurring repeatedly over a period of 6 weeks or more. This "snow winter type" occurred in 1977-1978 and 1978-1979, and the winter of 1981-1982 also fell within this second type of severe winter.

A list of the various major characteristics of the 1981-1982 winter is presented in table 1 along with those of the 1977-1978 and 1978-1979 winters. This allows a comparison with other recent winters (Changnon et al., 1980). The assessment of a winter's severity is based on all of these conditions including the number and intensity of the winter storms, the extremes of temperature, the total snowfall, snow depth records and persistence, and other factors.

Table 1. Analyses of Recent Severe Winters

	1981-82	*1978-79*	*1977-78*
Storm Characteristics			
Total number of storms	18	17	18
Number of ice storms	15	14	7
Number of severe ice storms	4	2	1
Number of blizzard conditions	5	3	8
Maximum single storm snowfall total, inches	20	24	15
Number of storms when snow covered Illinois	4	1	5
Average storm duration, hours	15	24	18
Dates of worst storm	29-31 Jan	12-14 Jan	24-26 Jan
Temperatures			
Mean temperatures, Dec-Mar, at			
Chicago	23.4°	22.7°	22.4°
Mt. Vernon	32.3°	29 7°	28.1°
Record daily lows broken	8 days	4 days	12 days
Snowfall			
Total snowfall, inches			
Northern Illinois	70	100	80
Central Illinois	65	50	70
Southern Illinois	40	50	50
Duration of snow cover	Record durations in Central Illinois	Record duration in Northern Illinois	Record duration in pans of Central and Southern Illinois
Snow depth records, inches	33 in South Central	40 in North	15 in South
Severity Assessment			
Number of deaths	34	10	62
Areas of greatest damage	Central and South	Northern Illinois, Chicago	Statewide
Area of worst winter record setting	Central and South Central	Northern 1/4	Southern 3/4

DATA SOURCES AND ANALYTICAL METHODS

Analysis of individual storms from 52 stations in Illinois with published snowfall and snow-depth values were used to plot storm maps for each severe storm. On each storm map, the beginning and ending times and dates, the amount of snowfall, the amount of precipitation, and the occurrence of other weather phenomena such as high winds, ice-pellets and glaze were noted. With this information, determination of the direction of storm movement, the earliest beginning and latest ending times of the storm within the state, and the beginning and ending times at the stations in the core of the storm area (typically 5 to 10 stations) were used to calculate point durations. Isohyetal analysis based on point snowfall values on each map were done to investigate the storm snowfall pattern. The extent of areas greater than 3 and 6 inches was determined by using a computer program to planimeter each storm map. The highest and lowest snowfall values in each storm were identified.

Snowfall totals for each month in the season were obtained from the Climatological Data for Illinois (EDIS, July 1982). Isohyetal patterns based on the point values of the snowfall totals were constructed for these months along with a seasonal map. These totals were compared with records from 50 Illinois stations with snowfall and snow-depth records dating back to 1900. Comparison of 1981-1982 seasonal snowfall and snow depths with the historical data allowed ranks of the 1981-1982 values to be determined.

Snow depths recorded by dates at four NWS stations representing a north-south cross section of Illinois were used to construct time-height profiles of snow cover.

WINTER DESCRIPTION AND CLIMATIC ASSESSMENT

Introduction

The winter of 1981-1982 in Illinois was the fourth severe winter of the past six winter seasons. The state experienced 18 severe winter storms, equalling the record high number of 18 experienced during the winter of 1977-1978. The severity of the numerous cold outbreaks of Arctic air in Illinois and the unusual length of the winter season characterized the severe winter of 1981-1982. The cold outbreak of 9-11 January 1982 produced what was termed the "coldest day of the century" over Illinois and the other 47 contiguous states, and the two consecutive severe winter storms that occurred across northern and central Illinois in April led many to label the 1981-1982 winter as the "winter that wouldn't die."

The conditions that produce a severe winter in a continental climate are extreme cold and heavy snow. The below normal temperatures and above normal snowfalls are illustrated in figure 1. The 1981-1982 winter season produced frequent outbreaks of record-breaking cold air masses. These began in the middle of December and persisted until the middle of February. Severe winter storms accompanied by unusual cold occurred on three consecutive January weekends. Several of these cold outbreaks were accompanied by high winds that further increased the impact of the cold. The periods of intense cold were not long-lasting and were separated by short periods of near or slightly above average temperatures. Another episode of record-breaking cold occurred during the first week of April in conjunction with two severe winter storms. Generally mild temperatures were experienced during the first half of December, the last half of February, and the last 3 weeks of March.

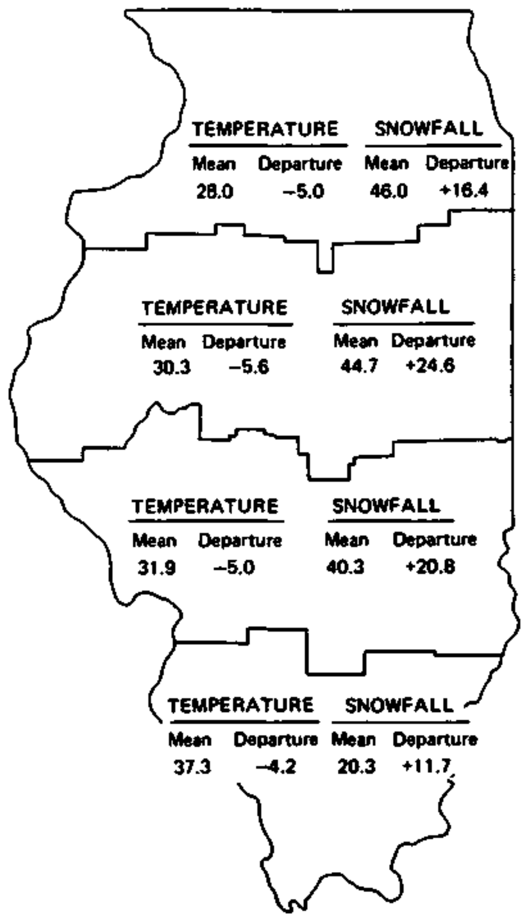

Figure 1. Regional mean temperatures (°F) and total snowfall (inches) and their departures from normal, December 1981-April 1982 period

Snowfall during the 1981-1982 winter season was record-breaking in many parts of central and southern Illinois. Three winter storms bringing heavy snow occurred in rapid succession in central Illinois during the last half of December. As a result, December snowfall totals came near or surpassed the record snowfall totals of December 1973. Another series of three winter storms occurred at the end of January and in the first two weeks of February in southern Illinois. These brought record snow depths to some parts of southern Illinois. Two winter storms that occurred in rapid succession in April affected northern and central Illinois. Record April snowfall totals were common in those areas affected by these late-winter storms.

Severity of 1981-1982 Winter

The unusual length of the 1981-1982 winter season, the 18 severe winter storms, and the outbreaks of record cold air collectively place this winter among the most severe experienced in Illinois. Analysis of temperature and snowfall values, along with their departures from long-term normals, helps quantify the severity of the 1981-1982 season.

Temperatures. The mean temperatures of the December through March period showed departures ranging from 3.0°F (2.4°C) below normal in the southeastern climatic division, to 6.0°F (4.8°C) below normal in the eastern climatic division. Within this 4-month period, January 1982 ranks among the five coldest January months on record in Illinois. Although there existed a prolonged (8 week) period of generally below normal temperatures from mid-December to mid-February, shorter periods of extreme cold particularly characterized the 1981-1982 winter. Moline in northern Illinois experienced 25 days of the 90-day (December-February) winter season of temperatures at or below 0° F (-17.8°C), and Urbana had 15 days of below 0° F during this 90-day period. Record cold temperatures were experienced statewide on 6 different periods in a 4-month span from January through April. Severe or unseasonable cold was experienced on 9-11, 15-17, and 25-26 January, on 5-7 and 10-11 February, and on 5-7 April.

Figure 2 shows minimum temperatures for the six dates that were the coldest of the season in Illinois. The lowest minimum temperatures recorded on 10 January occurred at Chicago Botanical Garden and Rockford with readings of -27°F. Of the 109 NWS stations recording temperatures in Illinois on 10 January, 48 had minimum temperatures at or below -20°F. Temperatures of -27°F were again recorded at Mount Carroll on 17 January, and then at Watseka on 10 February.

Snow. Snowfall and snow depth during the winter of 1981-1982 approached or surpassed records at many NWS stations. Urbana experienced record-breaking 18.5 inches (47 cm) of snowfall in December, while many central Illinois stations (Springfield, Decatur, and Jacksonville) reported their second-heaviest snowfall for December since records began in the 1890's.

January snowfall approached record levels in a band across south-central Illinois, where the 29-31 January super-storm deposited between 12 and 18 inches of snow. Hillsboro, Windsor, Charleston, Paris and Danville all reported record snowfall amounts for January ranging from 29.8 inches (75.6 cm) to 23.1 inches (58.7 cm).

Continued storminess in south-central Illinois during the first part of February led to record-breaking snow depth of from 20 to 33 inches (50.8 to 83.8 cm) in that area. Nashville in the southwest climate district reported a snow depth of 33 inches (83.8 cm) on 13 February. This was the deepest snow cover experienced in Illinois during this 1981-1982 winter season. Snow depths reached record levels in February at Urbana with 19 inches (48.3 cm), Piper City with 25 inches (63.5 cm), Jacksonville with 14 inches (35.6 cm), Windsor with 16 inches (40.6 cm), Belleville with 19 inches (48.3 cm), Sparta with 17 inches (43.2 cm), and Mt. Vernon with 15 inches (38.1 cm). February snowfall approached record levels in that same area with Mt. Vernon recording 19 inches (48.3 cm), equalling the record set in 1910.

The last period of snowfall occurred in April, when two late-season storms led to record snowfall totals in many areas of Illinois. Record April snowfall was experienced at Moline, Galesburg, Peoria, Gibson City, Watseka, Chicago O'Hare, and Kankakee with amounts ranging from 13.8 to 10.5 inches (35 to 26.7 cm). Snowfall amounts at these stations exceeded the previous record amounts that were set in April 1.920.

Monthly and Seasonal Snow Totals

Figure 3 shows an isohyetal analysis of point snowfall totals for every month of the 1981-1982 winter season. Shown in figure 4 is the isohyetal analysis of the seasonal snowfall

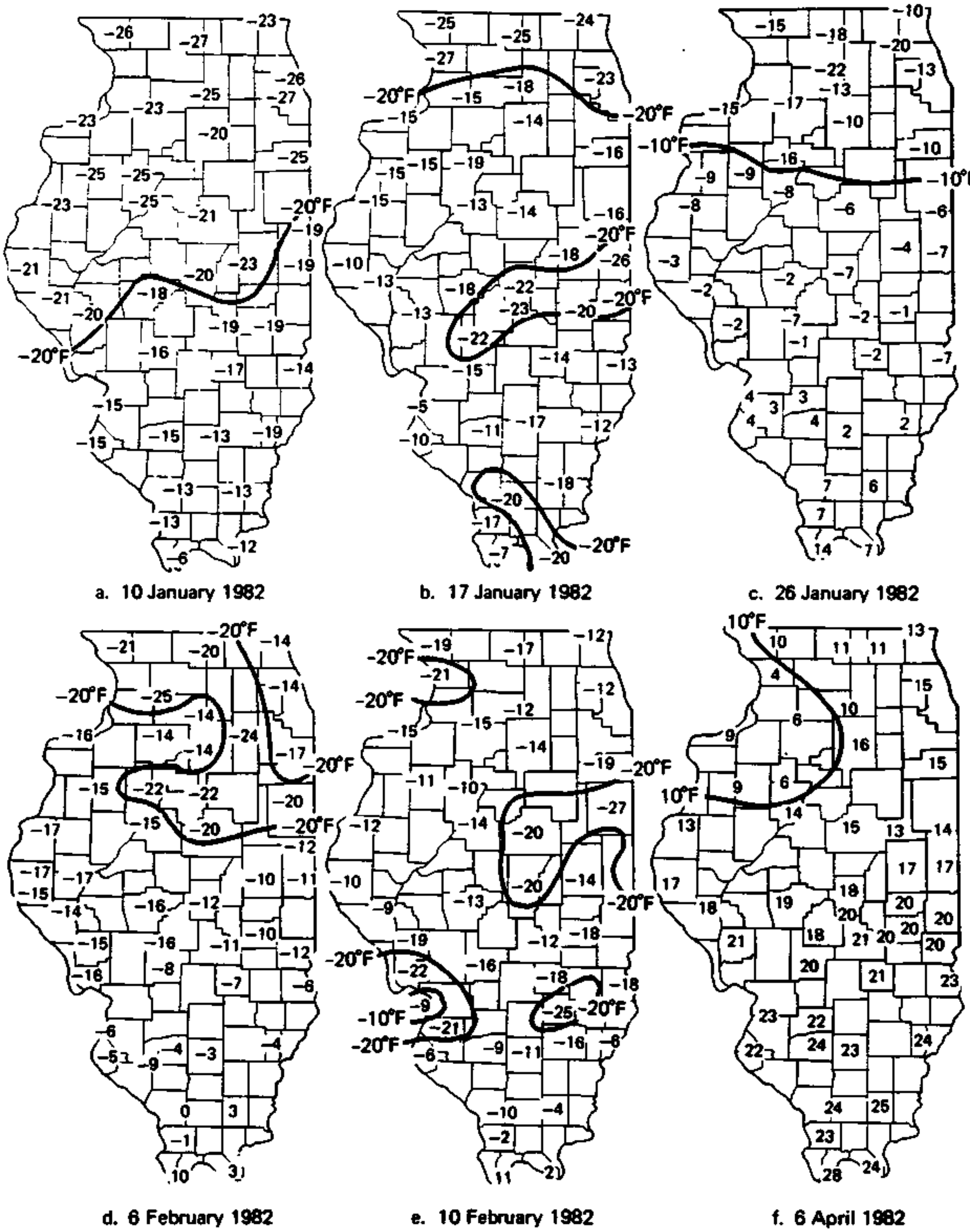

Figure 2. Minimum daily temperatures for the six record breaking cold days

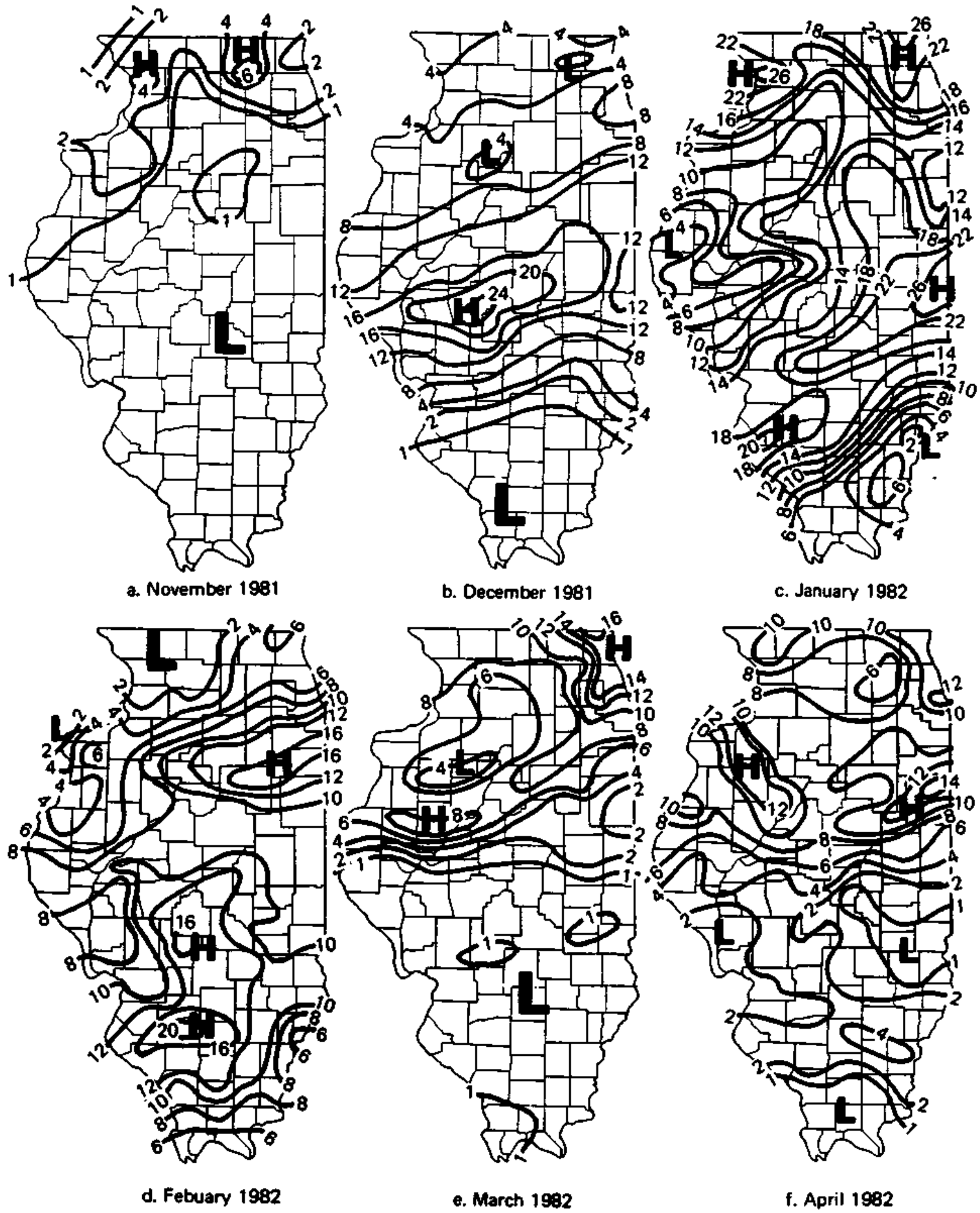

Figure 3. Monthly total snowfall in inches

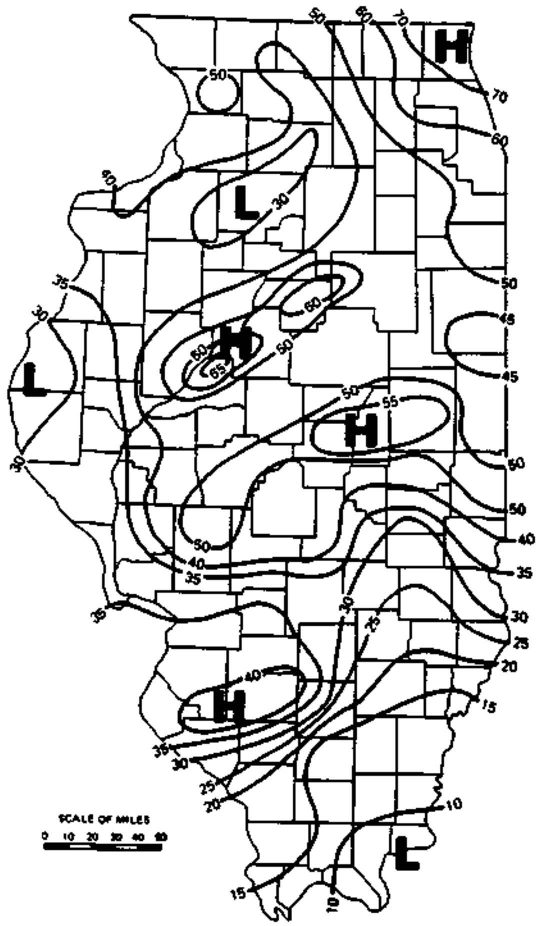

Figure 4. Snow totals for winter 1981-1982

for the 1981-1982 winter season. November and March were the only months that did not set snowfall or snow-depth records at some point in Illinois.

Figure 3 a shows the November snowfall pattern. Two snow storms occurred in northern Illinois, one being classified as severe. Marengo, with a total of 7 inches, had the greatest snowfall amount recorded in Illinois for November.

The December snowfall pattern is revealed in figure 3 b. The occurrence of three consecutive severe winter storms across central Illinois is reflected in the 16-inch (40.6 cm) band extending from Pittsfield to Gibson City. The west-southwest orientation of the isolines of heavy snow indicate that the storms moved from the same general direction (SW or WSW). Below average snowfall was recorded in the northern third of Illinois, and little measurable snowfall was experienced in the southern third of the state.

The January snowfall pattern shown in figure 3c reveals a large heavy core of snowfall across south-central and southwestern Illinois. A large heavy band of snowfall extended from Waterloo in the southwest to Danville in east-central Illinois. Pockets of heavy snow are indicated in extreme northeastern and northwestern Illinois. The heavy snow in southern Illinois is the result of the 29-31 January severe storm, whereas the areas of heavy snow in northern Illinois are the result of storms earlier in January. West-central Illinois was the only area that had below normal snowfall in January.

The February snowfall pattern (figure 3d) shows areas of heavy snowfall in southern and northeastern Illinois. The greatest snow totals occurred in southern Illinois where a series of storms occurred early in the month. The area of heavy snowfall in the northeast is the result of weaker, but more frequent, storms. Snowfall was below normal in the same area of west-central Illinois that was below normal in January. Much below normal snowfall occurred in northwestern Illinois.

The March snowfall pattern shown in figure 3e shows areas of heavy snowfall in west-central and northeastern Illinois. The effect of the enhancement of snowfall by Lake Michigan is shown by the heavy amounts appearing in the northeastern part of the state. Snowfall totals were 1 inch or lighter south of approximately 40°N latitude.

The April snowfall pattern (figure 3f) reveals above normal snowfall occurred in nearly every part of Illinois. The only areas to escape the heavier than normal snow were southeastern Illinois and extreme southern Illinois. The largest and heaviest core occurred across north-central Illinois with many April snowfall records broken in that area.

The seasonal snowfall map of 1981-1982 for Illinois appears in figure 4. The highest seasonal amount occurred at Antioch (extreme northeast) with 72.4 inches (183.9 cm) being recorded. Areas of heavy seasonal snowfall appeared in southwestern, central, and northeastern Illinois. The Havana (central) snowfall amount of 69.5 inches (176.5 cm) was 330 percent above normal and exceeded the record of 60.5 inches recorded there in the 1977-1978 season. The Minonk seasonal total of 61.7 inches (156.7 cm) is also a record amount. The seasonal totals at Urbana and Paris were the second heaviest experienced on record, their record totals having occurred during the 1977-1978 winter season. Snowfall totals in the heavy core in the southwest are nearly 300 percent of normal, with Nashville and Red Bud recording 42.8 inches (108.7 cm) and 43.8 (111.2 cm), respectively. Snowfall amounts were above normal statewide, except for small areas in northwestern Illinois and west-central Illinois.

Snow Cover

The prolonged winter season, coupled with below normal temperatures and heavy snowfalls, led to long periods and large depths of continuous snow cover. Figure 5 is a height profile of snow cover at four stations in Illinois showing daily recorded values of snow on the ground.

The four stations chosen — Antioch, Hoopeston, Springfield, Nashville — represent a north-south cross section of Illinois. At Antioch in northern Illinois, the late November storm is notable; however, there was rapid melting, and no snow on the ground occurred until late December. Continuous snow cover was experienced from late December through mid-March at both Antioch and Hoopeston. Heaviest snow depths occurred in early to mid-February at all four stations.

The thaw that was experienced in the last two weeks of February, and the mild conditions of the last three weeks of March are clearly reflected in the diminishing snow cover

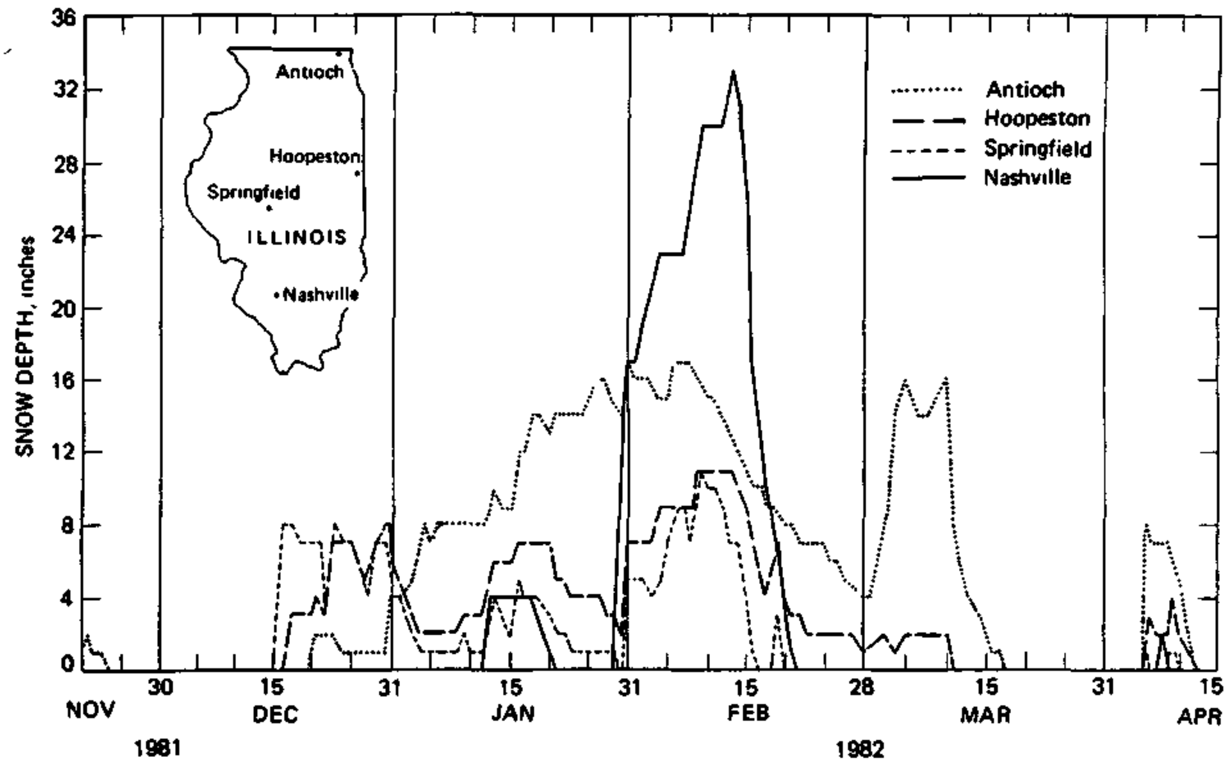

Figure 5. Temporal distribution of snow depths at 4 Illinois stations

in February and the loss of snow cover in March at all four stations. The height profile of Nashville in early February depicts the record snow depths experienced in south-central Illinois at that period.

Table 2 shows the longest consecutive runs of snow cover at depths of 20 inches (50.8 cm), 10 inches (25.4 cm), and 1 inch (2.54 cm) at the four stations for which height profiles are drawn (Antioch, Hoopeston, Springfield, and Nashville). Snow depths of greater than 20 inches at Nashville is representative of the deep snow cover at many southern and south-central Illinois reporting stations at that time. The longest consecutive number of days

Table 2. Snow Cover Statistics

	Longest consecutive cover ≥ 20 inches		*Longest consecutive cover ≥ 10 inches*		*Longest consecutive cover > 1 inch*		*Total days of cover > 1 inch*
	Dates from to	*Total days*	*Dates from to*	*Total days*	*Dates from to*	*Total days*	
Antioch		0	1/16-2/17	33	12/21-3/17	87	102
Hoopeston		0	2/9-2/14	6	12/17-3/10	84	90
Springfield		0	2/9-2/11	3	12/17-1/28	43	65
Nashville	2/3-2/15	13	1/31-2/18	19	1/31-2/21	22	31

with measurable snow cover occurred at Piper City in north-central Illinois, with 88 consecutive days with 1 inch or more on the ground (between 17 December and 14 March). Table 2 shows Antioch with 87 consecutive days, which is the second longest number of days with measurable snow cover experienced in the 1981-1982 winter season.

SEVERE STORMS

General Review

The isohyetal patterns of the 18 severe winter storms of 1981-1982 are shown in figures 6 through 8. Severe winter storms are identified by meeting one or more of these criteria (Changnon, 1969):

1) a snowstorm that produced 6 inches or more of snowfall at a point in 48 hours or less;
2) a snowstorm that produced conditions leading to property damages, deaths, or injuries regardless of the amount of snowfall;
3) a glaze storm in which 10 percent of the cooperative National Weather Service stations in Illinois reported glaze; and/or
4) a glaze storm in which property damage, deaths, or injuries occurred.

One severe storm occurred in late November, four in December, eight in January, two in February, one in March, and two in April. This totaled 18, a number equal to the record number experienced in the winter of 1977-1978. The eight in January is a record number, exceeding by one the seven in January 1979. The two that occurred in April equals the record number and helps illustrate the prolonged nature of the 1981-1982 winter.

Analysis of snowfall patterns indicated that the effects of Lake Michigan to enhance snowfall was evident in at least three storms including those on 29-31 January, 3-4 March, and 5-6 April (figure 8). Strong northeast winds induced by the passage of low pressure across to the south and east of Illinois added moisture to the air from Lake Michigan. The cold air passing over the relatively warmer lake water adds to the instability, and when the air is cooled and lifted as it passes over the adjacent land area, snowfall is increased.

Freezing rain occurred somewhere in Illinois in 15 of the 18 storms. In 4 of the storms, the extent of the freezing rain, rather than the amount of snowfall, classified it as a severe storm. Widespread glazing occurred on 20-21 December, 2 January, 20-21 January, and 21-22 January. The most damaging ice storm of the season occurred on 21-22 January. The most damaging ice storm of the season occurred on 21-22 January, when high winds accompanied glazing that occurred over 70% of the state. Interestingly, the greatest amount of snowfall recorded from that storm was only 1 inch.

High winds occurred in 6 of the 18 storms. Blizzard-like conditions were nearly statewide on 8-10 January and 17 January, and existed across northern Illinois in 3-4 January and 5-6 April, and in south central Illinois on 30-31 January. The lack of high winds in other storms would indicate a lack of extremely deep low pressure centers. Thunderstorms occurred in Illinois on only 4 storm periods, 3-4 January, 21-22 January, 29-31 January, and 5-7 April, another indication of the lack of deep low pressure areas.

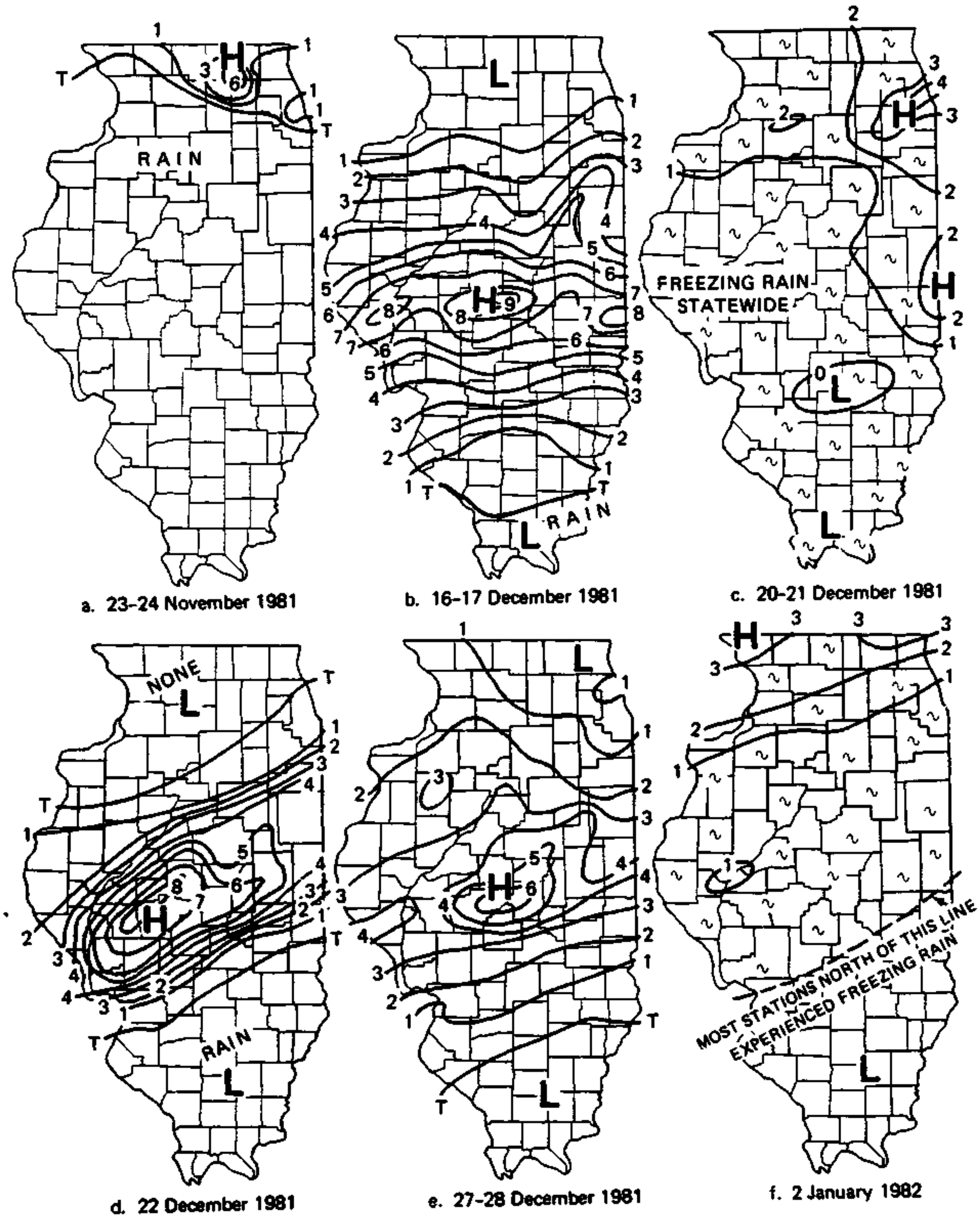

Figure 6. Snowfall patterns (inches) for the first six severe winter storms

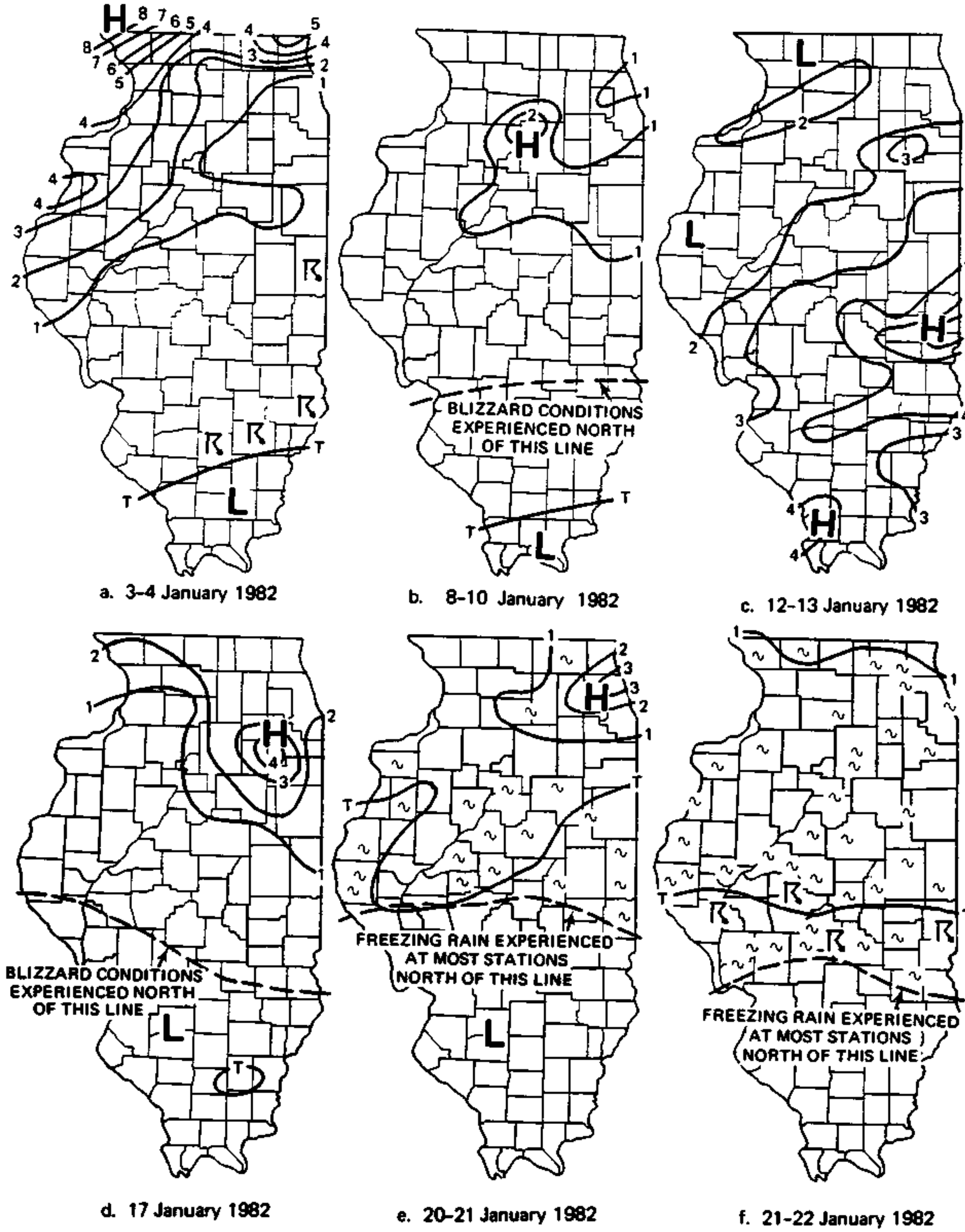

Figure 7. Snowfall patterns (inches) for the second six severe winter storms

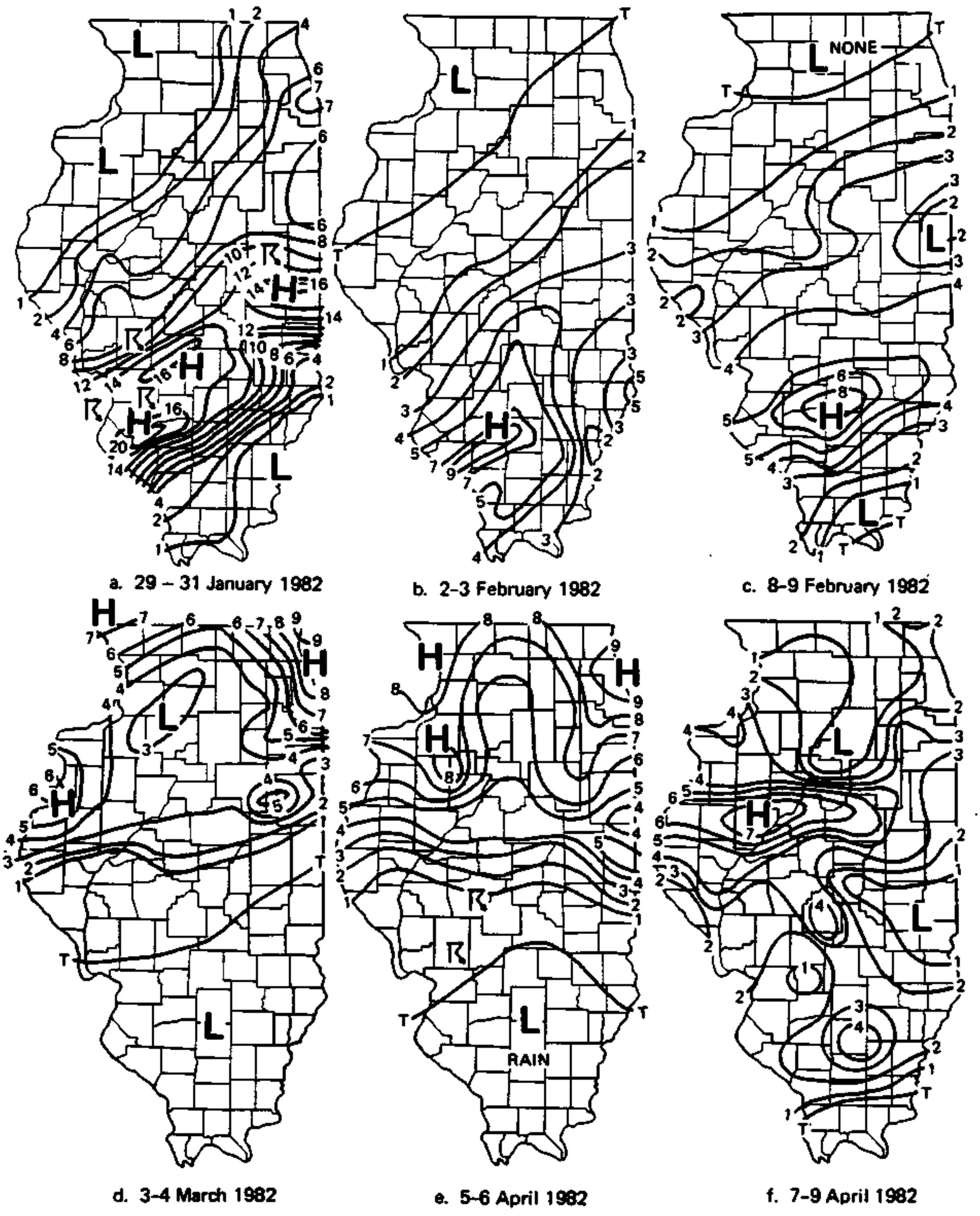

Figure 8. Snowfall patterns (indies) for the last six severe winter storms

Table 3. Storm Time and Motion Inventory

Storm date	*Begin Hour/CST*	*Begin Locale*	*End Hour/CST*	*End Locale*	*Average duration (hours) at locales with heaviest snowfall **	*Direction from which storm moved*
23-24 Nov	08	McLeansboro	00	Paris	12.0	W
16-17 Dec	09	Jerseyville	03	Antioch	16 9	WSW
20-21 Dec	18	Chester	18	Antioch	10.2	SSW
22 Dec	08	Jerseyville	23	Danville	8.9	SW
27-28 Dec	20	Quincy	16	Danville	14.1	WSW
2 Jan	05	Carlinville	24	Rockford	11.5	SW
3-4 Jan	12	Carbondale	20	Antioch	16.1	SSW
8-10 Jan	08	Rockford	23	Hoopeston	9.3	NNW
12-13 Jan	11	Belleville	7	Piper City	11.2	SW
17 Jan	08	Galena	22	Chicago	6.9	WNW
20-21 Jan	10	Greenfield	02	Chicago	7.7	SW
21-22 Jan	17	Harrisburg	24	Rockford	(ice)	SSW
29-31 Jan	14	Chester	24	Chicago	36.3	SW
2-3 Feb	18	Prairie DuRocher	24	Palestine	17.3	WSW
8-9 Feb	11	Carbondale	04	Lawrenceville	14.1	WSW
3-4 Mar	15	Quincy	20	Aurora	16.5	WSW
5-6 Apr	02	Moline	02	Chicago	16.5	WSW
7-9 Apr	13	New Boston Dam 17	09	Piper City	32.5	W

** Typically based on value of 5 to 10 stations in each storm.*

Storm Characteristics

Table 3 presents, for each storm, its earliest beginning time and latest ending time in Illinois. The 18 storms began at varying times of the day. Six began between 0900 and 1300 which is the preferred 4-hour period of initiation (Changnon, 1969). Table 3 also shows average point durations at locales within the heaviest snowfall area along with the direction from which each storm moved across the state. The median duration of the storms during the 1981-1982 season was 15.1 hours. The 17 January snowfall associated with a record breaking cold push was only *6.9* hours duration, whereas the superstorm of 29-31 January produced rain and snow for an average 36.3 hours at those locations with heaviest snowfall. The median time for the severe winter storms studied from 1900 through 1960 was 14.2 hours (Changnon, 1969).

The directions from which the storms moved (table 3) indicated that 6 storms moved from the westsouthwest direction, 5 from the southwest, 3 from the south-southwest, 2 from the west, 1 from the westnorthwest, and 1 from the north-northwest. The preferred motion is from the westsouthwest and southwest, the direction being dependent on the synoptic type and storm track of the individual storms.

Table 4 lists the largest and smallest snowfall amounts for each of the identified 18 severe winter storms. The largest amount occurred at Red Bud, where 20.0 inches of snow

Table 4. Storm Snowfall Summary

Storm date	*Highest state values (inches) and locale*		*Lowest state values (inches) and locale'*	*Areal extent (square miles)*	
				≥ 3 inches	*≥ 6 inches*
23-24 Nov	6.0	Marengo	0	700	60
16-17 Dec	9.0	Decatur	0	28,220	11,480
20-21 Dec	4.5	Chicago Midway	0	1,000	
22 Dec	8.5	Jacksonville	0	15,920	4,350
27-28 Dec	6.8	Decatur	0	16,020	460
2 Jan	30	Galena	0	780	
3-4 Jan	8.0	Galena	0	6,340	460
8-10 Jan	2.9	Chicago O'Hare	0		
12-13 Jan	6.5	Pans Waterworks	.8 Bentley	23,900	300
17 Jan	4.0	Channahon Dresden	0	1,060	
20-21 Jan	3.5	Chicago O'Hare	0	140	
21-22 Jan	1.0	Freeport	0		
29-31 Jan	20.0	Red Bud	0	31,130	21,000
2-3 Feb	9.0	Sparta	0	18,020	3,230
8-9 Feb	8.2	Nashville	0	27,110	2,630
3-4 Mar	8.6	Chicago O'Hare	0	26,070	12,540
5-6 Apr	10.5	Chicago Midway	0	27,320	15,170
7-9 Apr	8.3	Peoria	0	14,730	3,370

• *If more than one locale, the station is not listed*

fell during the 29-31 January storm, the smallest amount occurred at Freeport, where 1.0 inch of snow fell during the 21-22 January ice storm.

The areal extent of the 3- and 6-inch snowfall cores of each storm (table 4) show that the 29-31 January storm had the largest areal extent in both the 3- and 6-inch cores. The storms of 8-10 January and 21-22 January did not have snowfall totals greater than 3 inches; however, the 8-10 January storm was characterized by extreme cold and blizzard-like conditions, and the 21-22 January storm was characterized by glazing and high winds nearly statewide. The smallest 6-inch core was experienced during the 23-24 November storm, that being an extremely localized heavy wet snow, and the smallest 3-inch core was experienced during the 20-21 January storm, which was another storm characterized by widespread glazing.

Synoptic Weather Conditions

Changnon (1969) identified five weather types associated with severe winter storms in Illinois. These types are identified by the origin of their low pressure center and its subsequent track. Figure 9 depicts the general characteristics of these five types.

Examination and classification of the individual severe storms during the winter of 1981-1982 revealed a preponderance of storms of types 2 and 6. Type 6 storms are those which do not exhibit characteristics of the other five types, such as frontal passages and low tracks through Illinois or west of the Mississippi River. Table 5 lists the number of storms of

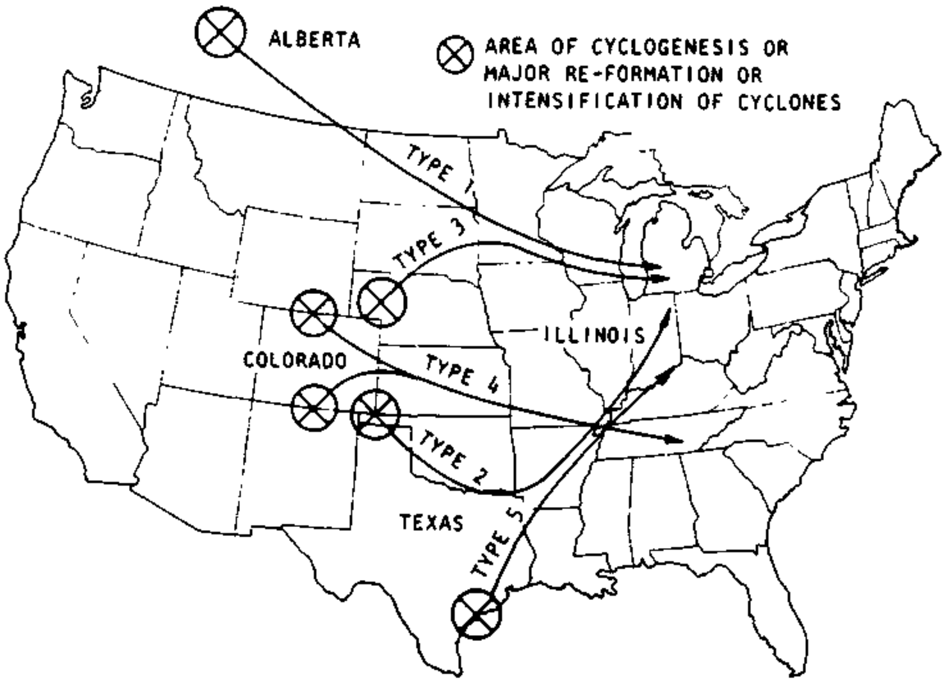

Figure 9. Depiction of weather types related to severe winter storms in Illinois

each type during the winter. Storm development and track were determined for each storm from the Daily Weather Map series and the storm sequence was plotted on maps. In a few cases where the positions of weather systems on the Daily Weather Maps were at odds with the plotted data, the systems were re-analyzed and adjusted. The following is a summary of the development of each storm. Surface weather patterns for each storm are depicted in figure 10 a-r. All times are CST.

23-24 November 1982 (Storm Type 1). At **0600** on 23 November a strong 500 mb short wave extended from the western Canadian provinces down into the northern plains.

Table 5. Frequency of Cyclonic Types Producing Severe Winter Storms in the Winter of 1981-1982

	Type	*Frequency*
1	(Alberta)	2
2	(Great Plains)	6
3	(Great Plains north)	0
4	(Colorado)	3
5	(Texas-Gulf Coast)	1
6	(Miscellaneous)	6
		18

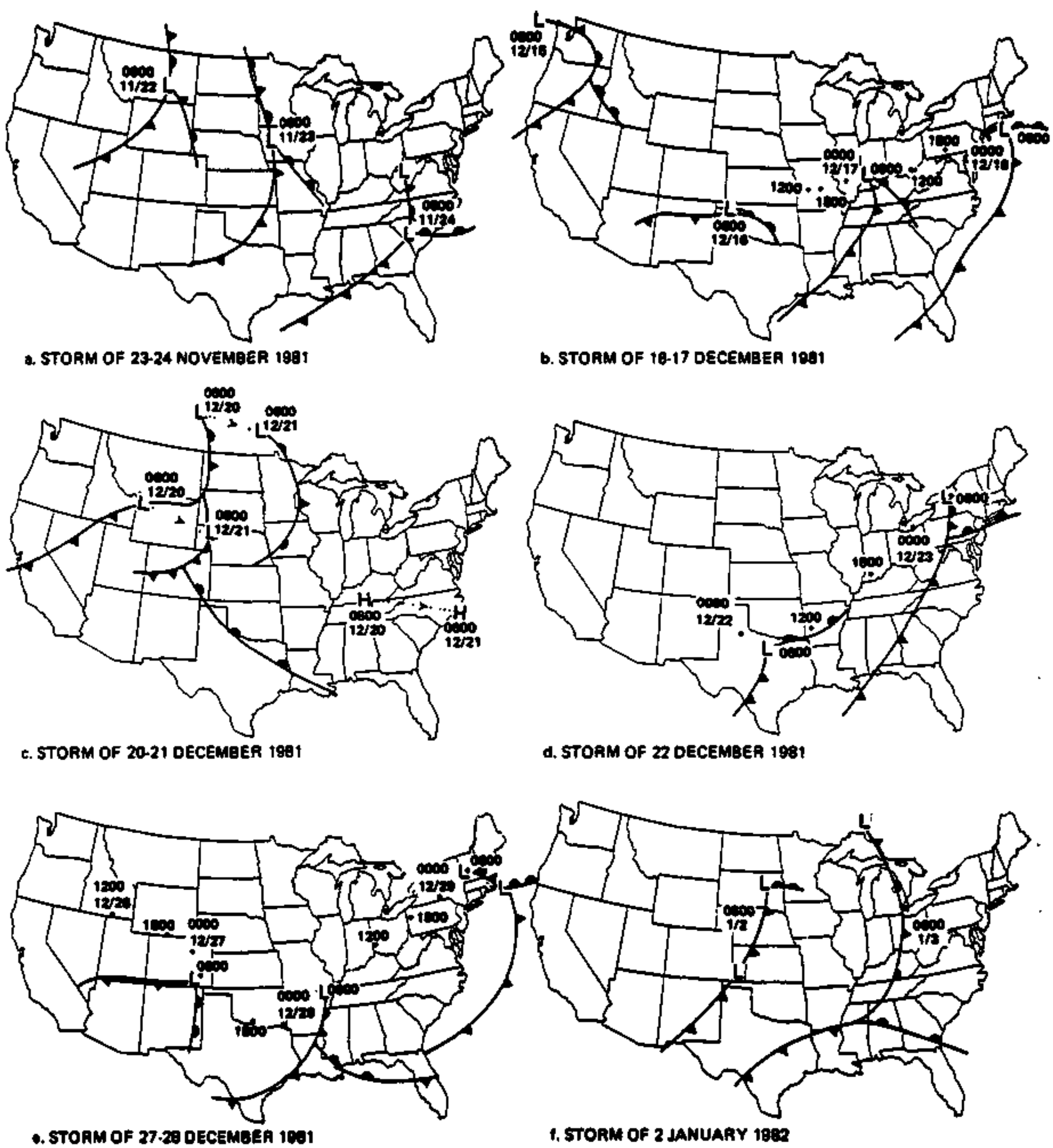

Figure 10. Movement of surface westher systems

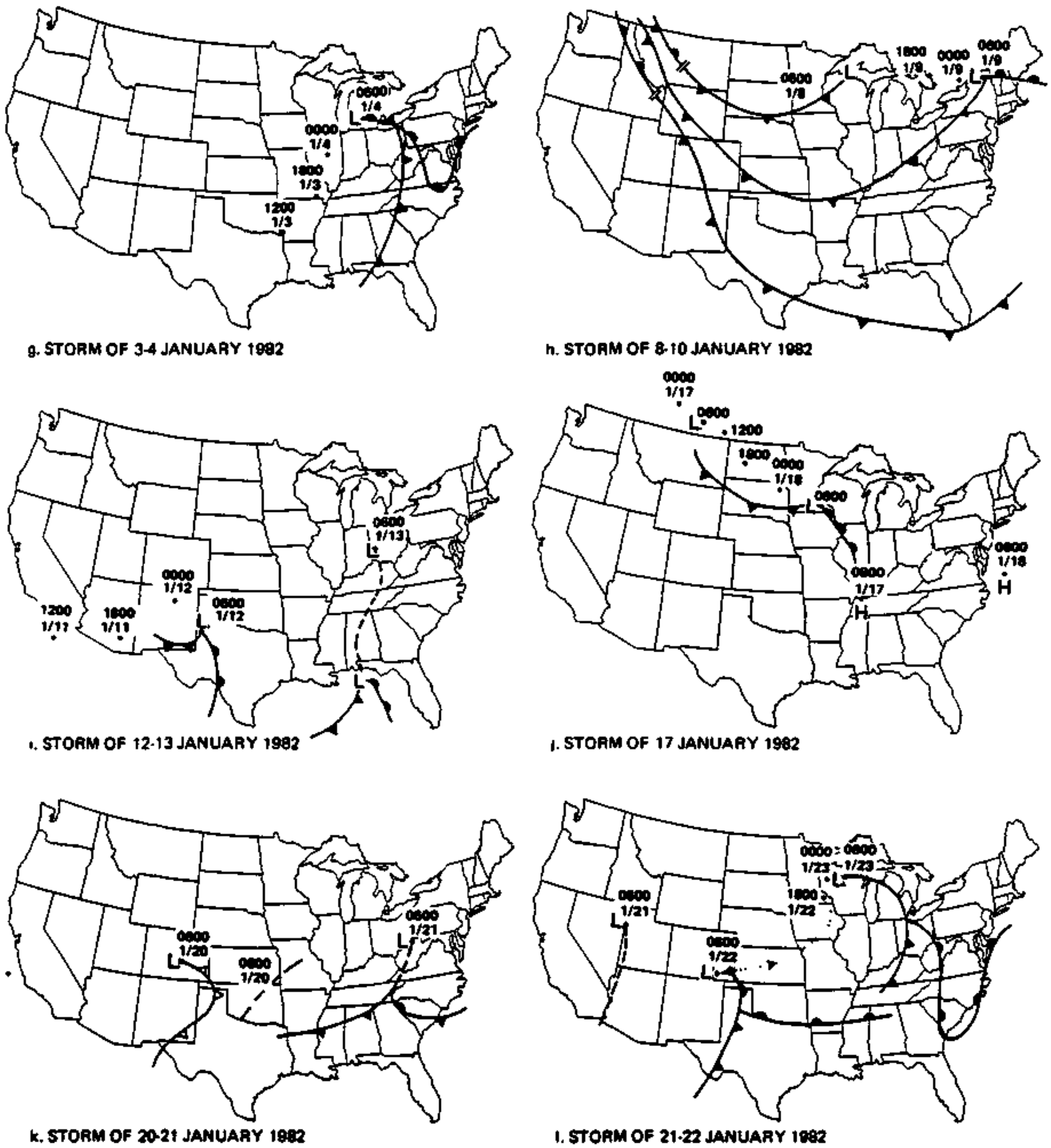

Figure 10. Continued

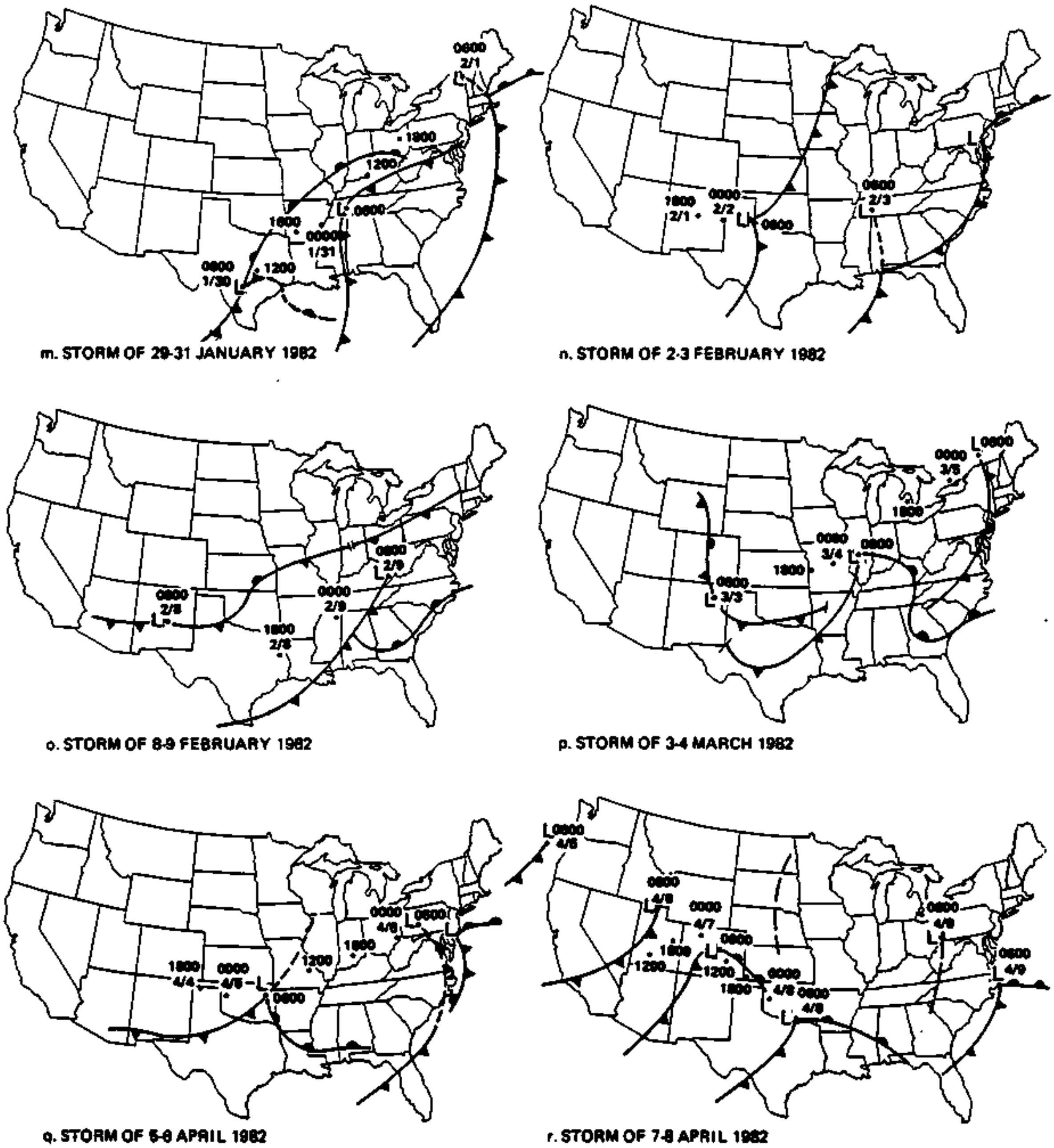

Figure 10. Concluded

A surface low was centered over western Iowa with a cold front extending south into Oklahoma and Texas. This system moved to the southeast during the day, and snow, sleet, and some freezing rain developed over northern Illinois. The heaviest snow was concentrated over northeastern Illinois as the low moved through the state. By 0600 on 24 November, the low was located over South Carolina and moving eastward. Precipitation in Illinois ended about 2400 on 24 November.

16-17 December 1981 (Storm Type 2). An upper level trough moved into the central plains on 14 December, while on the surface a cold front moved through Illinois. While the southern portion of the trough moved east, another short wave moved into the Pacific Northwest on the 15th. As the trough moved southeast into the long wave position, the associated surface low moved into the Oklahoma Panhandle by 0600 CST 16 December. The surface low moved eastnortheast out of Texas and Oklahoma on 16 December into Missouri. The storm moved slowly through central Missouri and through south central Illinois, producing moderate to heavy snow across the central portion of the state. By 0600 on 17 December the storm center was located near Evansville, Indiana. It then moved off the East Coast by the morning of 18 December.

20-21 December (Storm Type 6). A large cold high centered over central Kentucky on the morning of the 20th covered most of the eastern half of the United States. Strong northwest winds at 500 mb on 20 December backed to the west by the 21st. As the high retreated off the East Coast, warm moist air from the Gulf of Mexico was funneled into the Midwest, over the top of the cold air layer near the surface. This overrunning resulted in freezing rain, sleet, and snow over all of Illinois.

22 December 1981 (Storm Type 2). A 500 mb short wave moved from the Pacific into central California on the morning of 21 December. By 0600 on 22 December the short wave was located in central New Mexico, and a surface low had formed in north-central Texas. The surface low moved northeastward during the day of 22 December as the upper level winds backed to the southwest in response to a short wave in the northern plains merging with the southern trough. The surface low moved rapidly through the Ohio Valley, producing heavy snow in central Illinois. The low was located over Lake Erie by 0600 on 23 December.

27-28 December (Storm Type 2). Another short wave trough moved in from the Pacific in a strong band of westerlies at 500 mb. The surface low developed over Idaho early on 26 December, and moved to Colorado by the morning of 27 December. Redevelopment of the low occurred in southern Oklahoma in the ensuing 24 hours, and by the morning of 28 December the storm was moving northeastward through Arkansas. Moderate to heavy snow fell across central Illinois, with lighter snow to the north. The storm continued on northeast through the Ohio Valley during the day and by 0600 on 29 December was located in southern Vermont.

2 January 1982 (Storm Type 6). The precipitation with this storm (freezing rain in central Illinois, snow in northern Illinois) developed ahead of an advancing cold front which originated over the Rockies on 1 January. This was an overrunning situation, with high pressure over the northeastern United States producing east to southeast winds over the Midwest

3-4 January 1982 (Storm Type 6). A strong 500 mb short wave trough that came off the Pacific on 2 January moved into Colorado and New Mexico by early 3 January. By that time a surface low was forming over Oklahoma. During the next 24 hours the low intensified as the 500 mb trough became cut off, and the storm followed a path through Arkansas, southeast Missouri, and up through the middle of Illinois, producing heavy snow and high winds in the western part of the state. By 0600 on 4 January a deep surface low (central pressure 983.6 mb or 29.01 inches) was located near Grand Rapids, Michigan, producing high winds across the Midwest.

8-10 January 1982 (Storm Type 6). In the three days preceding this storm, strong ridging was taking place off the West Coast at 500 mb, resulting in a buildup of cold air over the Northwest Territories of Canada. A very strong short wave located over the western edge of Hudson Bay at 0600 on 8 January was reflected at the surface by a low over northern Wisconsin trailing a strong cold front. Snow developed ahead of and behind the cold front, which began its passage through Illinois during the late afternoon of 8 January. By 0600 9 January the low pressure center was centered over northern New York and the cold front extended through the Ohio Valley through extreme southern Missouri and Kansas and then along the lee of the Rockies. A strong high pressure system in central Canada was pushing southeastward.

During the next 24 hours a series of events occurred which resulted in extremely cold and windy conditions. The 500 mb low near Hudson Bay on 8 January merged with a weaker low over Quebec by early 9 January. During the day of 9 January this 500 mb low underwent rapid intensification. This resulted in the explosive deepening and intensification of a surface low over the northern Canadian Maritimes. In addition, the surface low moved southwest from the Maritimes to the southern end of Hudson Bay. The extremely large pressure difference between this low (970 mb) and the Arctic high (1057 mb) on 10 January " resulted in a very strong pressure gradient. The bitter cold air that had been building in Canada during the previous six days was thus channeled into the nation's midsection with the help of 30-40 mph winds. The high winds and blowing snow resulted in ground blizzard conditions over northern and central Illinois.

12-13 January 1982 (Storm Type 2). The Arctic air mass that spread into the United states on 10 and 11 January still covered the nation on 12-13 January. At 500 mb a major trough covered the entire country on 12-13 January. An open wave began moving into the southwestern United States on 11 January. A surface low developed over Baja, California, midday on 11 January, then moved to the Texas Panhandle by 0600 on 12 January. This low moved northeastward during the next 24 hours, while the secondary low formed over the Gulf Coast. Snow spread over the Midwest early on 12 January, and continued through early 13 January as the complex low system moved east. Moderate snow fell over central and southern Illinois, with light snow in the northern part of the, state.

17 January 1982 (Storm Type 1). Very strong westnorthwest flow began to develop at 500 mb across the country on 16 January, and extended from the Pacific Northwest to the Appalachians by 17 January. A strong cold front moved through Illinois late on 15 January and early on 16 January as the 500 mb flow became established. High pressure moved out of western Canada and to the central plains on 16 January. By 0600 on 17 January, the high was centered over western Tennessee, resulting in strong southwest surface winds across the Midwest. A low that had formed over Alberta was moving southeast into North Dakota. As the low moved across the northern Midwest and into the Great Lakes, snow spread across northern and central Illinois accompanied by high winds and extreme cold. There was considerable blowing and drifting of snow in northern and central Illinois. This was primarily an overrunning situation, and most of the snow ended by 2200 by 17 January. The low pressure center became diffuse as it crossed the Great Lakes region on 18 January.

20-21 January 1982 (Storm Type 4). A large surface high pressure system over south central Canada at 0600 on 20 January extended through most of the eastern United States. At 500 mb, a weak ridge extended from the Gulf of Mexico through the northern plains, with westnorthwest flow over Illinois. A short wave had moved out of a major trough along the West Coast into the lee of the Rockies. As this trough moved through the ridge on the 20th, winds aloft backed into the southwest, and the relatively warm, moist air overrunning the low level cold air mass resulted in widespread precipitation over the Midwest and East. Freezing rain fell across central Illinois, while light snow spread over the north as a weak inverted surface trough moved through the Midwest. By the morning of 21 January a weak surface low associated with the short wave trough aloft was over the central Appalachians. However, another major storm was already taking shape in the west.

21-22 January 1982 (Storm Type 6). The major 500 mb trough off the West Coast on 20 January moved into California by 0600 on 21 January. A surface low associated with the upper level system was located in northern Utah. In the meantime the high over southern Canada was strengthening while moving eastward rather slowly, keeping the cold air entrenced in the Midwest. By 0600 on 22 January the western surface low was in southeastern Colorado. As the 500 mb trough progressed eastward and strengthened, the surface low intensified and moved northeastward. The path of the storm kept the center west of Illinois. East and southeast winds produced another overrunning situation, with extensive freezing rain and sleet in northern and central Illinois. By 0600 on 23 January a strong storm center was located over central Wisconsin (central pressure 983 mb), causing high winds across Illinois.

29-31 January 1982 (Storm Type 5). This storm, the biggest and most damaging of the season, did not really become organized until the afternoon of 30 January. On the morning of 29 January, a high pressure system was located over Ohio and moving eastward. Surface winds were east and southeast throughout the Midwest. At 500 mb, split flow characterized the flow pattern. A strong cutoff low was centered over Arizona in the southern branch, and a strong short wave was moving out of southwestern Canada in the northern branch. Surface lows were located over New Mexico and North Dakota. Overrunning precipitation broke out over Illinois in the afternoon on 29 January in response to the approaching low and associated cold front in the northern plains. Heavy rain fell over southern and central Illinois, while some snow, sleet and rain occurred in the north. By 0600 on 30 January the cold front was pushing through Illinois. Meanwhile, the cutoff low in the southern branch moved to southeastern New Mexico, and a surface wave was located in southern Texas. During the night of 30 January, the 500 mb low became an open trough, and the low in Texas moved northeastward. High pressure over the northern Great Lakes provided the source of cold air, and as the storm headed northeastward heavy snow broke out across central and southern Illinois, with light to moderate snow over the northern third of the state. High winds resulting from the pressure gradient between the storm and the high to the north resulted in blizzard-like conditions over the southern two-thirds of the state.

Because of the severity of this storm, it is described in greater detail elsewhere in this report.

2-3 February 1982 (Storm Type 4). A large amplitude 500 mb trough covered the entire United States on the morning of 2 February. A low pressure center developed over central New Mexico late on 1 February and was located over the Texas Panhandle at 0600 on 2 February. This was actually a frontal wave, although as the low moved eastward the northern part of the front became rather diffuse, and was analyzed as an inverted trough by 0600 on 3 February. Moderate to heavy snow began to fall in southern Illinois late on 2 February and continued into the afternoon of 3 February. Light snow fell in northern and central Illinois.

8-9 February 1982 (Storm Type 2). A 500 mb short wave moved into the southern Rockies late on 7 February and early on 8 February, and it was reflected on the surface by a large area of low pressure through the southwestern United States. A frontal wave in central New Mexico at 0600 on 8 February moved to eastern Texas by 1800. It then moved northeastward through northern Mississippi and into eastern Kentucky by 0600 on 9 February. Moderate to heavy snow fell across southern and central Illinois.

3-4 March 1982 (Storm Type 6). The 500 mb pattern on 3 March was characterized by a general west-to-east flow across the country. A short wave was located in the flow over the southern Rockies. Cold air settled into the Midwest on 2 March as an Arctic high pushed southeastward out of Canada and into the northern Great Lakes. A low developed in response to the short wave in New Mexico on a stationary front which stretched eastward off the Atlantic Coast. As the surface low began its move northeastward, warm and moist Gulf air started to overrun the cold air over Illinois. The storm track took the low center through central Missouri and central Illinois. Heavy snow fell over northern Illinois, while the central part of the state received freezing rain and sleet.

5-6 April 1982 (Storm Type 2). A series of strong 500 mb short wave troughs moved into the United States from the Pacific during the first week of April. The second trough of the series was over the Rockies at 0600 on 5 April. A surface low was located in Oklahoma at the time, while a cold high pressure air mass centered over Saskatchewan settled in over the northern Midwest. Precipitation broke out with the system early on 5 April, and spread over all of Illinois during the day. Heavy snow fell over northern Illinois, while snow and sleet fell in central portions of the state. The storm intensified as it moved through southern Illinois and Indiana, creating winds which resulted in near blizzard conditions in northern Illinois. Intensification of the low began as the 500 mb short wave moved toward the long wave trough over the eastern United States. By 0600 on 6 April the storm was located over southern New Jersey.

7-8 April 1982 (Storm Type 4). This storm was already in the making as the last storm was dumping snow on Illinois. It resulted from a third short wave in the series moving through the fast westerly flow over the United States. At 0600 on 5 April the storm was off the Oregon coast, and by 0600 on 7 April it was redeveloping over southeastern Colorado. From there the storm followed an optimum track for heavy snow in Illinois. Snow began in Illinois late on 7 April as the storm moved southeastward into southern Oklahoma. From there the low turned northeastward, moving through Arkansas and then up the Ohio Valley. Central Illinois took the brunt of this storm as moderate to locally heavy snow fell across the area. By 0600 on 9 April the low center was located over West Virginia. However, snow lingered in northern Illinois as the 500 mb short wave moved across the Midwest.

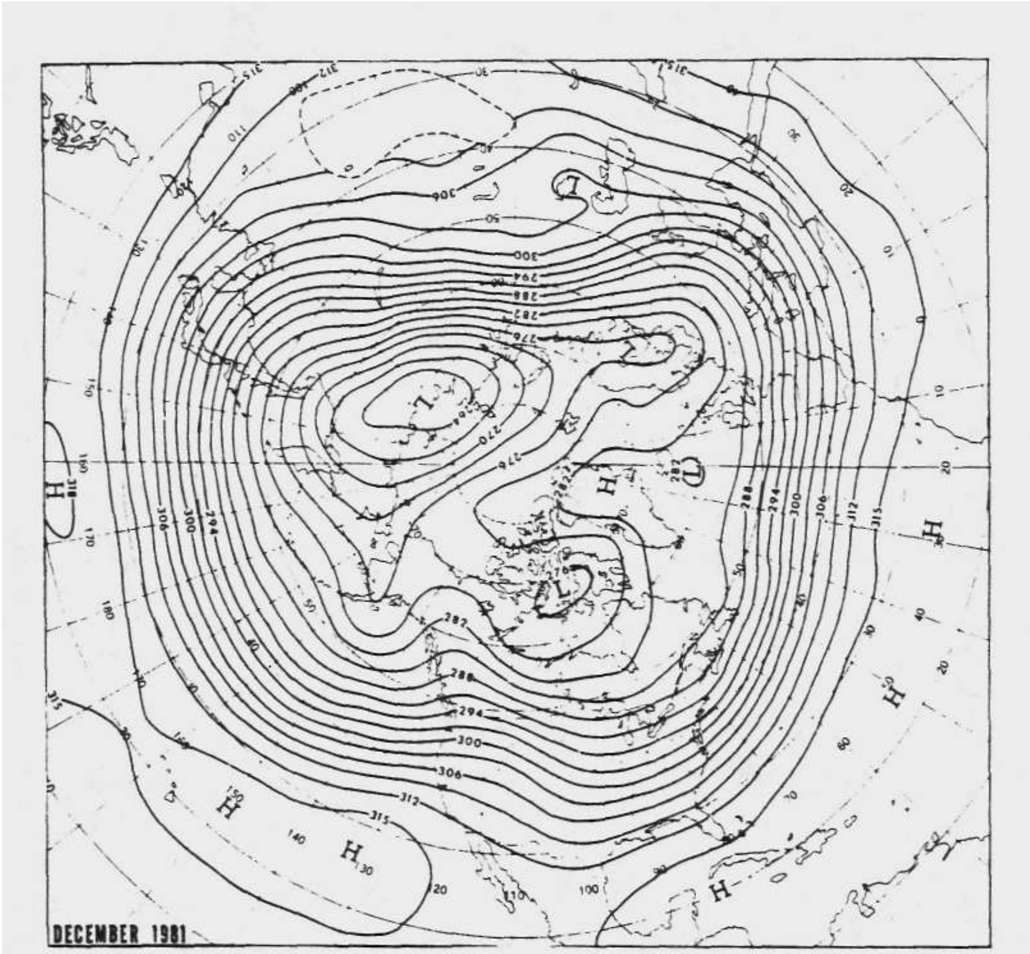

Figure 11. Mean 700 mb height contours (decameters) for December 1981

Upper Level Circulation Patterns 1981-1982

The key to understanding the surface weather patterns and storm tracks for any season lies in the upper level circulation. This section examines the upper circulation patterns of the 1981-1982 winter, and compares these with those of the severe winters of the late 1970s.

December 1981. A mean ridge at 700 mb along the West Coast and a trough over the eastern United States combined to produce northwest flow over the Midwest during December. There was some week-to-week variability in the pattern, but the general characteristic did not vary much. The mean 700 mb height contours are depicted in figure 11. Discussion of variability of the upper air patterns during the month will involve comparison with this mean pattern.

The mean ridge/trough pattern over the United States in December contributed to lower than normal temperatures over most of the country east of the Great Plains (Taubensee, 1982). Precipitation was greater than normal in the vicinity of the eastern trough from central Illinois eastward. The heaviest precipitation amounts were in an area extending from west central Illinois through the southern Great Lakes, and along the eastern seaboard.

During the first week of December (30 Nov-4 Dec) the axis of the trough shifted west of the Mississippi River, resulting in a southwesterly flow aloft over Illinois. This led to a generally mild and wet week over the state. By the second week, however, the trough had progressed into the western Atlantic while the western ridge axis moved into a position over the Rockies. The low amplitude of the ridge at this time permitted mild Pacific air to spread over the western two-thirds of the country, including Illinois. Eastward from Illinois temperatures averaged below normal because of the flow around the trough in the Atlantic.

The third week of December (14-20) saw a major amplification and shift in the 700 mb circulation. The western ridge strengthened and retreated to the West Coast, while a trough deepened over the Midwest. The mean trough axis was over the Mississippi River Valley, a favorable pattern for storm tracks through the Midwest. Temperatures throughout the Midwest averaged below normal while precipitation was above normal, especially in a band from eastern Nebraska through north and central Missouri, central Illinois, and Indiana. It was during this week that Illinois experienced the first nearly statewide severe winter storm of the season.

The mean upper level circulation amplified even further during the week of 21-28 December. The pattern retrograded, and the trough over the Midwest deepened, resulting in continued heavy precipitation in the eastern half of the country. Temperatures continued to average below normal but modified as the winds aloft backed to the west. The trough broadened over the central United States the last week of the month as a deep 700 mb low became established over the west side of Hudson Bay. This brought about a continuation of the cold, wet weather over the Midwest and East.

January 1982. Two features of the mean 700 mb circulation over North America during January contributed to a very cold and very wet month over the Midwest. A strong broad trough was located over the eastern United States and the western Atlantic, while a strong ridge established itself in the eastern Pacific. The mean 700 mb height contours for January are depicted in figure 12.

There was large week-to-week variability in the circulation pattern during January (Wagner, 1982). The flow during the month was characterized by a series of short wave troughs spinning off the Arctic low in Canada that had been established near the end of December.

During the first week of January the 700 mb circulation began to show more amplitude off the West Coast as the ridge re-developed. The ridge in combination with the Arctic low in Canada and trough over the East began the series of blasts of Arctic air into the United States. During the week of 10 January amplification of the circulation pattern continued, with the trough axis from Ontario to the eastern Gulf of Mexico (Wagner, 1982). The ridge had also strengthened, and air from the Northwest Territories of Canada was funneled into the midwestern United States, keeping temperatures well below normal.

Large changes occurred in the 700 mb circulation in the third week of January. The mean 700 mb pattern indicated the northern Canadian low moved east into the northern Canadian Maritimes, with the attendant trough extending into the Atlantic. The ridge in the eastern Pacific strengthened and retreated to the west, permitting a trough to develop along the West Coast. This allowed some slight ridging across the Midwest, but it was not enough to prevent cold air outbreaks from moving into the area.

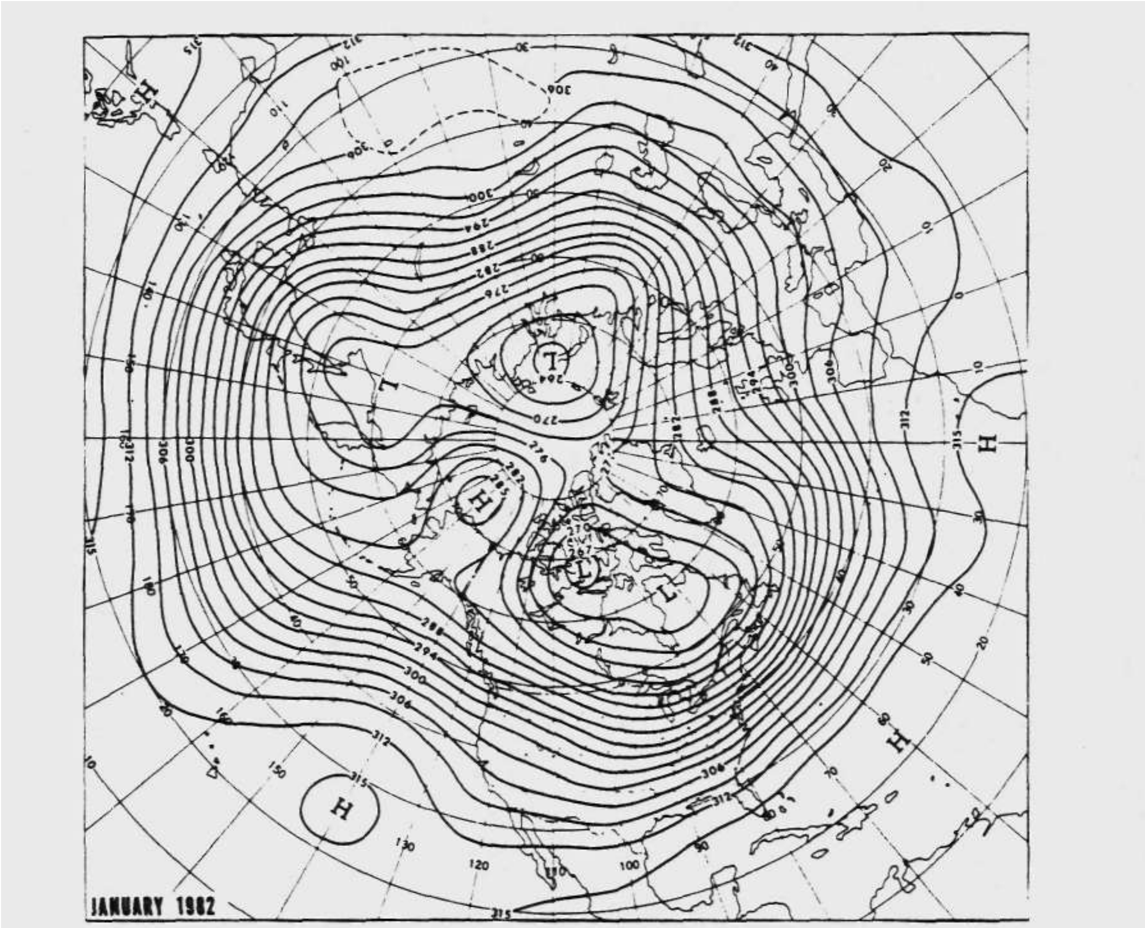

Figure 12. Mean 700 mb height contours (decameter*) for January 1982

The last week of the month was characterized by a general weakening of the circulation pattern over the country. Winds aloft over the central United States continued to blow from the northwest, keeping temperatures colder than normal, but not as cold as earlier in the month. A trough that moved into the middle of the country the last three days of the month produced a storm which dropped heavy precipitation in the Midwest (Wagner, 1982) and led to blizzard conditions throughout central and southern Illinois.

February 1982. There again was large week-to-week variability in the circulation pattern over the country during February. Figure 13 depicts the mean 700 mb height contours for the month. In contrast to December and January, the flow pattern allowed Pacific air masses to move into the country, while the Arctic air intrusions were mostly confined to the upper Great Lakes and northeast. However, the mean pattern does not reflect the variability of the month. Illinois and the rest of the Midwest experienced colder than normal weather the first two weeks of the month, and warmer than normal weather the last two weeks.

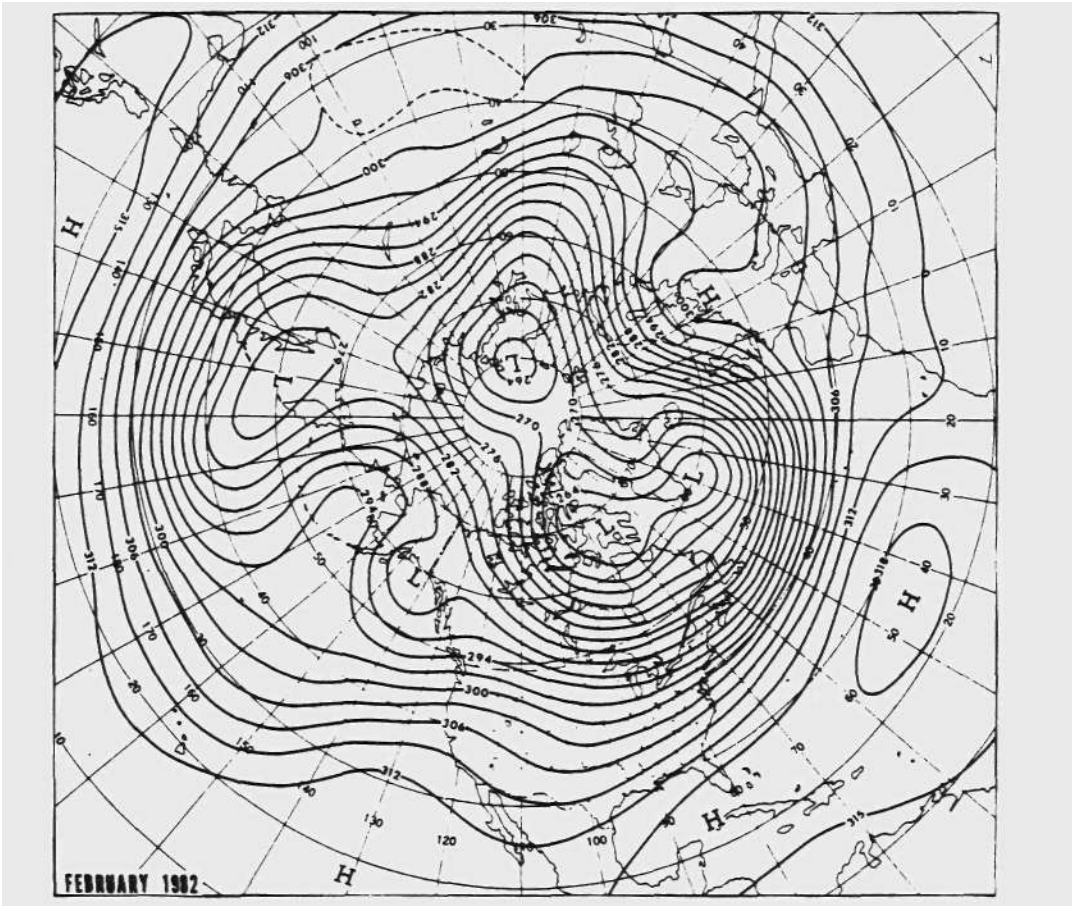

Figure 13. Mean 700 mb height contours (decameters) for February 1982

The average circulation pattern during the first week of February was characterized by a re-establishment of a strong ridge in the eastern Pacific and a broad, large amplitude trough over the United States. The ridge, in combination with a strong low over northern Hudson Bay, funneled more Arctic air into the western two-thirds of the country. This resulted in some record cold days in Illinois during the week. With the axis of the mean trough extending through the Great Plains, the pattern was favorable for winter storms in the Midwest. Two major storms struck Illinois during the first ten days of the month.

By the second week in February the trough over the central United States began to weaken as a low began to develop in the Gulf of Alaska (Dickson, 1982). However, the Hudson Bay low was still sufficiently strong to maintain the flow of Arctic air into the central United States, and temperatures remained well below normal in Illinois.

Intensification of the Gulf of Alaska low and progression of the Hudson Bay low into the Atlantic set the stage for a warming trend during the third week of February. Strong southwest flow over the eastern Pacific and westerlies across southern Canada allowed mild maritime air to replace the Arctic air of the previous weeks. A broad but weak trough over the central United States produced some precipitation over the Midwest and Illinois, but because of the mild air a good part of it was rain. This major change in the circulation pattern allowed average temperatures in Illinois to climb above normal for the first time since the first week of December. Although winds aloft over the Midwest turned more northwesterly during the last week of February, air masses continued to be mostly of maritime origin, and average temperatures remained above normal in Illinois.

Comparison of 1981-1982 Winter Circulation with That of Previous Severe Winters. With a total of 18 severe winter storms in Illinois, the winter of 1981-1982 tied the record for number of severe storms in a season that was set in 1977-1978 (Changnon et al, 1980; Changnon and Changnon, 1978). An obvious question is how the upper level circulation during the winter of 1981-1982 compared with that of the previous severe winters. The seasonal mean 700 mb height contours were used for the comparison.

Figure 14 is the seasonal mean 700 mb height contour for the winter of 1981-1982. Figures 15 through 17 are the seasonal mean 700 mb height contours for the winters of 1976-1977, 1977-1978, and 1978-1979.

The circulation during the winter of 1981-1982 was more similar to that of 1978-1979 than to the other two winters as far as the configuration of the mean flow. In the two earlier winters (1976-1977 and 1977-1978) the Aleutian low was very large and deep with large (both in magnitude and in areal coverage) negative height departures over the Pacific. Both the winters of 1978-1979 and 1981-1982 had areas of positive departures over the Pacific and much less development of the Aleutian low, with the low farther west in 1981-1982. However, the centers of the positive and negative height departures over the Pacific were reversed between the two winters. The broad area of positive departures (+55) between 145° and 180° west longitude in 1978-1979 was replaced by an area of low negative departures (-19) in 1981-1982. Similarly, the small area of negative departures (-35) at 170°E in 1978-1979 was replaced by an area of high positive departures in 1981-1982. The most striking similarity between all four mean patterns is the presence of a low between 60° and 75°N latitude and 60°-90°W longitude. Troughing extended south from this low, pushing the westerlies south of their normal position. Two other aspects of the three previously mentioned winters were also found in the mean circulations of 1981-1982; a blocking ridge over the North Atlantic and ridging over the western Arctic (Harnack, 1980). The ridging over the western Arctic contributed to the advection of Arctic air masses into the central and eastern United States. The mean western Arctic ridge was extremely strong during January. Heights over the region were 72 meters (236 feet) higher than normal (Wagner, 1982), while heights over the northern Great Lakes were much below normal. The strong ridge over the western Arctic was most favorable for the development of successive very cold Arctic air masses which were then funneled south and eastward. This feature was primarily responsible for the "Weekend Cold Waves" of January. The Arctic ridge was not very pronounced in December, and by February had retreated west to the Aleutians.

The Winter's Worst Storm: 29-31 January

The storm that struck Illinois and the Midwest during the last weekend of January 1982 was the most severe and damaging storm of the winter. Heavy rain (5 inches), snowfall (up to 20 inches) and strong winds (45 mph) characterized the event. The hardest hit area of

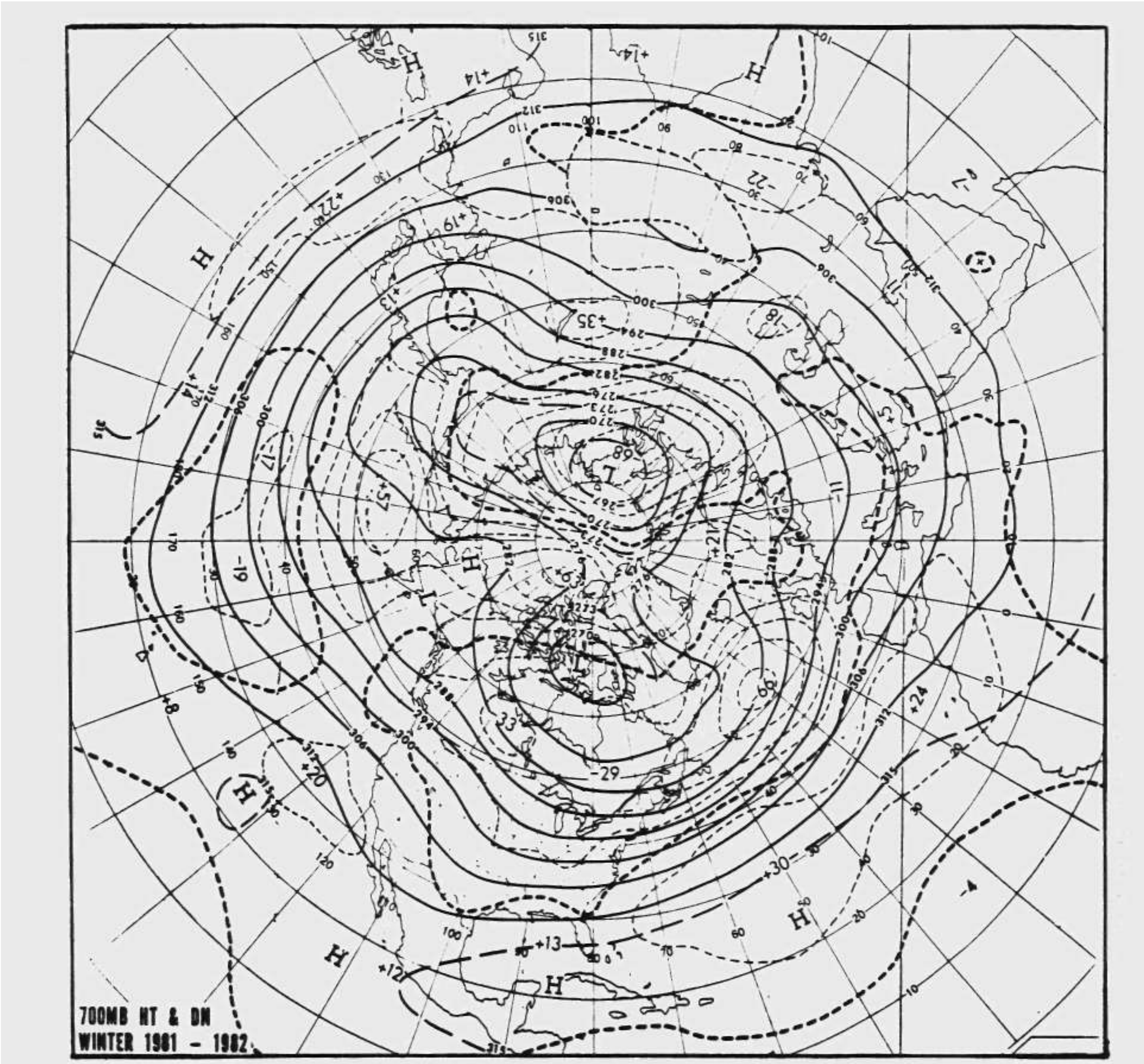

Figure 14. Mean 700 mb height contours (decameters) and departure from normal for winter 1981-1982

the state was southwestern Illinois where the heaviest snowfall occurred, although heavy snow fell over central Illinois as well.

This section examines the synoptic weather conditions of the storm with particular reference to its development and movement. The storm was particularly notable meteorologically because of its duration of over 36 hours in Illinois. However, snowfall was not continuous during that period.

Data. Copies of the 3-hour surface analyses, and the 12-hour 500 mb and 850 mb analyses were the primary data used for this study. In addition, 15 hours of Service A

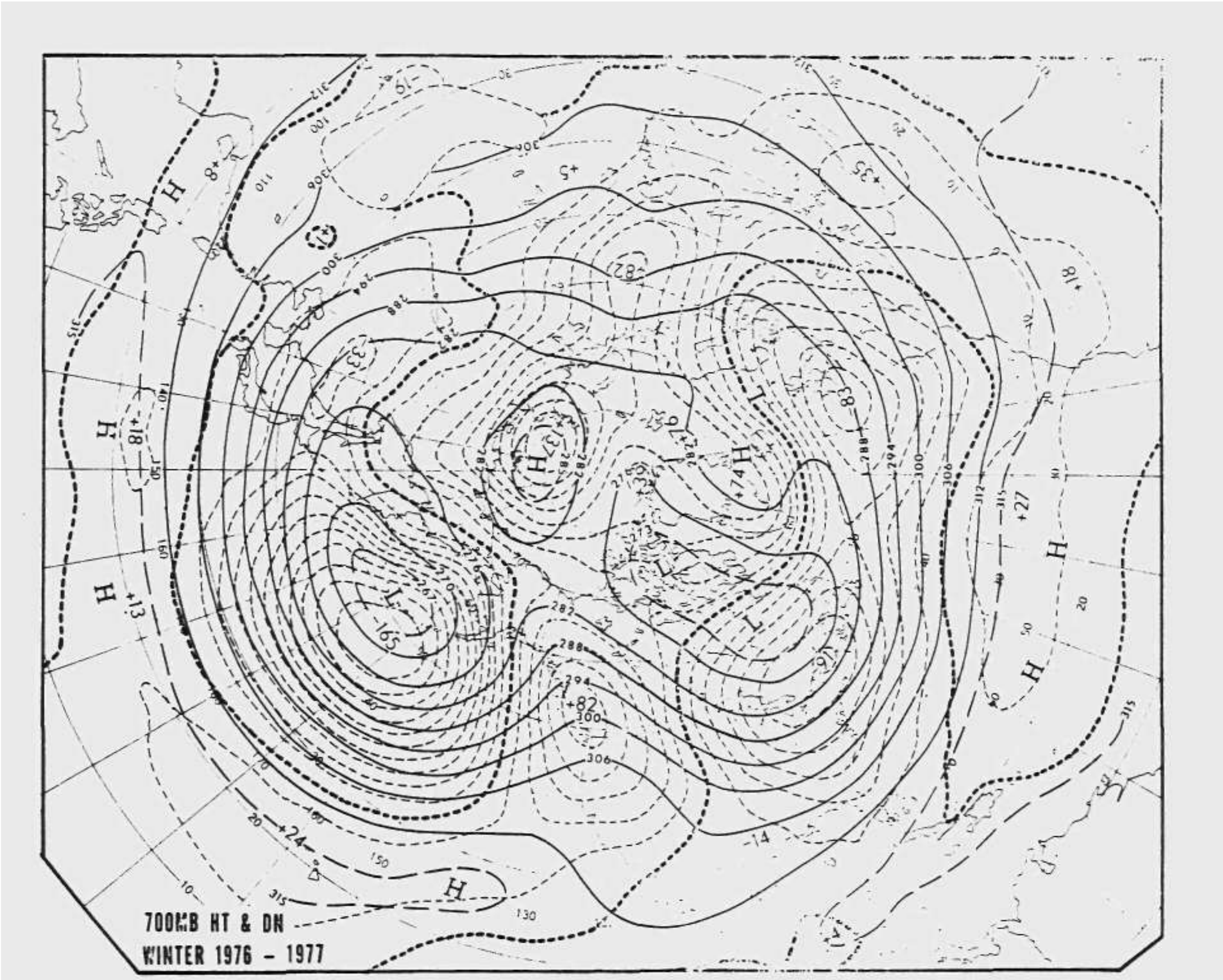

Figure 15. Mean 700 mb height contours {decameters) and departure from normal for winter 1976-1977

(aviation) surface observations for the Ohio Valley states were available and used to examine the time series of observations across the state. The initial analyses for the LFM (Limited Fine Mesh) model also were used.

Discussion. The upper level disturbance which eventually caused the storm was located off the Pacific Northwest coast in the morning of 27 January. By the morning of 28 January the upper low was in the process of developing a closed circulation. On the surface, the upper level low was reflected by a broad area of low pressure over northern California and Nevada at 0600 on 28 January. At the same time, high pressure associated with a maritime Polar (mP) air mass was moving into the Midwest behind a cold front which passed through Illinois the night before.

Over the next 24 hours the general surface pattern did not change a great deal as the 500 mb low developed its closed circulation. The development of the storm is chronicled in 12-hour intervals below. Each section will include a discussion of the weather in the preceding 12 hours.

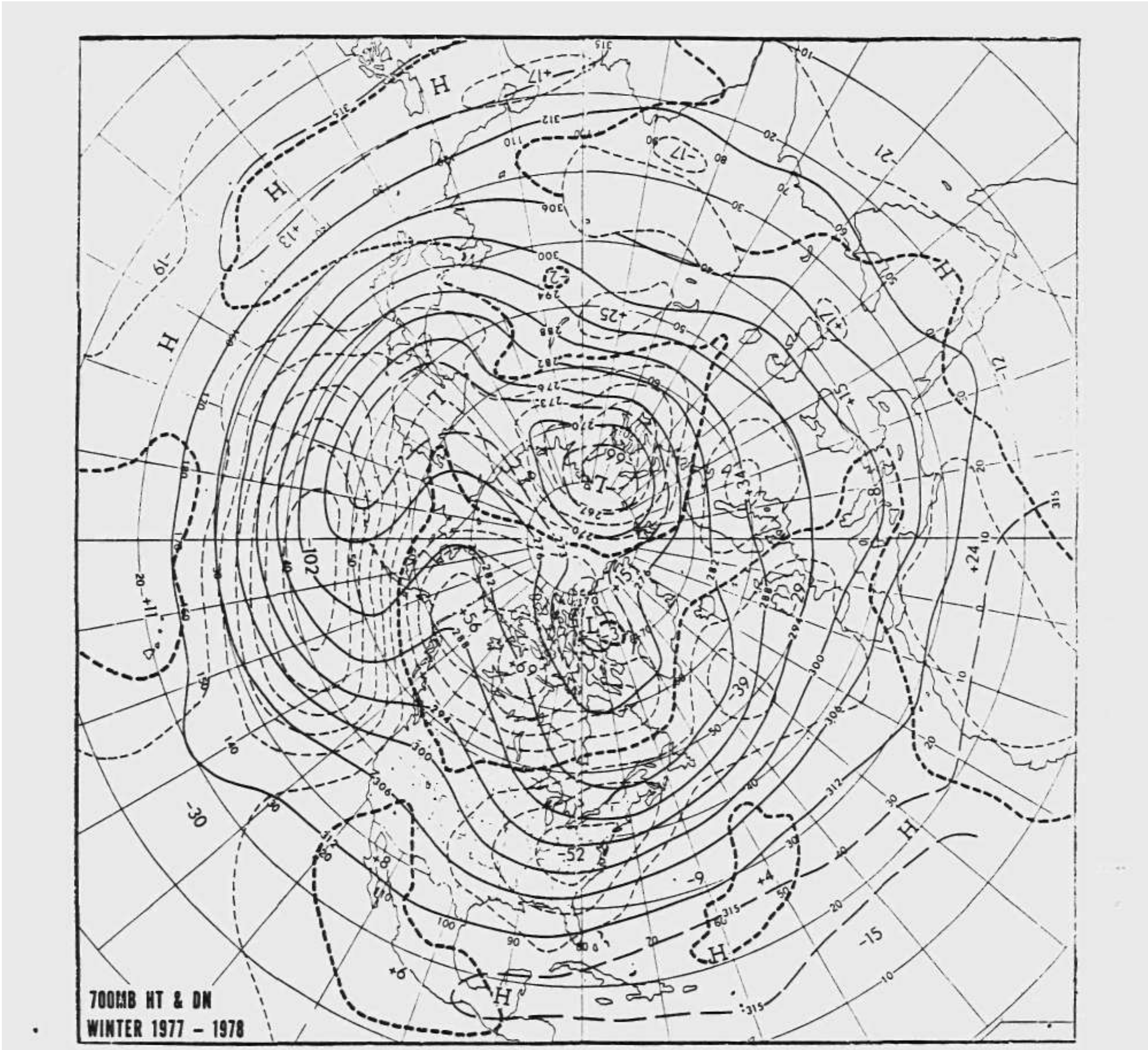

Figure 16. Mean 700 mb height contours (decameters) and departure from normal for winter 1977-1978

0600 CST Friday, 29 January. The mP surface high was centered over southern Ohio, and the old front stretched along the Gulf Coast from Florida to a weak surface low in New Mexico (figure 18). Warmer air was already returning to the central plains in the southerly flow on the back side of the high. Some light precipitation had developed in the overrunning air from Texas into western Iowa. The 500 mb low had developed a closed circulation and was centered over northwestern Arizona. Some light snow was falling over Utah and Colorado as a result of the cyclogenesis.

1800 CST Friday, 29 January. As southerly flow developed over Illinois during the day, the overrunning precipitation spread throughout the state. Rain broke out in southern

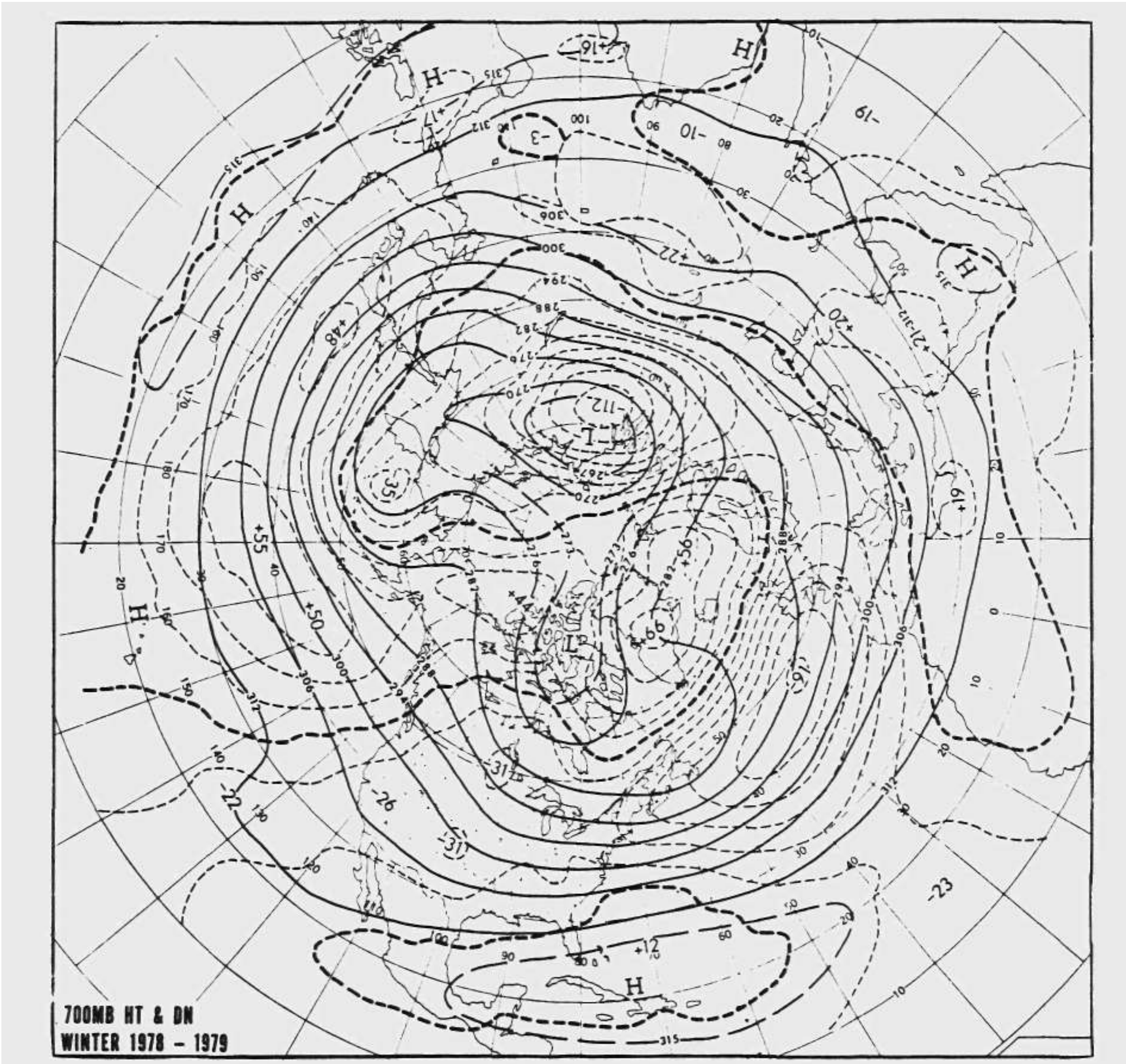

Figure 17. Mean 700 mb height contours (decameters) and departure from normal for winter 1978-1979

Illinois, while sleet and snow which initially developed over central Illinois changed to rain. Strong warm air advection was occurring from the surface to 700 mb. Surface temperatures were in the 40's (°F) in southern Illinois, and in the low 30's over northern Illinois. By this time the mP high had moved to the Delaware coast. The low over New Mexico early in the day had moved southeastward and weakened, while a new low had developed over the Big Bend area of Texas (figure 19). At 500 mb, the closed low was centered over western New Mexico. The strongest 12-hour height falls were centered over El Paso, Texas. A strong band of westerlies continued across the northern tier of states.

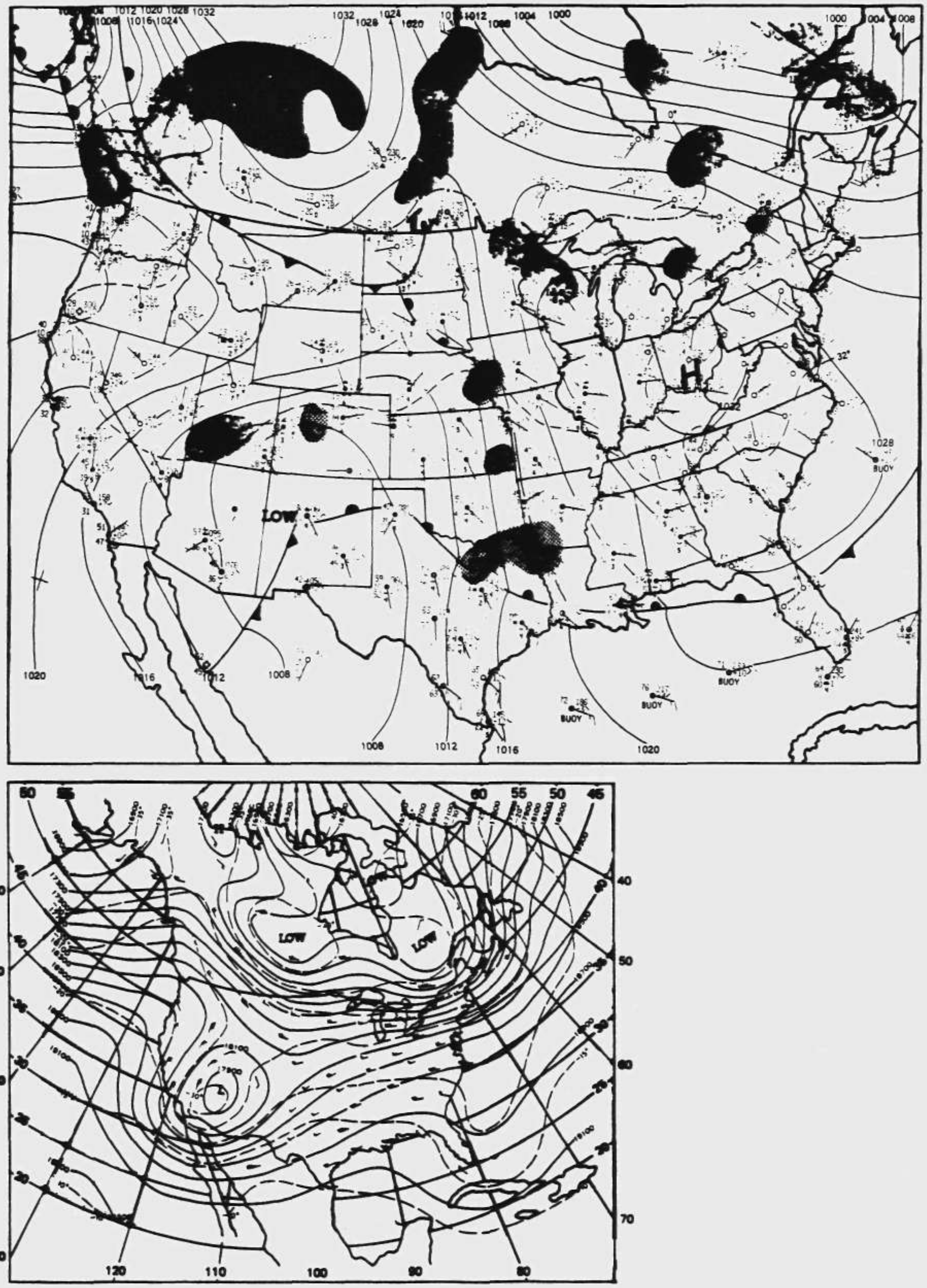

Figure 18. Surface weather map and 500 mb map for 0600 CST 29 January 1982

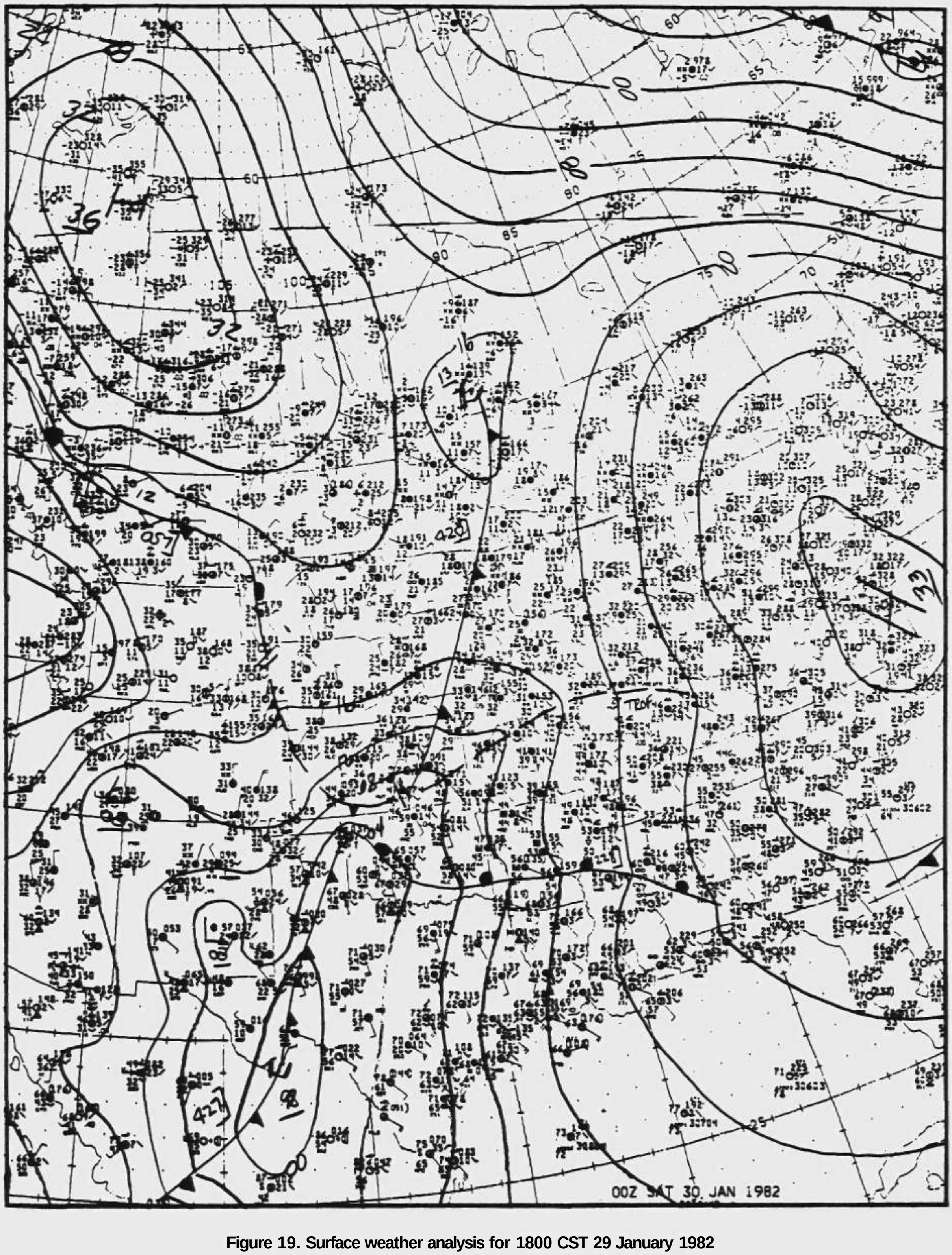

Figure 19. Surface weather analysis for 1800 CST 29 January 1982

0600 CST Saturday, 30 January. During the night the front that had been along the Gulf Coast moved north as a warm front. Rain continued in Illinois, and thunderstorms were occurring from Oklahoma through Missouri along an inverted surface trough. The surface wave in Texas had moved to the Big Bend area and had become more organized (figure 20). A cold Arctic surface high to the north was centered over Saskatchewan. It nosed into the northern plains behind a cold front which stretched from a low near James Bay to near Chicago, through northern Missouri, and then back into Montana. Surface temperatures near the center of the high were as low as -42° F (—41°C). Temperatures in Illinois ranged from the mid 30's in northern Illinois to upper 50's in the south.

At 500 mb the cutoff low had moved to just east of El Paso, Texas. A strong vorticity center was positioned just southwest of the low center. Upstream a well-defined short wave was moving out of the Gulf of Alaska.

At this time there was little snowfall associated with the Texas low. Most of the precipitation was in the form of rain. The 850 mb temperatures at 0600 CST were as high as 50°F (10°C) in southern Missouri, and 32° to 50°F (0° to 10°C) in Illinois. The 32°F (0°C) isotherm at 850 mb extended from central Michigan across extreme northern Illinois, to the Nebraska-Kansas border and northwestward.

1800 CST Saturday, 30 January. By the late afternoon of 30 January, the stage was being set for a major snowstorm across the lower Midwest, although all the factors were not yet in place. During the day the surface frontal wave moved eastward then northeastward at about 46 mph. By 1800 the low was centered just south of Hot Springs, Arkansas. The cold front which entered northwestern Illinois during the morning had pushed through to the Ohio River by noon, and cold air spilled southward at all levels. Precipitation changed from rain to sleet, and then to light snow in central Illinois and Indiana. Moderate rain was falling in southern Missouri and northern Arkansas.

With the surface low more organized, strong southerly flow pulled warm air northward from the Gulf of Mexico south of the front. North of the front, north to north-northeast winds funneled in the cold Arctic air. A strong surface convergence zone was established along the cold front and a strong baroclinic zone was strengthening over the Midwest. The 0° F (-18°C) surface isotherm extended across southeastern Minnesota, while the 70° F (21°C) isotherm ran across to northern Mississippi and Alabama (figure 21).

At 500 mb, the cutoff low was located just eastnortheast of Midland, Texas. The height fall center (-140 meters, 459 feet) had weakened a little and moved slightly east-northeast of its 0600 position, indicating that the cutoff low would soon begin lifting out to the northeast (Weber, 1976). Upstream, two short waves were evident. A fairly weak short wave in Nevada and California was moving southeast into the trough, and upstream from that a strong short wave was entering the Pacific Northwest.

Cold air which had been pooled in southern Canada at 850 mb began penetrating south during the day, and 850 mb temperatures in Illinois were dropping. The 32°F (0°C) isotherm cut through central Illinois and northern Missouri, and in this case coincided well with the analyzed 1000-500 mb thickness of 5400 meters (17,712 feet) and the rain/snow line at the surface. The cutoff low at 850 mb was centered over extreme southeast Oklahoma.

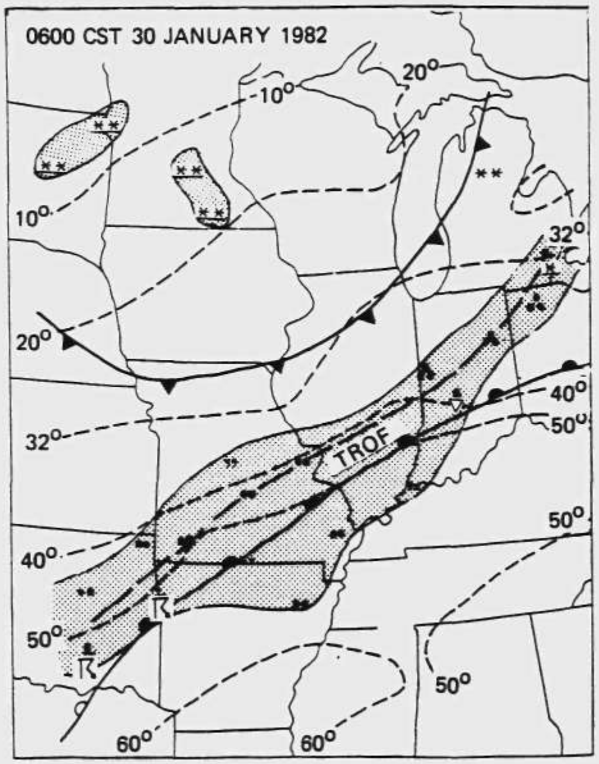

Figure 20. Surface weather conditions and isotherms (° F) for 0600 CST 30 January 1982

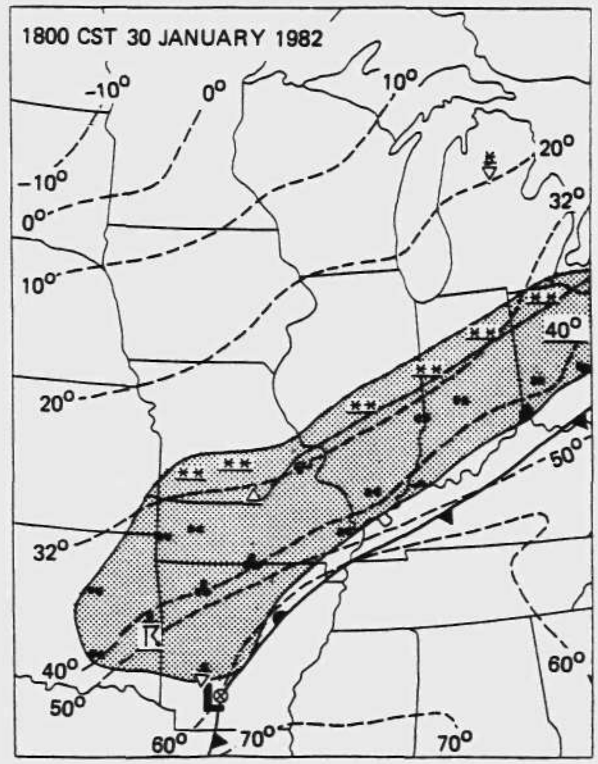

Figure 21. Surface weather conditions and isotherms (° F) for 1800 CST 30 January 1982

0600 CST Sunday, 31 January. During the night of 30-31 January, the surface low moved northeastward and intensified. Prior to intensifying, however, precipitation ended over the northern two-thirds of Illinois (figure 22a), while rain and some mixed precipitation continued over the southern third. The surface low slowed considerably, moving about 25 mph between 1800 on 30 January and 0600 on 31 January. By midnight on 30 January precipitation redeveloped over central Illinois as snow, while light to moderate rain continued over southern Illinois. The 32° F (0°C) surface isotherm had not yet progressed into southern Illinois. The large Arctic high over North Dakota at 1800 on 30 January moved eastnortheast, and at 0600 on 31 January, it was located just north of Lake Superior. The surface low was located about 45 miles west of Nashville, Tennessee. The strong pressure gradient between the high and low center produced strong north-northeast winds across Missouri, Illinois, and Indiana.

Figures 22a through d show the precipitation patterns and temperature analysis at 3-hour intervals from 2100 on 30 January to 0600 on 31 January. Moderate to heavy snow developed rapidly in an area from central Missouri across Illinois to northeast Indiana. Thunderstorms were reported at several locations in an area from St. Louis to Champaign, indicative of strong convective activity.

The low at 500 mb had just about become an open trough by 0600 on 31 January. The low was located near Ft. Smith, Arkansas, and a strong height fall center (-190 meters,

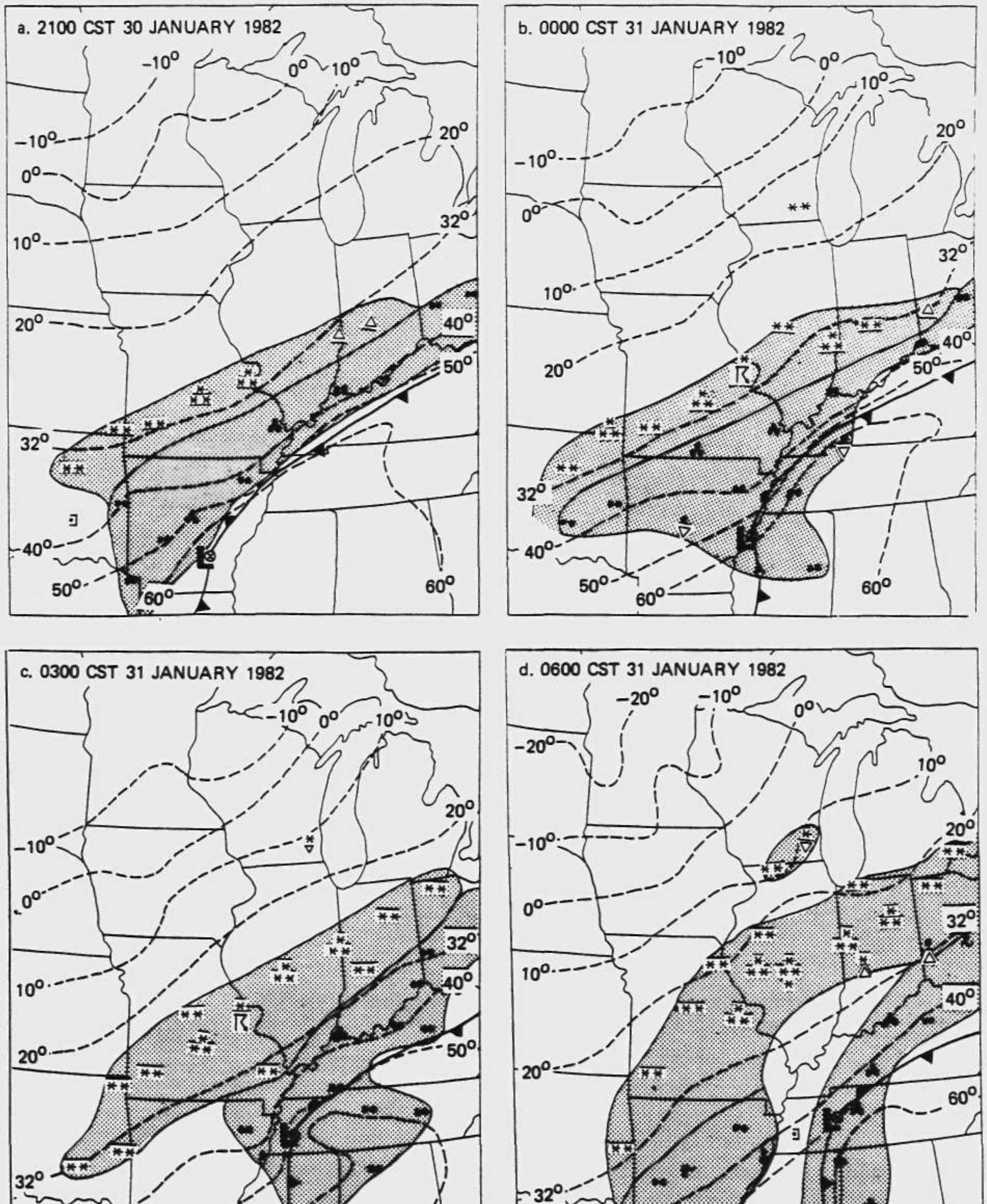

Figure 22. Surface weather conditions and isotherms (° F) for 30 and 31 January 1982

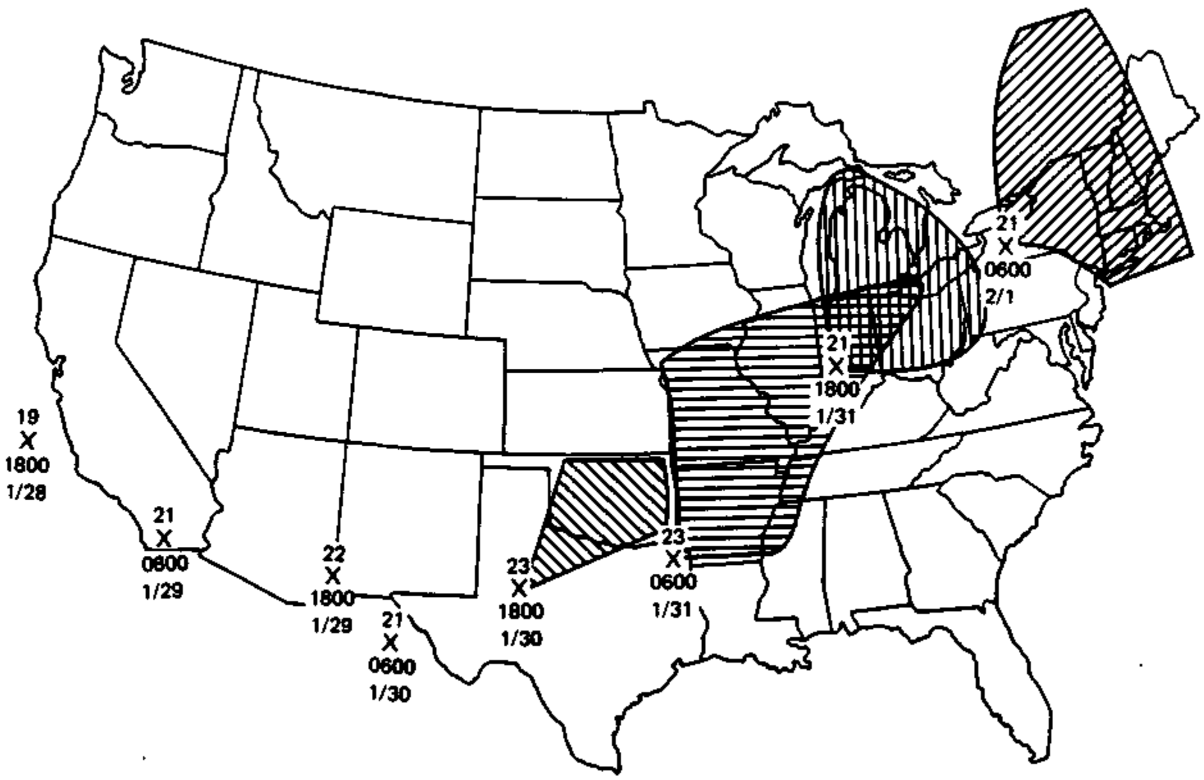

Figure 23. 500 mb vorticity center (x10^{-5}/sec) track and area of PVA for last 4 positions (all times CST)

623 feet) was over northern Louisiana and southern Arkansas. A strong vorticity center was over northern Texas. The area of greatest positive vorticity advection (PVA) was over southern Missouri and south central Illinois (figure 23). The weak short wave over Nevada 12 hours before was still identifiable over southern Arizona and the Baja, while the stronger northern short wave was over Idaho and Oregon.

A strong cutoff low at 850 mb was centered over Jonesboro, Arkansas, at 0600 on 31 January. The 32°F (0°C) isotherm extended across Illinois from south of Champaign to south of St. Louis, and marked the approximate southern edge of the snow area.

1800 CST Sunday, 31 January. The low pressure center moved erratically during the day, especially between 0600 and 1200. This period is when snow was the heaviest in central Illinois, reducing visibilities to an eighth of a mile at times. During this 6-hour period, the low moved at an average speed of 32 mph, but at only 16 mph between 0600 and 0900. The storm picked up speed during the afternoon, traveling at 39 mph between 1200 and 1800. Table 6 shows the speed of the storm for successive 3-hour intervals. By 1800 the low was centered over Ohio, but light snow still continued to fall in east-central Illinois. The heavy snow had moved into southern Michigan and northwest Ohio.

The surface high over southern Canada moved eastward at about the same speed as the storm center during the day, so strong surface winds continued, compounding the problem of heavy snow. Figures 24a through d depict the precipitation patterns and temperature

Table 6. Speed and Direction of Movement of the Low Pressure Center for Storm of 29-31 January

Time interval (CST)	*Approximate speed of low center (mpb)*	*Direction of movement*
0600-0900 30 Jan	41	NE
0900-1200	14	E
1200-1500	60	NE
1500-1800	46	NE
1800-2100	14	E
2100 30 Jan-0000 31 Jan	28	ENE
0000-0300 31 Jan	32	NE
0300-0600	23	ENE
0600-0900	16	NNE
0900-1200	46	NE
1200-1500	35	NE
1500-1800	46	NE
1800-2100	37	NE

analyses at 3-hour intervals for the period 0900 through 1800. There was a strong baroclinic zone across Illinois most of the day, but especially in the morning. At 0600 temperatures were 10° F (—12°C) across northern Illinois, but in the middle 30's in southern Illinois. As the day progressed, this difference became much less as the storm moved away and the cold air penetrated southward.

The 500 mb low lost its closed circulation completely by 1800. A well-defined trough extended from Lake Superior through eastern Illinois and into western Mississippi. The height fall center (-190 meters, 623 feet) was over northern Kentucky. A strong northerly center was located near Indianapolis, with the maximum PVA over northwestern Ohio and southeast Michigan. This was the area where the heaviest snow was falling at 1800.

The short wave in the Pacific Northwest at 0600 was now over the central Rockies, acting as the "kicker" for the Midwest trough.

The 850 mb low was centered over Toledo, Ohio, at 1800. Cold air was penetrating the Gulf states, and the 32°F (0°C) isotherm was into southern Mississippi and central Alabama. It still marked the rain/snow line in the areas where precipitation continued to fall, mostly in Ohio, Pennsylvania, and northward.

Summary of Storm Features. This storm produced 15 to 20 inches of snow on a small portion of southwestern Illinois, and 10 to 15 inches of snow across a band approximately 110 miles wide and centered on a line from St. Louis to Danville. The exceptional features of this storm were, first, the large amount of snow deposited in a fairly short time (about 18 hours of snowfall), and second, the length of the storm (a little over 36 hours), where storm duration is measured from the onset to cessation of precipitation in Illinois. Precipitation did not end in southern Illinois once it started on 29 January, but did come to a brief end in central Illinois before beginning again as snow. Northern Illinois received little rainfall initially, and was only on the fringes of the snowfall area. Heavy snowfall near the

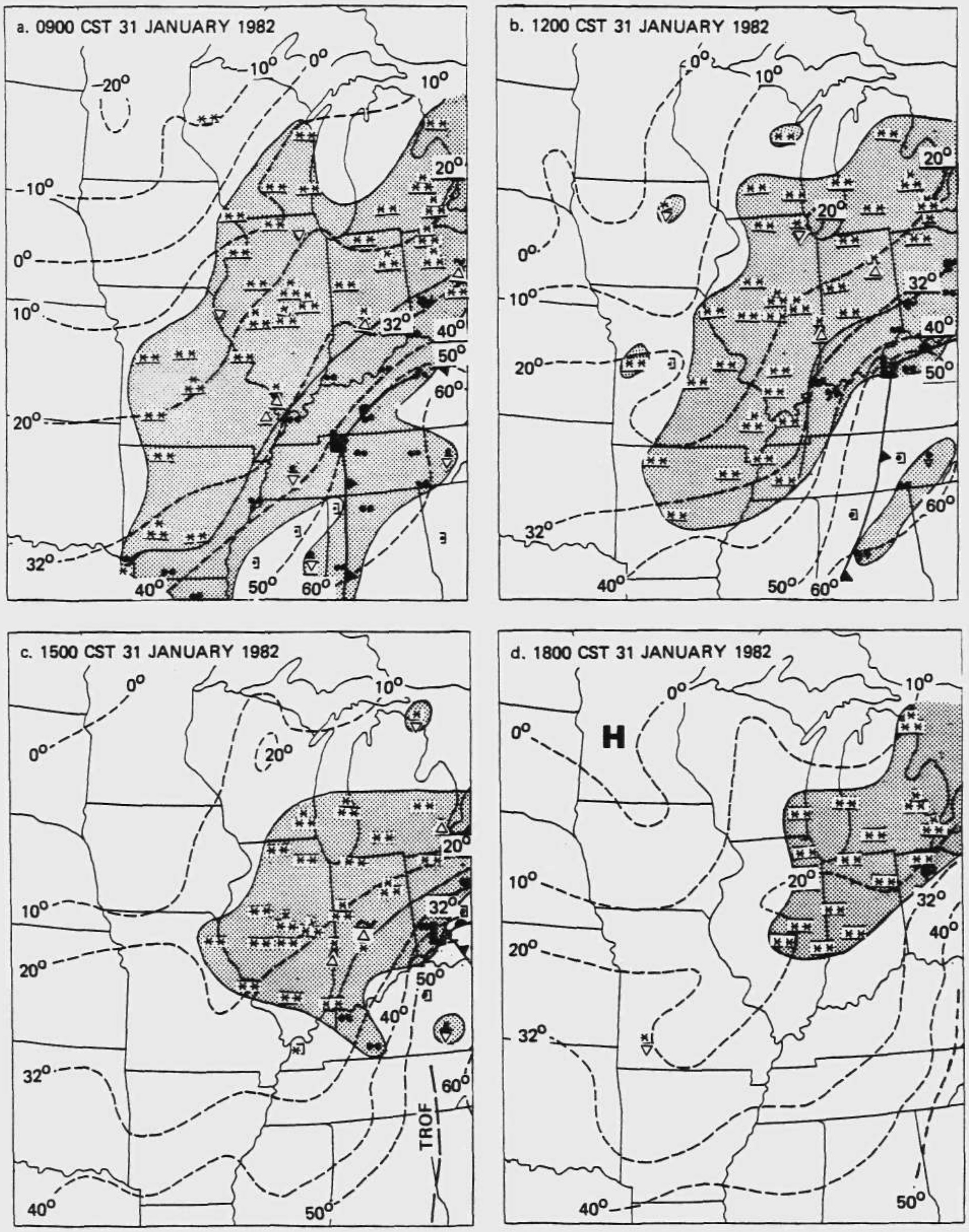

Figure 24. Surface weather conditions and isotherms (°F) for 31 January 1982

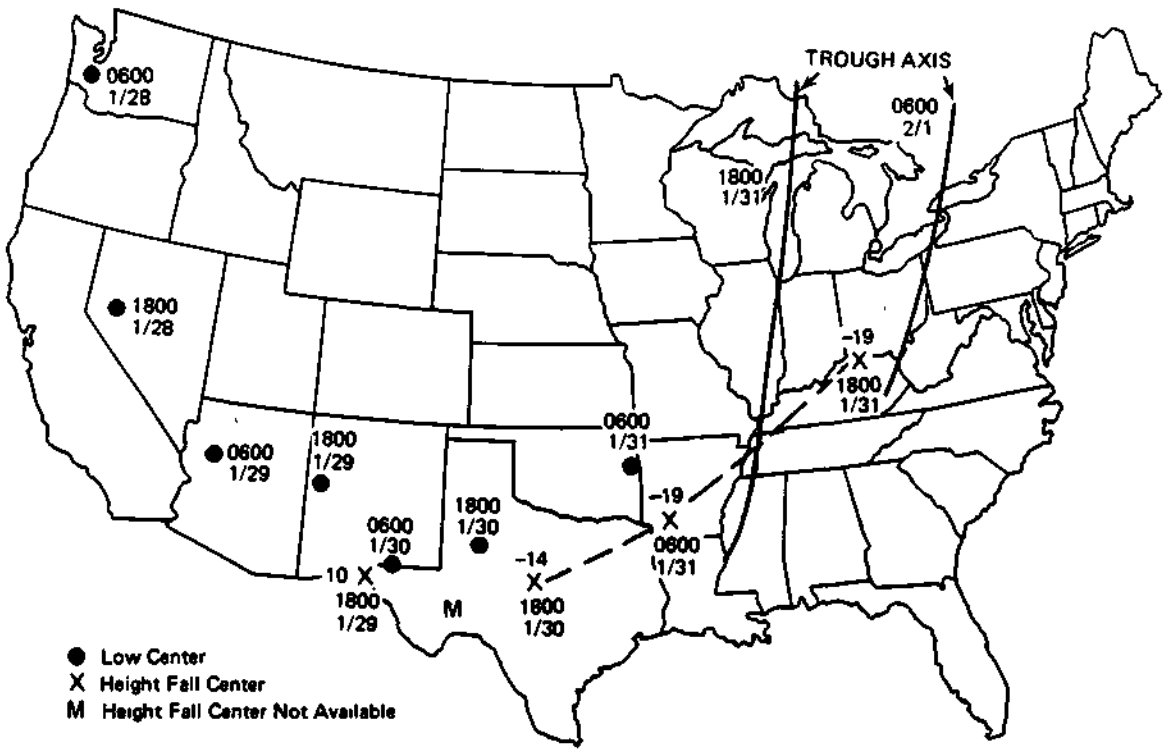

Figure 25. 500 mb low center and height fall center tracks 28-31 January 1982

Chicago area was the result of the northeast winds off Lake Michigan (7 inches there against 3 to 5 inches in the remainder of northeastern Illinois). The following discussion examines the reasons for the exceptional features of this storm.

Length of the Storm. The reasons for the long duration of this storm are not hard to determine when one looks at the overall weather pattern over the Midwest. Prior to the onset of the storm a cold high pressure had moved into the Midwest, then to the East Coast. As the surface high moved to the East Coast in the fast westerly flow in the northern branch at 500 mb, strong southerlies at the surface through 700 mb returned warm and moist air to the Midwest. Overrunning was fairly strong and this sustained precipitation until the surface low in Texas became organized and made its contribution. The strong contrast in air masses across Illinois provided an unstable zone favorable for precipitation in the southern portion of the state. In the absence of such strong overrunning, the storm duration would have been much less, perhaps confined to the period of snowfall.

Amount and Intensity of Snowfall. Many factors enter into the occurrence of heavy snowfall, such as the path and intensity of the surface low and upper level systems, and availability of cold air and moisture. Timing was also a factor in the heavy snowfall. The development of the 29-31 January storm can be called "classical" in that what occurred fit in very well with documented relationships between various synoptic weather features and heavy snowfall.

Figure 25 depicts the path of the 500 mb low beginning at 1800 on 28 January. This figure also shows the path of the 500 mb height fall center at 12-hour intervals, beginning

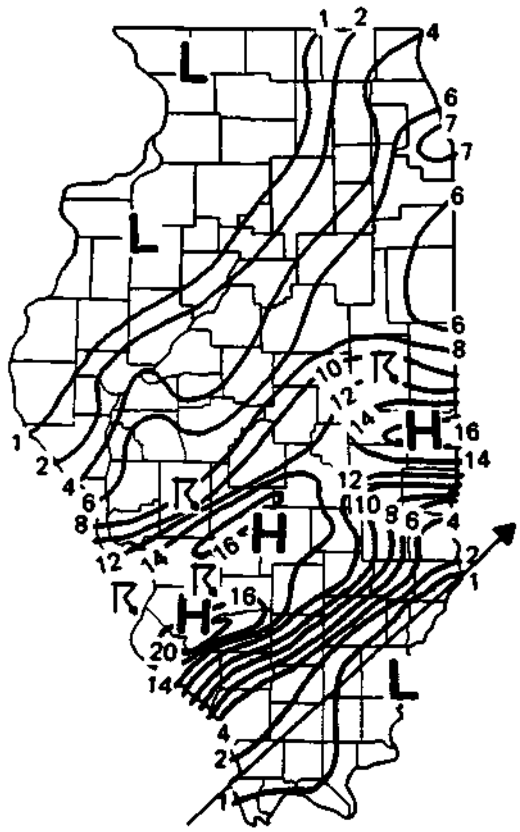

Figure 26. Path of 500 mb vorticity center through Illinois and snowfall from storm of 31 January 1982

with 1800 on 29 January (0600 on 30 January was not available). Weber (1976) has shown that the path of the height fall center is a good indicator of the movement of the 500 mb low and the area of heavy snow. Where a strong surface high is located over the upper Midwest, as was the case with this storm, the heavy snow will lie approximately parallel to and to the left (northwest) of the height fall center's path. In this case the southern edge of the heavy snow ($\geq$ 4 inches) area was 125 miles northwest of and parallel to the 500 mb height fall track.

The advection of positive vorticity associated with the 500 mb trough is an excellent indicator of upward vertical motion in the atmosphere and thus of precipitation potential. Figure 23 depicted the path of the vorticity center associated with the 500 mb trough beginning at 1800 on 28 January, and the area of positive vorticity advection (PVA) beginning at 1800 on 30 January. PVA was the strongest during the period from 0000 to 1200 on 31 January, the time when snowfall was the heaviest in a band from central Missouri across Illinois into central Indiana. The strength of the vorticity advection was evident not only from the intensity of the precipitation, but also from the convective activity. Thunderstorms, unusual during a snowstorm, were observed in an area from St. Louis to Urbana. This convection and accompanying moderate to heavy snowfall may have been responsible for the small core of very heavy snowfall southeast of St. Louis, although none of the co-

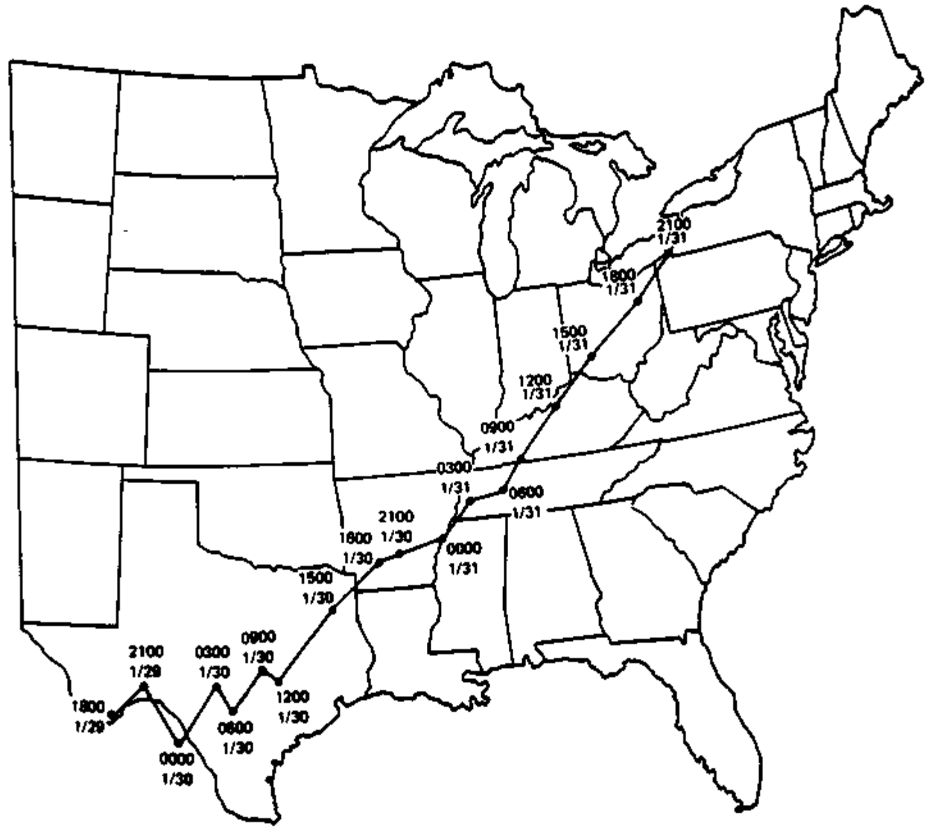

Figure 27. Path of surface low center, 29-31 January 1982 (all timet CST)

operative observers in that area reported thunder. However, the thunderstorms occurred between midnight and 0300 or 0400, so most observers probably would not have noted it. The vorticity center followed a track northeastward through southern Illinois and into central Indiana. The southern edge of the heavy snowfall was about 35 miles northwest of the track, and the core of heaviest snow about 65 miles northwest of the track (figure 26). There was generally less than an inch of snow south of the vorticity center path.

The path of the surface low (figure 27), although erratic at times, was the optimum for heavy snow across central Illinois. This low is classified as a type 5 cyclone (Changnon, 1969) since its organization and intensification took place over southeastern Texas. Type 5 lows are the second highest producers of severe winter storms in Illinois. Aside from the path of the storm, the slowing of the storm's forward speed as it moved across the Mississippi River and into Tennessee was also a factor contributing to additional snowfall.

Finally, the timing of all the various elements of the storm was ideal for the development of snow. The approach of the storm center coincided with the intrusion of cold Arctic air into the Midwest both on the surface and aloft. The low became a wave on the Arctic front as it moved up through the Midwest. Very warm, moist air over the Gulf states fed into the system throughout its development, and was another important factor to the development of heavy precipitation.

IMPACTS OF SEVERE STORMS AND LOW TEMPERATURES

General Impacts

The impacts described herein are a mixture of those relating to the severe winter storms and those relating to the temperatures which reached record low levels in mid-January and again in early April. It is not reasonable to separate the general impacts of these two weather extremes because they are generally interrelated, commonly with very low temperatures following a major winter storm. The winter led to 34 deaths and costs estimated at $1.039 billion above those experienced in a normal winter.

There were 18 severe winter storms in 1981-1982, but only 6 of these produced notable impacts. The 6 storms with severe and extensive impacts, and the areas where these impacts were felt most, included:

1) 16-17 December in central Illinois
2) 8-10 January in northern Illinois
3) 15-17 January in central Illinois
4) 29-31 January in central and southern Illinois (the single most damaging storm of the winter)
5) 2-3 February in southern Illinois
6) 5-6 April in northern Illinois

All of these six storms produced certain similar impacts in their area of greatest severity including 1) major multiple automobile accidents, 2) major effects on commuter systems (increased ridership and great delays in service), 3) many vehicles off the roads in ditches and many cars abandoned, and 4) large numbers of motorists stranded, often in small communities.

One notable aspect of the impacts of the winter of 1981-1982 was the fact that they were felt thoughout the state. The most recent other extremely severe winter, that of 1978-1979, was extremely severe but only in the northern third of Illinois where most of the severe impacts occurred. This was not the case in 1981-1982, with all parts of the state experiencing at least two extremely damaging severe winter storms during the mid-December to mid-April period.

The nature of the winter storms and the related low temperatures, both in the degree of severity and geographic placement, tend to dictate the types of impacts. In general, the major effects of the winter storms and low temperatures in 1981-1982 were felt in two broad areas: 1) travelers and transportation systems, and 2) energy usage and costs. Thus, the transportation and energy sectors were those most influenced.

As will be shown, these impacts were experienced by all Illinois citizens. The local, state, and federal government agencies had to deal with the energy and transportation system problems. To a lesser extent, there were impacts on agriculture, education, business, and the environment. One interesting aspect of the winter impacts was that there were severe winter storms in four out of five weekends in January — 2-4 January, 8-10 January, 17 January, and 29-31 January. In many respects, these weekend-centered storm periods were fortunate with less requisite for employee travel and fewer travelers at risk.

The records of impacts in Illinois were largely obtained from study of newspaper clippings, many of them found in the "Press Summary" produced by the Illinois Information Service. Further information was obtained from "Storm Data," a NOAA publication (EDIS, 1982). It should be realized that our identification of impacts is less than encompassing. Many events occurred which escaped our attention and the sources of our information.

Study of the impacts of the winter of 1981-1982 in Illinois reveals a situation that is in contrast with recent prior severe winters in 1977-1978 (Changnon and Changnon, 1978), and in 1978-1979 (Changnon et al., 1980). In those earlier severe winters, there was a notable lack of preparation, particularly by local and state government agencies that deal with the extremes of winter. One of the lessons apparently learned from these other recent severe winters was a greater degree of preparation in many municipalities and agencies. For example, the Illinois State Water Survey with assistance from ESDA prepared winter storm informational materials and Governor Thompson announced, in early December, "Winter Storm Preparedness Week" for Illinois. This new program helped provide widespread information about how to deal with winter storms. The Illinois Department of Transportation had increased its budget for snow removal and roadway repair and bought $10 million of new trucks. Many local communities had adopted larger budgets for snow removal and purchase of salt supplies.

Another series of impacts in 1982 related to flooding which occurred in central and southern Illinois during January, February, and March as a result of the heavy January rainstorms in southern Illinois, snowmelt in central and northern Illinois, and ice accumulations in the Illinois and Kankakee Rivers. These impacts are not documented to any extent in this report because they are described more fully in another Water Survey report dealing with these winter-spring floods (Changnon et al., 1983).

Travel and Transportation Systems

Several of the impacts that fall under the label of transportation systems are enumerated in other sections, particularly under "government agencies" where the problems and costs of snow removal and maintaining streets and highways are enumerated. These impacts were sizable.

Impacts on individual travelers were largely related to trips in automobiles and buses. Travel by trains and airlines was not drastically affected although airports at Chicago and in central Illinois were closed for two 1-day periods (16-17 December storm and the 8-10 January storm). The major problems concerned automobiles and trucks. In several storms including those on 16-17 December, 8-10 January, and **29-31** January, there were cases of multiple car accidents involving between 20 and 40 automobiles. In one storm (8-10 January), 2300 automobile accidents were reported. This type of problem impacted on the owners' pocketbook and on automobile insurance costs.

In the Chicago metropolitan area, one of the major impacts was on the commuter system. During and after storms, there were notable, 10 to 25% increases in those riding the RTA and CTA. At the same time, there were often major delays in commuter services. System maintenance was delayed by the cold.

One of the problems in the worst storms of December, January, and April was the many abandoned vehicles which had become trapped in the snow either on or alongside roads. These abandoned vehicles were major hazards to traffic and difficult problems for the snow removal equipment.

As in the prior severe winters (1977-1978 and 1978-1979) a major problem was the large numbers of travelers who were stranded, typically in small communities in all parts of Illinois. Large numbers of stranded travelers, reported as between 3,000 and 10,000 per storm, occurred on 16-18 December, 9-13 January, 17-18 January, 30 January-3 February, and 6 April.

The damage to automobiles due to accidents with other vehicles and objects on slick and snow covered highways, was further compounded, beginning in late January, by the damages due to rough highways and streets. Potholes produced from previous severe winters began to break open with fillings popping out in late January. (This is documented further under government agency impacts.) This brought on damages to numerous trucks and automobiles (tires destroyed, wheels out of alignment, shocks and springs damaged) as the crack fillers came apart. Efforts by local and state agencies to fill these potholes in February-March were frustrated by continuing freeze-thaw cycles which removed the new crack filler.

Utilities — Energy and Water

Many of the impacts relating to extremely low temperatures in January and in April concerned high fuel usage. Presumably this brought increased income to the gas and electric utilities, although they had numerous problems. The energy-related impacts are also documented under impacts to government agencies and under health, safety, and related problems.

Those who paid for fuel found extremely high fuel bills due to the cold temperatures, particularly in January and February. In the Chicago area, figures were available for atypical user. In January, a typical household (6 rooms) using natural gas paid $221, as compared with $151 in January 1981. Utilities reported that half of this $70 January cost increase was due to the weather. A record was set on 16 January for the greatest usage of natural gas on a weekend day in northern Illinois. Then, February natural gas bills were 38% higher, with typical household costs of $167 versus $121 in 1981. At the end of February, the natural gas companies in northern Illinois indicated that the costs for gas averaged $803 per winter per household, versus $603 for 1981, a 32% increase due to weather. The additional costs for natural gas in Illinois due to the weather was estimated at $0.7 billion for the 1981-1982 winter.

State and federal regulations related to providing service to delinquent payers of utility bills and to providing funds for low and fixed income households made problems for the utilities. Utilities had to make adjustments and not disconnect delinquent payers during January and February. By the first of March, the delinquent payers of gas bills in Illinois numbered 35,000, representing $23.6 million in overdue bills. The federal program for providing up to $400 per household to low and fixed income families did not begin in Illinois until February. Payments handled by DCCA to deserving recipients were not received until late February and March, helping to create delinquent payments.

Another activity presumably related to the severe winter was the rate increase requests by gas utilities. For example, in early March, Peoples Gas in northern Illinois requested a $115 million rate increase. If nothing else, the timing of the rate increases were tied to the extreme winter, presumably to appear defensible and aligned with the severe winter period. Drinking water outages occurred in a few northern Illinois communities. Low temperatures caused frozen mains, broken pipes, and frozen reservoirs. Barrington and Lake Villa were without water for 3 days, 11-13 January.

Public Health, Safety, and Related Problems

There were 34 documented deaths from the severe winter storms and low temperatures in 1981-1982. On 16-17 December two were killed in a snow-related auto accident near Bloomington. The two storms on 9-13 January produced 18 deaths, some due to being trapped and freezing to death and others due to overexertion. Ninety-eight frost bite cases were reported with these storms. Then with the storms on 29-31 January, 10 were killed in Illinois including 5 involved in snow shoveling and exposure, and 5 in automobile accidents. The 18 February storm produced two more deaths by auto accidents, and the two early April storms each produced a death. This total of 34 far exceeds the 10 recorded in the most recent severe winter, 1978-1979. There is no record of the number injured, although the newspaper accounts of the storms in December and January indicate that at least 550 people had experienced injuries in snow-related automobile accidents. Thirty people in Chicago were treated for carbon monoxide poisoning in January.

Another major impact was the aggravation and anxiety produced by the storms. For example, water pipes froze in many homes in northern Illinois due to the protracted severe cold January temperatures. The extreme cold produced the exceptionally high energy bills (noted above to have been 32% higher than in the prior winter). This was a particular problem for those with low and fixed incomes. The federal assistance to help pay these bills was quite delayed in Illinois. Home overheating in Chicago, as a result of cold, caused 200 homes to burn.

The problems associated with travel were also costly, dangerous, and anxiety-creating There were unexpected delays in travel, with thousands being stranded for 1 to 3 days. Damages to personal vehicles, due to storm related accidents and the increase in potholes, were also a major problem.

The extreme storms in mid-December, mid-January, and early February produced absenteeism with many businesses and government agencies being closed from Vi day up to 3 days in several storms. This represents a loss in individual income. Chicago area factories reported orders were below normal, and fast food restaurants reported up to 50% reductions in sales.

Other reasons for anxiety were medical emergencies. Several babies were born in automobiles and ambulances trapped enroute to hospitals. One of the few noted benefits related to health and safety in the winter was the low incidence of influenza. State health officials attributed this to the lack of social interactions brought on by the severe winter conditions.

In summary, the severe winter brought to all individuals in Illinois, some anxiety and concern, plus higher costs of living. This was related to higher fuel costs, occasional automobile accidents, some flood damages, and landscape damages due to the severe winter. Schools were closed in the Chicago area after the 8-10 January storm and again with the 6 April storm. Snow days were recorded in all parts of the state with most schools in Illinois being closed between 2 and 6 days.

Government Agencies

Local governments experienced, as expected, high costs. The severe storms meant additional use of salt, and with frequent weekend storms there were high overtime salary payments. Many cities experienced winter storm related costs that exceeded their budgets by 60 to 80% by early February. In Chicago alone, overtime to firemen by the end of December cost the city $128,700. The extreme cold made firefighting slow and inefficient. Fifteen fire fighters were injured in Chicago fighting overheating fires. Low temperatures required keeping buses operating during the night several times in January in Chicago, at a cost of $16,000 per night. In addition, flooding along the Illinois River brought considerable damages and local and state government costs of $6.9 million at Wilmington, Chillicothe, and Peoria.

Impacts to state government were major and diverse. Probably the most impacted state agency was the Illinois Department of Transportation. This agency, in anticipation of the 1981-1982 winter, had purchased $10 million worth of new trucks. By late January, half of the $47 million IDOT had allowed for road care and snow removal had been expended. Potholes began to develop rapidly in January and February, with additional repair funds being provided, beyond those in the budget, by transfers from new construction funds. The appearance of deep potholes throughout the state in February was attributed to a wet fall and winter plus the cold and frequent freeze-thaw cycles. IDOT reported on 11 February that the winter snow storms had cost the state between $18 and $20 million. This is compared with a cost of $10 million in the winter of 1980-1981, and $13.8 million in 1979-1980. After initial pre-winter orders the price of salt was raised, and the frequent and extensive storms created much overtime costs for state employees working on the highways. In early April, IDOT reported that the warmer than normal weather in late February caused damage to already patched roads. IDOT then planned to use 70,000 tons of mix for pothole repair, at a cost of $6 million, as compared to a normal annual value of $3 million. They were able to achieve this additional $3 million by transferring funds from other areas including reduced personal services and gasoline funds. Thus, the reported additional costs for snow removal, purchase of salt, and pothole repairs were about $26 million which was almost double the costs in the prior two winters.

The Illinois Commerce Commission (ICC) was also involved in the winter, particularly as related to utility rates. The ICC allowed the reconnection of gas heat for 12,000 needy households.

Governor Thompson declared 15 southern Illinois counties as disaster areas on 24 February. This was a result of the severe winter storms in the area on 29-31 January and 3 February. Counties included were Alexander, Bond, Clinton, Fayette, Jefferson, Livingston, Macon, Madison, Marion, Monroe, Montgomery, Perry, Randolph, St. Clair, and Wabash. This meant that property owners which experienced snow-ice related damages could apply for lower property assessments. It also allowed ESDA to get funding reimbursements from the State Disaster Assistance Fund to pay for services including charges for the National Guard, and it further allowed for appeals to federal assistance. ESDA and other state agencies were impacted in relation to the floods of the spring of 1982, but that is documented in another report (Changnon et al., 1983). The National Guard was called out by the Governor to help in snow removal in southern Illinois after the 29-31 January storm. The National Guard also helped in the flooding problems.

Agriculture

The severe winter, particularly the low temperatures, produced serious agricultural damage in Illinois. The severe cold of mid-January ruined the Illinois peach crop. Flooding of rich bottomland soils along the Illinois River occurred in the February-March-April period. This damaged property and delayed planting. Cattle producers used up their feed faster and by mid-February it became difficult and costly to buy additional feed. Severeal growers reported frozen livestock. Others reported that hog diseases spread rapidly because of prolonged confinement. The extreme cold in January without snow cover in the southern third of the state produced damages to the winter wheat crop. Finally, the record low temperatures of early April caused some damage to apple buds in southern Illinois.

Environment

A variety of negative and positive effects occurred as a result of the severe storms and low temperatures. The negative effects included impacts on wildlife such as rabbits, bobwhite, quail, and pheasant. There was a loss of cover allowing predators to have easier access to these animals. There was a loss of food, primarily due to the long and deep snow cover, and the snow cover and low temperatures also caused many of these varieties to freeze or suffocate. It was estimated by 1 March that about 50% of all ground-feeding birds had been killed due to the long snow cover, high winds, and low night time temperatures, coupled with the lack of habitats for food and for protection. The lack of oxygen in Ramsey Lake due to thick ice cover and snow cover produced a massive fish kill evaluated by the Department of Conservation as $50,000.

One of the apparent benefits of the extremely cold winter was the effect on the gypsy moth. The expected increased outbreak of the damaging moths in the summer of 1982 did not occur. The number of counties with gypsy moths in 1982 was 9, down from the 14 in 1981. The count of moths in 1981 was 3,000 but had reduced to 500 in 1982. These reductions were attributed to the winter weather.

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REFERENCES

Changnon, S.A., Jr. 1969. *Climatology of Severe Winter Storms in Illinois.* Illinois State Water Survey Bulletin 53, 45 p.

Changnon, S. A., Jr., and D. Changnon. 1978. *Record Winter Storms in Illinois, 1978-1979.* Illinois State Water Survey Report of Investigation 88, 23 p.

Changnon, S. A., Jr., D. Changnon, and P. Stone. 1980. *Illinois Third Consecutive Severe Winter, 1978-1979.* Illinois State Water Survey Report of Investigation 94, 36 p.

Changnon, S. A., Jr., J. Lardner, J. Vogel, and P. Vinzani. 1983. *Floods of Winter-Spring 1982 in Illinois.* Illinois State Water Survey Report of Investigation 105, 66 p.

Daily Weather Map Series. November 16, 1981-April 11, 1982. National Oceanic and Atmospheric Administration, Washington, DC.

Dickson, Robert R. 1982. *Weather and Circulation of February 1982 — A Highly Variable Month over the United States.* Monthly Weather Review, 110:446-451.

Environmental Data and Information Service. 1982. *Climatological Data for Illinois, July 1982.* National Oceanic and Atmospheric Administration, Washington, DC, 8 p.

Harnack, Robert P. 1980. *An Appraisal of the Circulations and Temperature Pattern for Winter 1978-1979 and a Comparison with the Previous Two Winters.* Monthly Weather Review, 108:37-55.

Taubensee, Robert E. 1982. *Weather and Circulation of December 1981 — Dryness Alleviated over the Southwest.* Monthly Weather Review, 110:230-236.

Wagner, A. James. 1982. *Weather and Circulation of January 1982 — A Stormy Month with Two Record Cold Waves.* Monthly Weather Review, 110:310-317.

Weber, Eugene M. 1976. *Major Snowstorm Development over the Midwest United States.* Air Weather Service Report No. 3WW TN 76-2, 84 p.