

MAJOR ARCTIC OUTBREAKS AFFECTING LOUISIANA

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ABSTRACT

The forecaster is provided with guidelines to assist in the subjective evaluation of the onset of Arctic outbreaks into the deep south several days in advance. Upon analyzing the synoptic patterns prior to and during an event, it was determined that several classic signatures exist which set the stage for a major Arctic outbreak into Louisiana and the other Gulf Coast States.

There have been 20 major Arctic outbreaks during the past 103 years. Ten of these outbreaks have affected some portion of the state since 1948.

1. INTRODUCTION

Louisiana is subject to major Arctic outbreaks which produce severe freezes. These can produce extensive economic losses to agricultural, commercial, and public property. The freezes in the early 1980's destroyed most of the orange groves and some of the tropical trees in southeastern Louisiana while also causing considerable commercial and public losses due to power outages and frozen water pipes.

There have been 20 major Arctic outbreaks during the past 103 yr. Ten of these outbreaks have affected some portion of the state since 1948. Notable outbreaks since 1948 have occurred during 1949, 1951, 1962 (twice), 1963 (twice), 1982, 1983 (twice) and 1985. Of these, four freezes (1951, 1962, 1963 and 1983) affected the entire state.

Although the frequency of occurrence is only about once every 5 yr, the forecaster has a responsibility to forecast these freeze events several days in advance to allow agricultural interests, utility companies, and the public to take necessary precautions to protect property and prevent potential losses. Pattern recognition is an important tool in helping forecasters determine when conditions exist for a surge of Arctic air into the southeastern United States. This additional tool can help forecasters decide when the potential exists for a southward surge of an Arctic airmass.

This study was designed to provide the forecaster with guidelines to assist in the subjective evaluation of the onset of Arctic outbreaks into the deep south several days in advance. Upon evaluating the past 10 major arctic outbreaks for which upper air data were available, several significant patterns (signatures) were recognized which led to the onset of an Arctic outbreak into Louisiana as well as the Gulf Coastal States.

2. CLIMATOLOGY

a. General

The principal influences that determine the climate of Louisiana are its subtropical latitudes and the Gulf of Mexico.

The primary airmass affecting the state is Maritime Tropical which develops in the Atlantic high-pressure anticyclone. This spreads warm humid air across the state from the Gulf of Mexico for considerable periods of time during the winter season. (This influence is evident from the fact that the average water temperature of the Gulf along its northern shore ranges from 57° to 63°F most of the winter season.) However, for varying periods of time surges of polar and Arctic air spread southward from the Canadian provinces (Continental Polar airmass) or from the eastern Pacific (Maritime Polar airmass) (Fig. 1). During the Winter these regions experience extreme minimum temperatures lower than those in any other comparable area of the world (Trewartha, 8).

Minimum temperatures (°F) across the state normally average in the 30s north to the low and mid 40s south during the winter months of December through February and in the lower 40s north to near 50 south in November. However, average temperatures are somewhat deceptive as minimum temperatures in the lower teens across the north and in the lower 20s across portions of the south are not uncommon for short periods during the winter season.

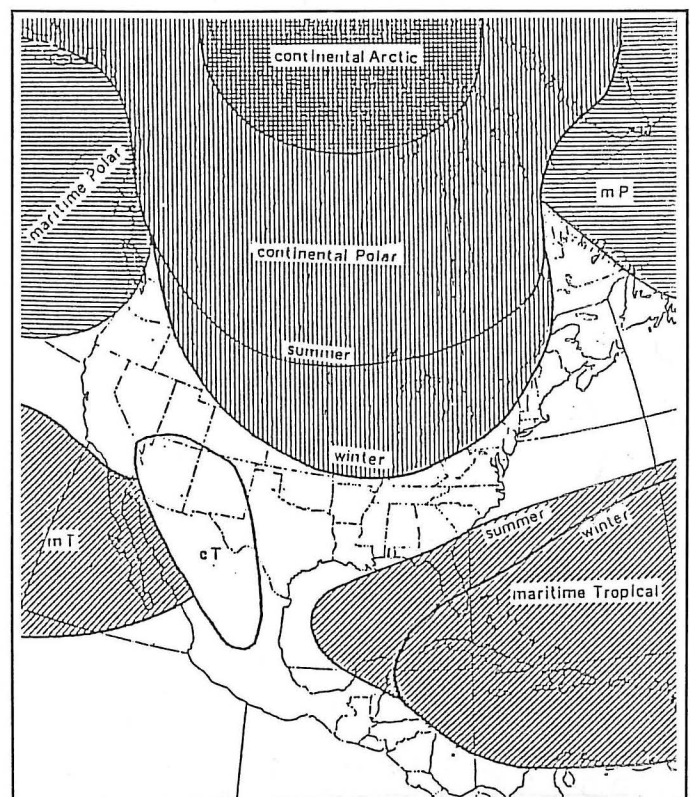


Fig. 1.—Airmass locations across North America.

The record low temperatures for the state range from a -16°F at Minden in northwestern Louisiana to 15°F at Boothville and 21°F at Burrwood, both in the lower reaches of the Mississippi River Delta. Because of its subtropical influence, the record low temperature in Louisiana is the second warmest (to Florida) of the lower 48 states.

b. Arctic Freeze

An event was defined as a major Arctic outbreak when the temperature dropped to, or below, a critical value at two or more stations in two or more climatological divisions. These were generally short-term events of 1 to 3 days. The severe winter seasons of the late 70's are not included even though the cold air mass remained entrenched over the state for long periods of time, because the coldest daily temperatures hovered a degree or two above the critical values which were established for this study.

To eliminate all but the most severe freeze episodes, a critical minimum temperature was derived for each of the 67 climatological stations across the state (Figs. 2a and b).

Using these values with an areal coverage of at least two stations in two or more climatological divisions, 20 Arctic outbreaks were identified in Louisiana since 1885. Of these 20, only 8 affected the entire state (refer to Table 1). (See section 4 for information on "classical signatures" for recog-

nizing in advance a major Arctic outbreak for the Gulf Coast States).

Major Arctic outbreaks across Louisiana are generally accompanied by some freezing precipitation and/or snow with the initial surge, but only a few events produced heavy snows (see Johnson and Mortimer, (4)). Major Arctic outbreaks also appear to occur in cycles, with occurrences in several seasons and a break of 8 to 11 yr before the next occurrence. This appears to fit the solar sunspot cycle best, with most episodes occurring during the period between a peak and a lull in sunspot activity.

3. SIGNATURES

a. General

Pattern recognition can help a forecaster decide when the conditions exist for a surge of Arctic air into Louisiana and when to deviate from numerical guidance. Although numerical guidance has improved over the last several years, the guidance is still based on statistical methods which will not identify most rare or extreme events. The best improvement can be made in the short-medium term (2 to 3 days) forecast. Actual minimum temperatures are not necessarily as important as the cold trend indicated in long-range forecasts (3 to 5 days). However, identifying the potential for a severe freeze

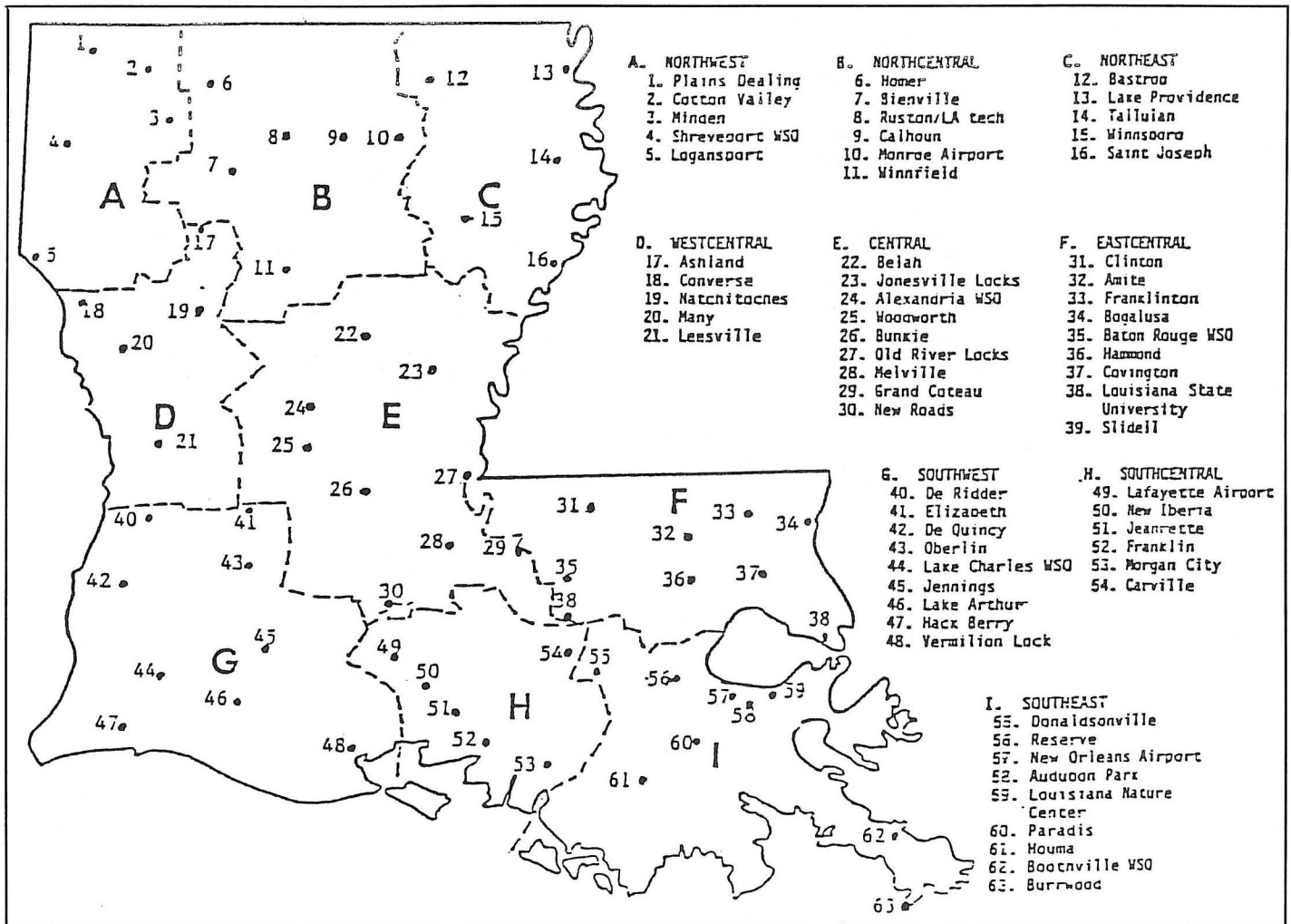


Fig. 2a.—List of cities and climatic divisions for Louisiana used in the climatological data.

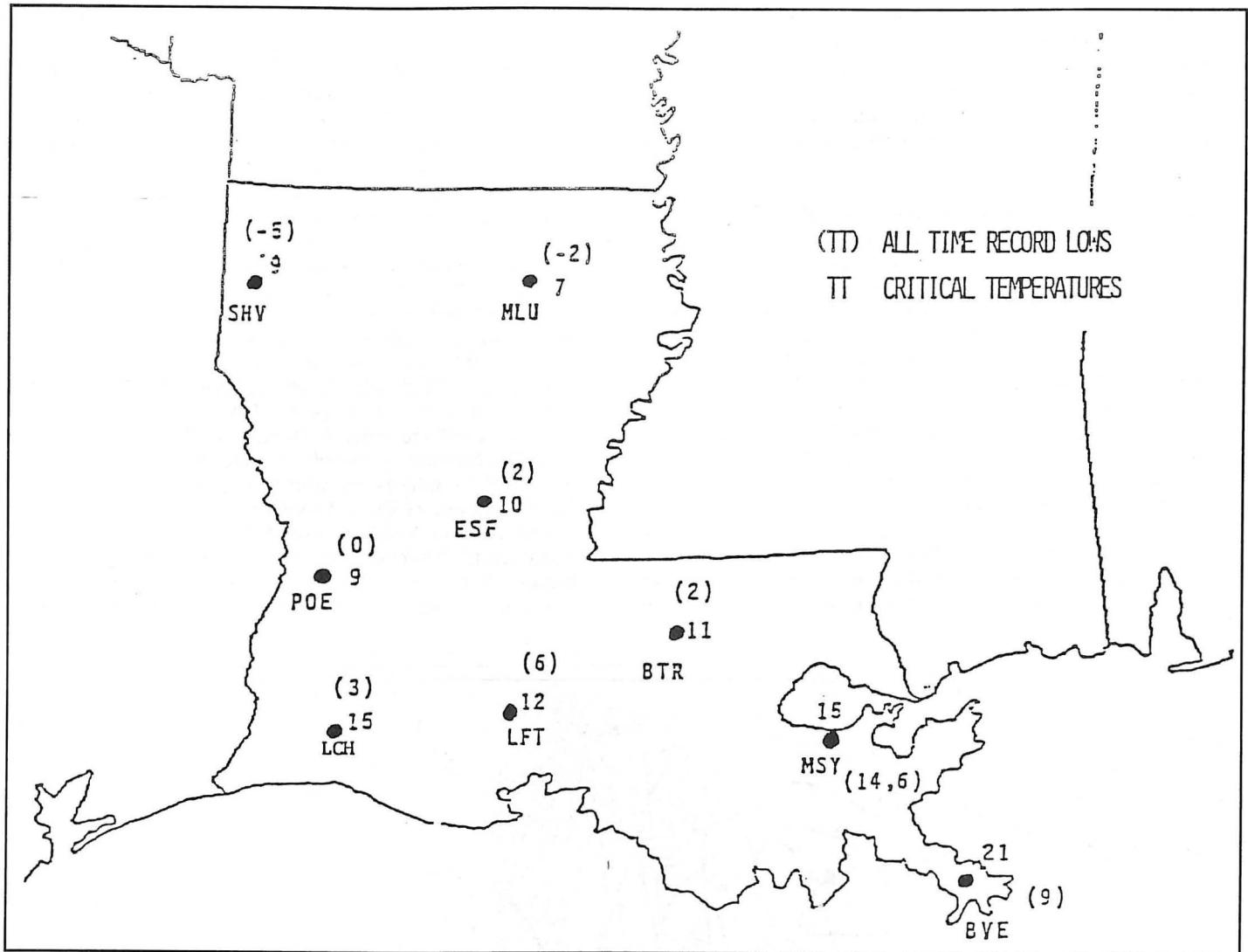


Fig. 2b.—Critical temperatures (°F) for major Arctic outbreaks affecting Louisiana and the all time record low temperatures in Louisiana.

Table 1. List of Arctic outbreaks affecting Louisiana during the past 103 years and portions of the state affected.

| Date | Area | Climate Regions |
|-----------------|-----------------------------|---------------------|
| 1-9-1886 | Entire state | |
| 2-8-1895 | Entire state | |
| 2-13-1899 | Entire state | |
| 2-13/14-1905 | North | A, B, D |
| 1-12-1918 | Entire state | |
| 12-23-1929 | North & west | A, B, C, D, G |
| 1-18/19-1930 | North & west | A, B, D, G |
| 1-17 to 19-1940 | North & southwest | A, B, C, D, G |
| 1-27-1940 | Northeast thru east central | C, E, F, I |
| 1-18 to 24-1948 | All except southeast | A, B, C, D, E, G, F |
| 1-31/2-1-1949 | Northwest | A, B, D |
| 2-1/2-1951 | Entire state | |
| 1-11/12-1962 | Entire state | |
| 12-12/13-1962 | East half | C, E, F, H, I |
| 1-24/25-1963 | North & southeast | A, B, C, E, F, I |
| 12-23/24-1963 | Extreme north | A, B, C |
| 1-9 to 13-1982 | Entire state | |
| 12-24/25-1983 | Entire state | |
| 12-30/31-1983 | West and north | A, B, C, D, G |
| 1-19 to 22-1985 | Northeast & southeast | C, I, F |

threat is sufficiently important that it should be communicated to the agricultural community as well as to other businesses, public, and private interests. This will allow users to take actions commensurate with the assessed freeze potential. For example, a severe freeze threat even at a low confidence level 3 or 4 days in the future could trigger several low-cost actions such as a review of resources and accelerated harvesting. In southern sections of the state, some businesses and residences are vulnerable to major plumbing repairs if an advance warning of an impending severe freeze is not given.

As the confidence level of an impending damaging freeze increases, the actions to decrease losses would become more intense, expensive and widespread. For example, during the winter season of 1984-85, numerical guidance (even medium range) was exceptionally good in identifying a developing synoptic pattern that was to lead to a damaging freeze over the entire state of Louisiana as well as adjacent Gulf Coast States. Some 3 to 4 days of advance warning was given for the mid-January 1985 major Arctic outbreak which significantly reduced the economic losses statewide.

b. Upper Air Patterns

After analyzing the synoptic patterns prior to and during a major Arctic outbreak into the continental United States, it

was determined that several similarities existed. Since 1948, there have been 10 major freeze events which brought significant economic losses to the Bayou State. Since upper air data were not available prior to November 1948, the data sample was restricted to these 10 events.

Several features were found to be similar to those presented by McFarland (5) in his study of freezes affecting the Lower Rio Grande Valley of Texas. However, several subtle differences were found for events affecting Louisiana. McFarland's study utilized only three events which had upper air data available (i.e., since 1948). The study for Louisiana utilized 103 yr of data for freezes in Louisiana with 10 events occurring since 1948. Six signatures were noted at times during the Arctic outbreaks as described in Table 2. However, an additional major signature was common to one or more of the six classic signatures (patterns). The dominant signature noted for these 10 events was a strong ridge of high pressure over the eastern Pacific or West Coast of North America. Normally, this feature is in response to a deep, cold trough developing in the central Pacific between longitudes 160°W and 180° (Figs. 3 through 8).

The following is a scenario of events which may lead to a major Arctic outbreak into Louisiana and adjacent Gulf Coast States.

A week to 10 days before a major Arctic outbreak occurred

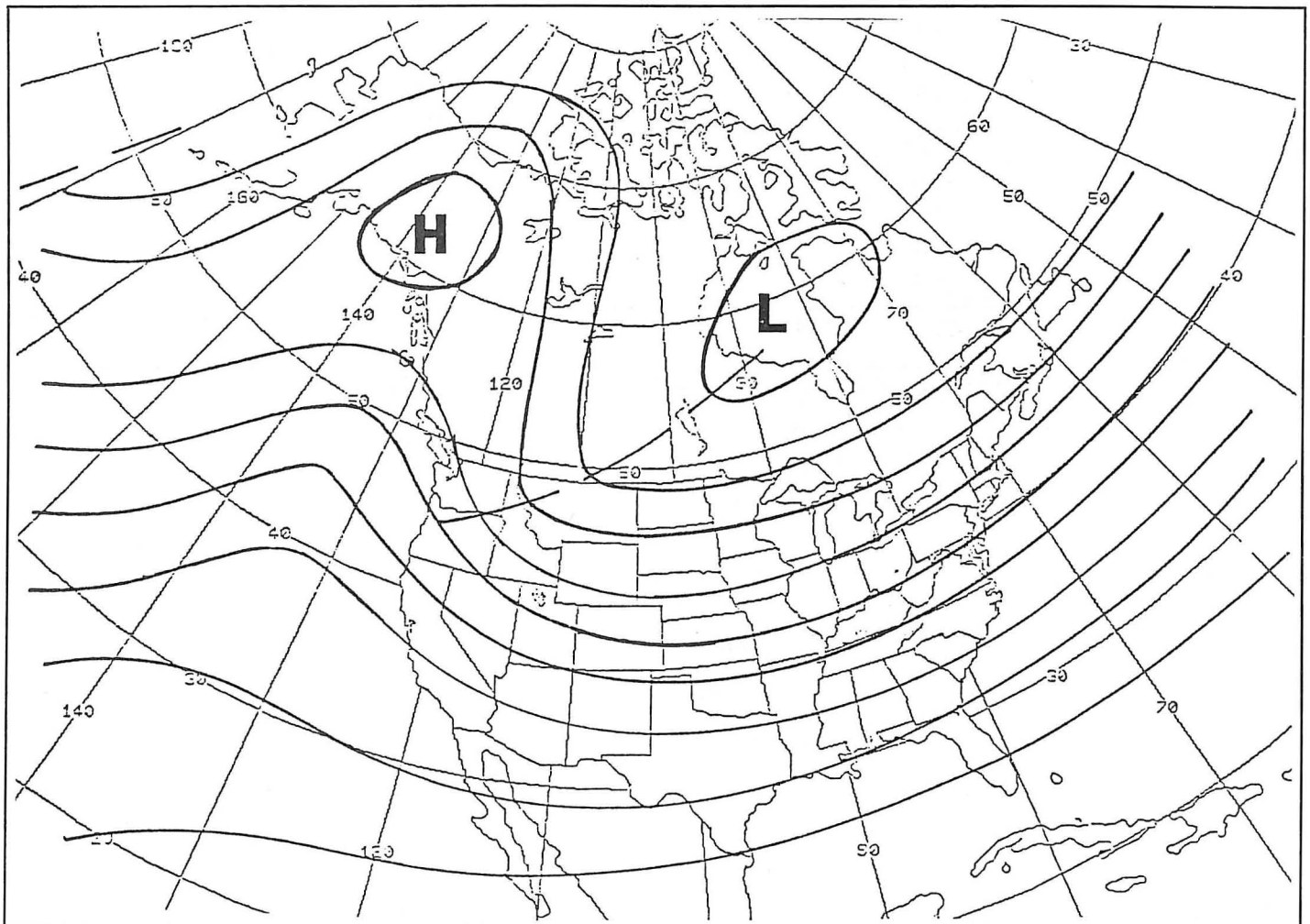


Fig. 3—Low near Hudson Bay with a trough extending west or southwest into southwest Canada or the Pacific Northwest. A series of short-wave (S/W) troughs would cause this trough to surge southward without cyclogenesis.

Table 2. Classic signatures associated with Arctic outbreaks into Louisiana

- 1) Low near Hudson Bay with a trough extending west or southwest into southwest Canada or the Pacific Northwest (Fig. 3). A series of short-wave (S/W) troughs would cause this trough to surge southward without cyclogenesis.
- 2) Low near Hudson Bay with a trough extending into the southwestern U.S. (Fig. 4), which progresses eastward into the Central Plains as a full latitude trough.
- 3) A closed Low moving southward through the prairie provinces of Canada (Fig. 5), which develops into a long-wave (L/W) trough without cyclogenesis.
- 4) A S/W trough in the southern branch of the westerlies moves eastward into the southwestern states. In the meantime another S/W in the northern branch of the westerlies moves eastward and frequently becomes in-phase with the L/W trough (Fig. 6). Occasionally, a closed Low was noted in the southern branch. This pattern is quite typical of a split flow in western North America.
- 5) A deep trough was over the eastern U.S., sometimes accompanied by a closed Low (Fig. 7).
- 6) Discontinuous retrogression of trough over the western U.S. (Fig. 8).

in Louisiana, a deep trough would move into or develop in the central Pacific between longitudes 160°W and 180° . In response to this development, a strong ridge would build over the eastern Pacific and extend into northern Alaska or the Arctic Ocean. The ridge axis was generally along or just west of 130°W in eight of the ten events, with a ridge over the West Coast of North America in two events. A short-wave omega block was superimposed on the long-wave ridge in several of the events (Fig. 3). The strength of this ridge

was influenced by the intensity of the upstream trough. The strength of the ridge also influenced the transitory speed of downstream troughs over North America. The development of this ridge was present in each event and should alert the forecaster to the potential for a surge of colder air.

In tandem with this strong ridge was a cold, deep low-pressure trough from Hudson Bay southward across the Central Plains of the United States. The strong, deep trough usually present over the central Pacific (Fig. 4) helped anchor

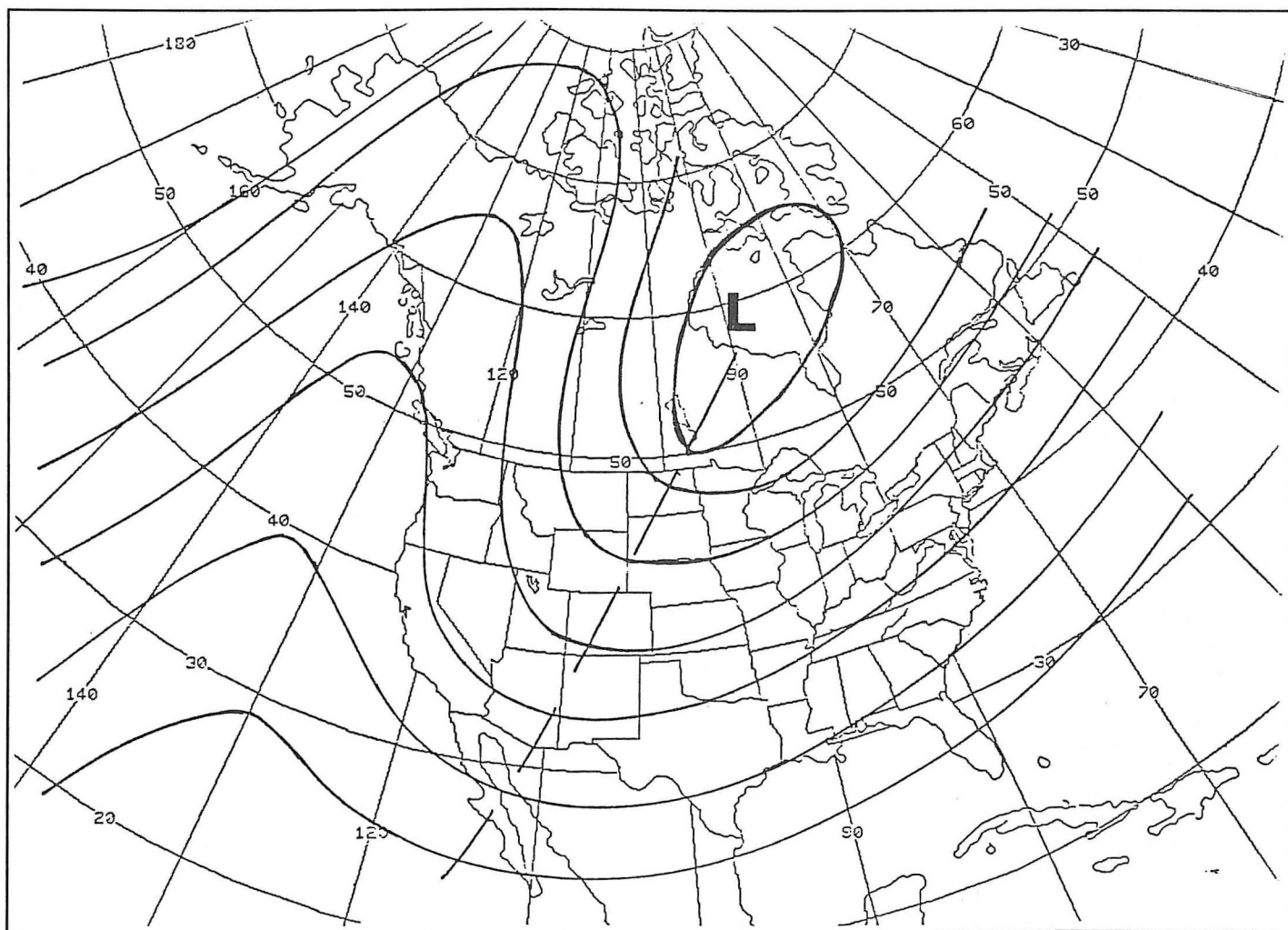


Fig. 4—Low near Hudson Bay with a trough extending into the southwestern U.S., which progresses eastward into the Central Plains as a full latitude trough.

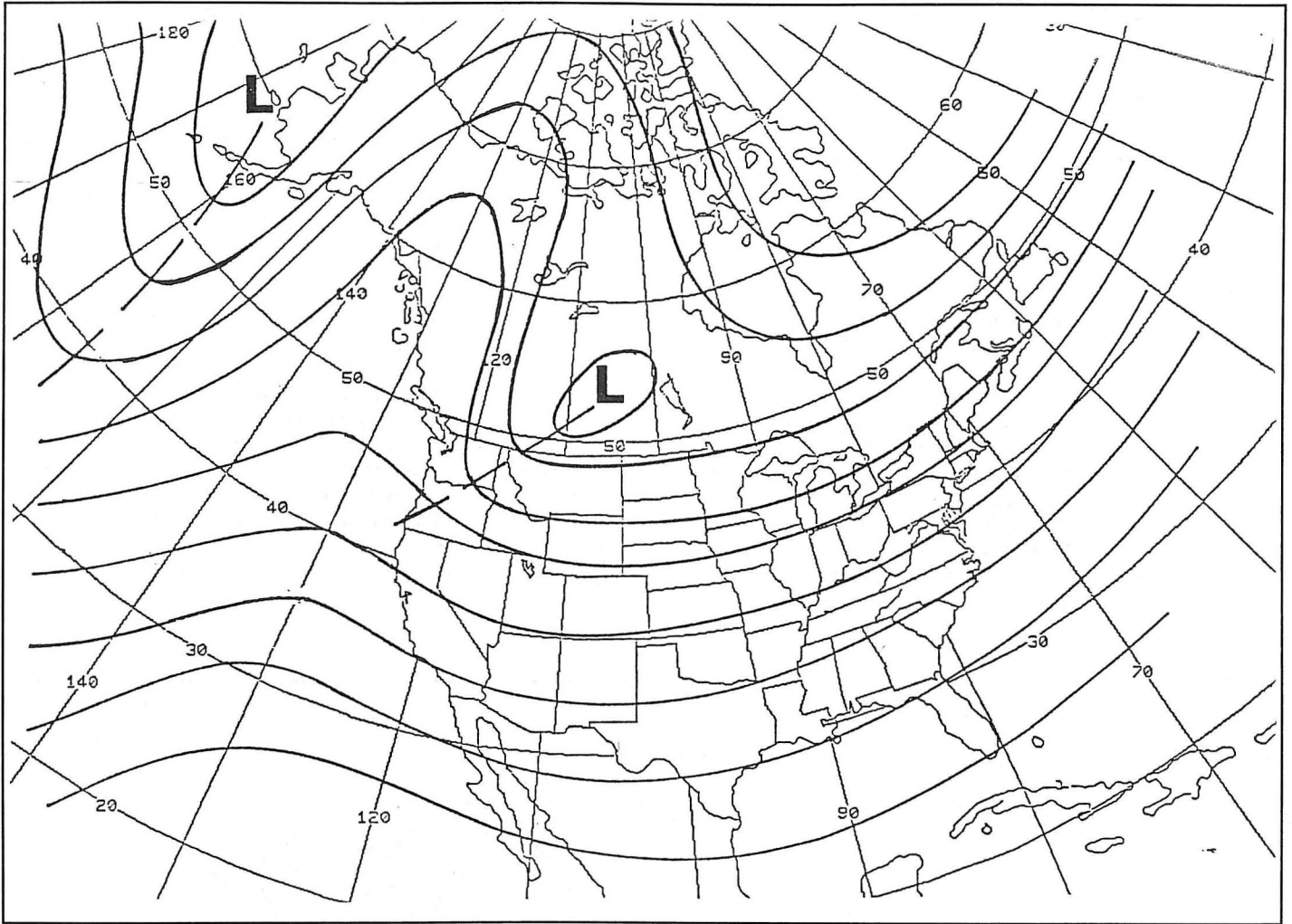


Fig. 5.—A closed low moving southward through the prairie provinces of Canada, which develops into a long-wave (L/W) trough without cyclogenesis.

this strong ridge-trough couplet over North America. The development of this rather stable long-wave pattern may be attributed to colder than normal waters over the north-central Pacific in the summer and fall seasons forcing warmer waters northward over the extreme eastern Pacific as described by Namias (7). Variations of this main synoptic pattern were identified and described as classic signatures in Table 2.

Over North America, there were several mechanisms present which eventually caused an Arctic air mass to surge southward. The authors identified six additional, though sometimes subtle, upper air signatures conducive to surges of major Arctic outbreaks into portions of Louisiana. The beginning signature did not persist throughout the entire event, but would evolve into one or more of the other features, except that an upper level ridge was dominant in all cases.

Seven events were associated with a closed Low near Hudson Bay (Figs. 3, 4, and 6). In three events, a trough extended east to west across southern Canada or into the northwestern United States. The trough would remain nearly stationary for several days with a strong northerly flow across Canada and a strong zonal flow south of the trough (Fig. 5). This allowed the cold dome of Arctic air to intensify over Canada. The west portion of the trough would then rotate

southeastward into the central plains, in response to a series of short-wave troughs. This allowed the Arctic air to surge southward. There were three events with a northeast-southwest trough from the Hudson Bay Low which moved eastward to establish a long-wave trough over the central states by the end of the event (Fig. 4). There was one event, 1985, in which the long-wave trough was established over the eastern states (Fig. 7).

Three outbreaks were associated with a short-wave moving eastward through the southern portion of the ridge into the southwestern states while the northern branch was across southern Canada or the northern tier states (Fig. 6). A split-flow pattern was normally located over western North America. These short waves became in phase with a stationary or slow-moving long-wave trough and accelerated the southern portion of the trough into the central or eastern states. Cyclogenesis occurred when a strong short-wave trough ejected east or northeast from the long-wave trough. This usually resulted in discontinuous retrogression of the long-wave trough over the western states (Fig. 8).

Three events were associated with a cold, deep Low in the Canadian Prairie Provinces with a short-wave trough extending into the Pacific Northwest. This trough rotated south-

eastward into the Central Plains and developed into a full-latitude trough that progressed eastward into the eastern states (Figs. 5 and 7).

Discontinuous retrogression occurred in over half of the events. This occurred when a short-wave was ejected east or northeast from the long-wave trough as a second short-wave approached from the northwest. This would give the long-wave trough the appearance of first moving eastward, then redeveloping westward with the upstream short wave (Fig. 8).

c. Surface Patterns

A high-pressure system intensified from the Yukon Territories southeastward into central and western Canada under the influence of a strong, building upper level ridge and a deep, cold Low or trough normally located in the Hudson Bay area. As strong short-wave troughs surged south or southeast towards the United States the Arctic High would move southeast into the northern Rockies and Plains States. On a few occasions the pressure would reach 1050 mb or higher from the Yukon to the northern Rockies (Fig. 9).

For the Arctic air to spread southward to Louisiana and the western Gulf Coast States, the Arctic surface High would

have to move or build south into eastern Texas. If the High moved east or southeast through the mid-Mississippi Valley or into Mississippi/Alabama the coldest air would be shunted more eastward.

An important factor for the development of record-breaking low temperatures in mid-winter was an extensive blanket of snow from the Plains States north and northwest through Canada. By mid-winter the frigid Arctic air and the fronts combined to form snow rather than rain from the northern and central Rockies eastward to the East Coast. While amounts were usually not heavy, snow persisted on the ground owing to persistent cold air outbreaks far to the south along the Gulf Coast. This often would lead to snow far south of normal. The snow cover in turn helped to refrigerate the Arctic air in its southward transit, partly through its increased albedo. The cover remained on the ground and was maintained by the frequent Arctic air surges and replenished by storms moving along the south and eastern seaboard as discussed by Namias (7). A recent example of this phenomenon was in December 1983 when two record-breaking events clobbered the Bayou State within a 1-week period. During this event, economic losses were widespread statewide but more devastating over southern Louisiana. An extensive snow cover

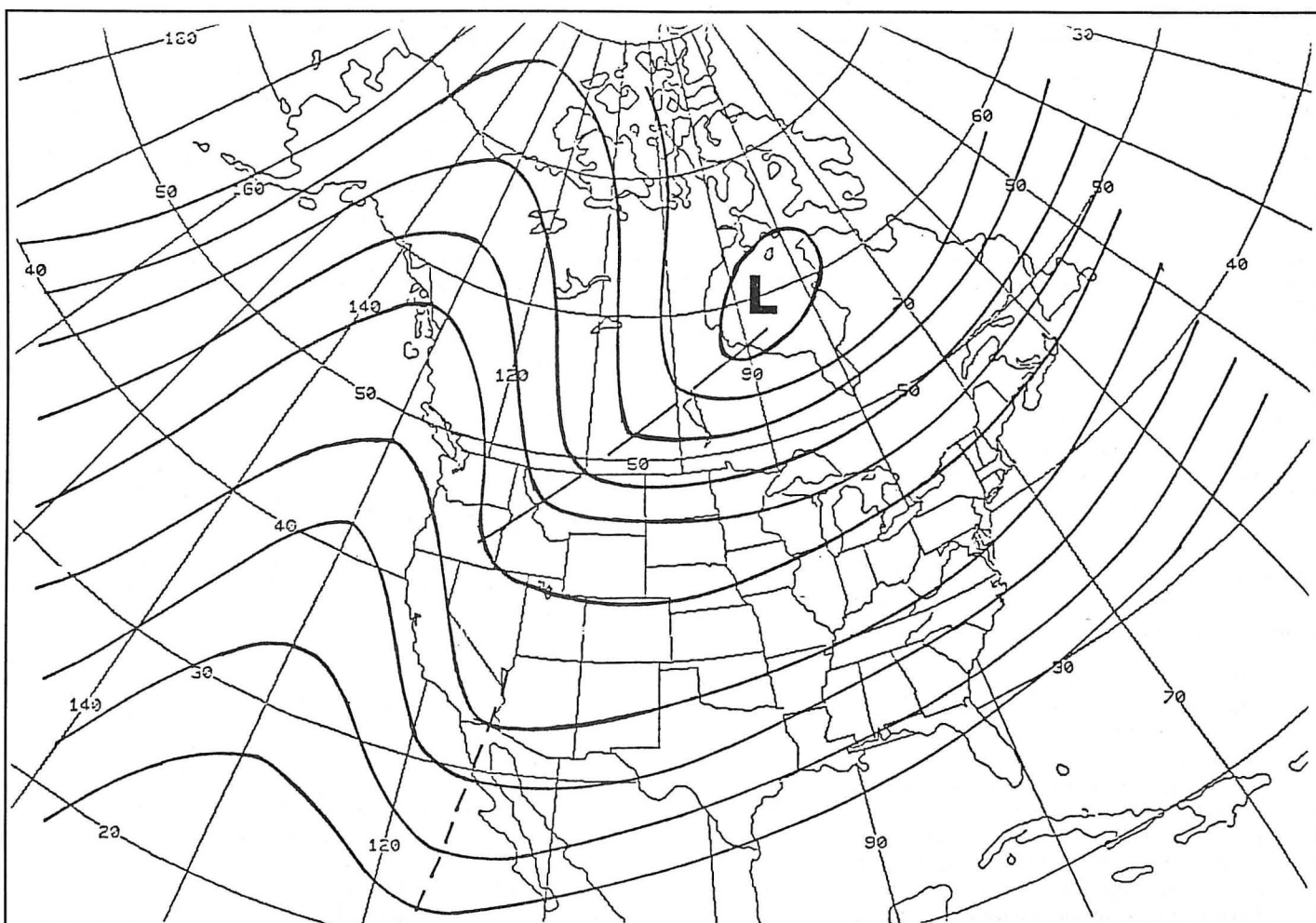


Fig. 6—A S/W trough in the southern branch of the westerlies moves eastward into the southwestern states. In the meantime another S/W trough in the northern branch of the westerlies moves eastward which frequently becomes in-phase with the L/W trough. Occasionally, a closed low was noted in the southern branch. This pattern is quite typical of a split flow in western North America.

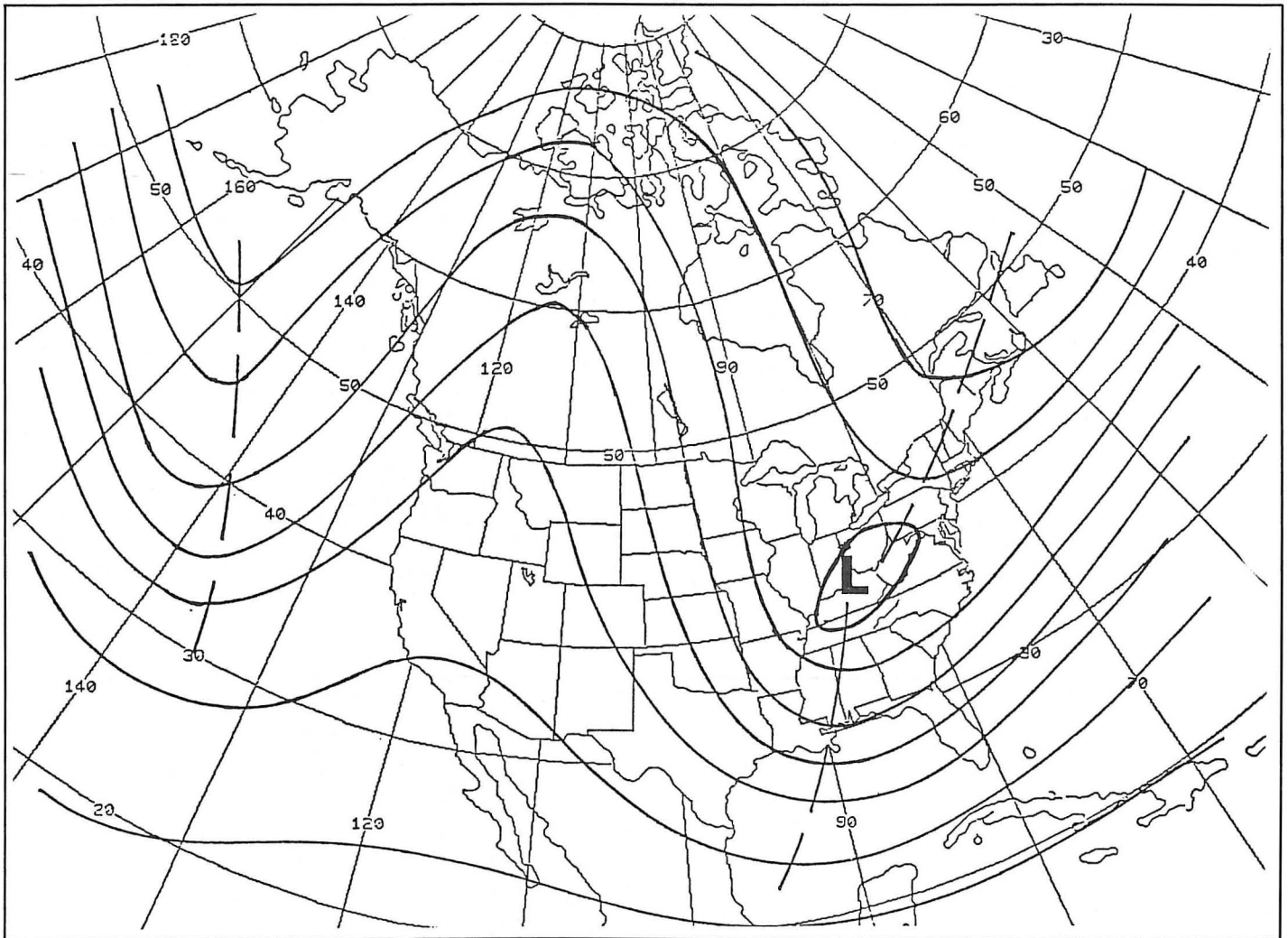


Fig. 7.—A deep trough over the eastern U.S., sometimes accompanied by a closed low.

was normally as far south as extreme northern Texas, Arkansas, and northern Mississippi during record-breaking Arctic outbreaks in Louisiana (Fig. 8).

4. ADDITIONAL FORECAST GUIDELINES

- 1) Follow 24-hr 500-mb height fall/rise couplets. Superimpose them on 500-mb map to correlate with deepening troughs or amplifying ridges.
- 2) Check pressure of surface High (generally 1050 mb or higher) and temperature of airmass (generally $[-]20^{\circ}\text{F}$ or colder) in western/central Canada (mainly inland areas away from marine influence).
- 3) Thickness patterns can be deceiving when examining Arctic air masses.
- 4) Note extent of snow cover from Canada southward into U.S.
- 5) Cross-sections can be used to distinguish the major Arctic air from the polar-type air.
- 6) Major Arctic outbreaks are usually associated with two or more synoptic patterns (signatures) over a period of several days to a week or more.
- 7) The majority of the events are associated with signatures 2 and 3 in addition to the major signature which is common to all events (strong ridge).
- 8) If the southern branch of the westerlies becomes a dominant pattern for the Gulf Coast States, the coldest airmass will be shunted eastward away from Louisiana, or overrunning conditions will develop. This was the case during the winter of 1979. This particular winter season was one of the coldest on record in many areas of Louisiana. However, for the reasons discussed above, the critical temperatures for a major Arctic outbreak were not reached.
- 9) In studying the possible relationship of El Niño occurrences to a major Arctic outbreak for Louisiana, it was determined that on several occasions, a record-breaking event would occur near the ending of an El Niño event.

5. CONCLUSIONS

This study was designed to provide the forecaster with guidelines to assist in the subjective evaluation of the onset

of Arctic outbreaks into the deep south several days in advance. After analyzing the synoptic patterns prior to and during an event, it was determined that several classic signatures existed which set the stage for a major Arctic outbreak into Louisiana as well as the remainder of the Gulf Coast States.

It was found that a major Arctic outbreak occurred about once every 5 yr. Thus, the forecaster has a responsibility to forecast these rare freeze events several days in advance. This allows the agricultural business interests, utility companies, and other interests to take the necessary precautions to reduce their potential losses. Even though numerical guidance has improved over the last several years, the forecaster must recognize those situations which will lead to the intrusion of Arctic air into the state. With the timely recognition of these classic signatures, the forecaster should be able to greatly curtail the economic losses in the state.

NOTES AND REFERENCES

1. Edward B. Mortimer is a Lead Forecaster at the National Weather Service Forecast Office in Albuquerque, NM. Previous

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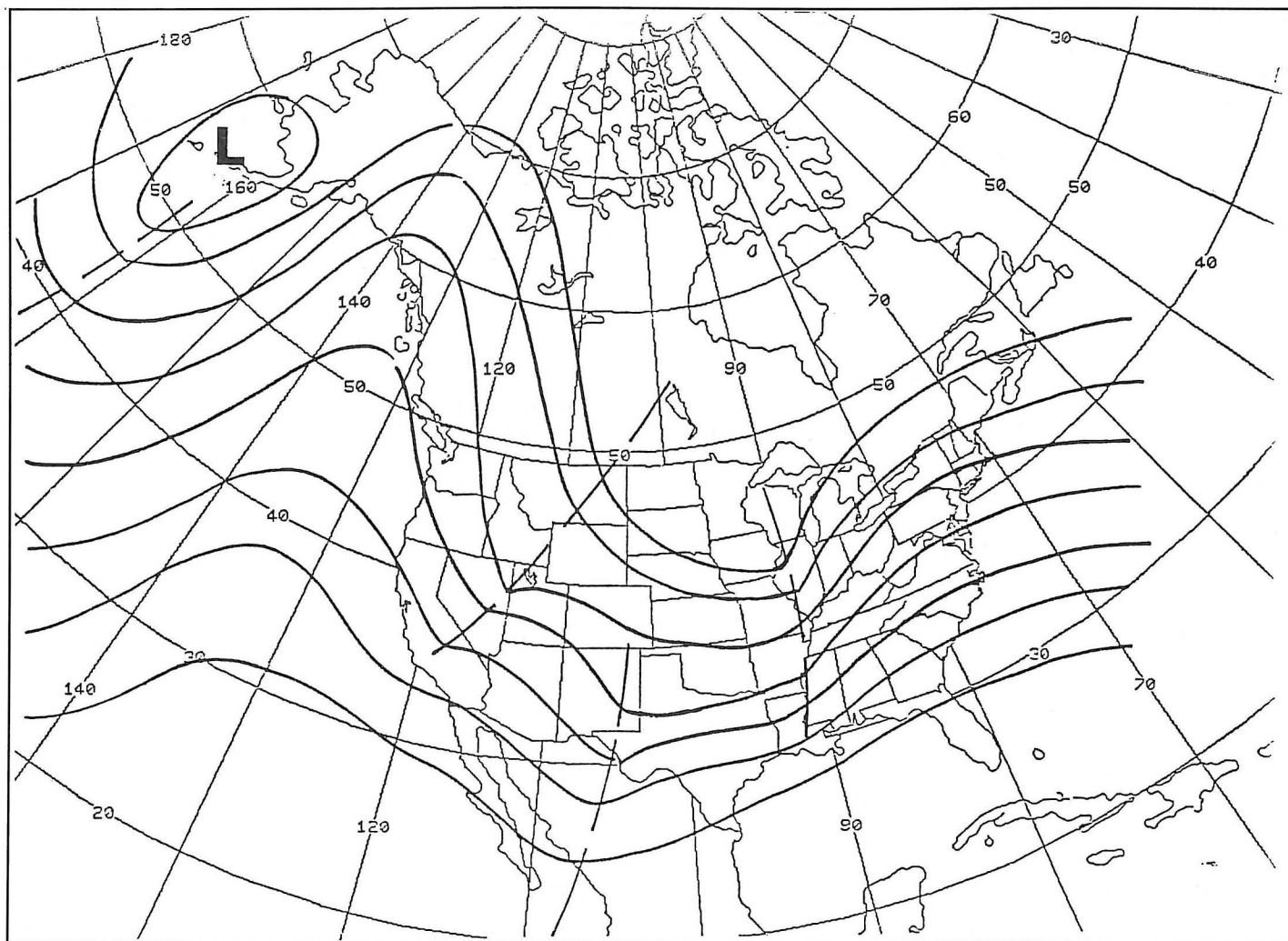


Fig. 8.—Discontinuous retrogression of trough over the western U.S.

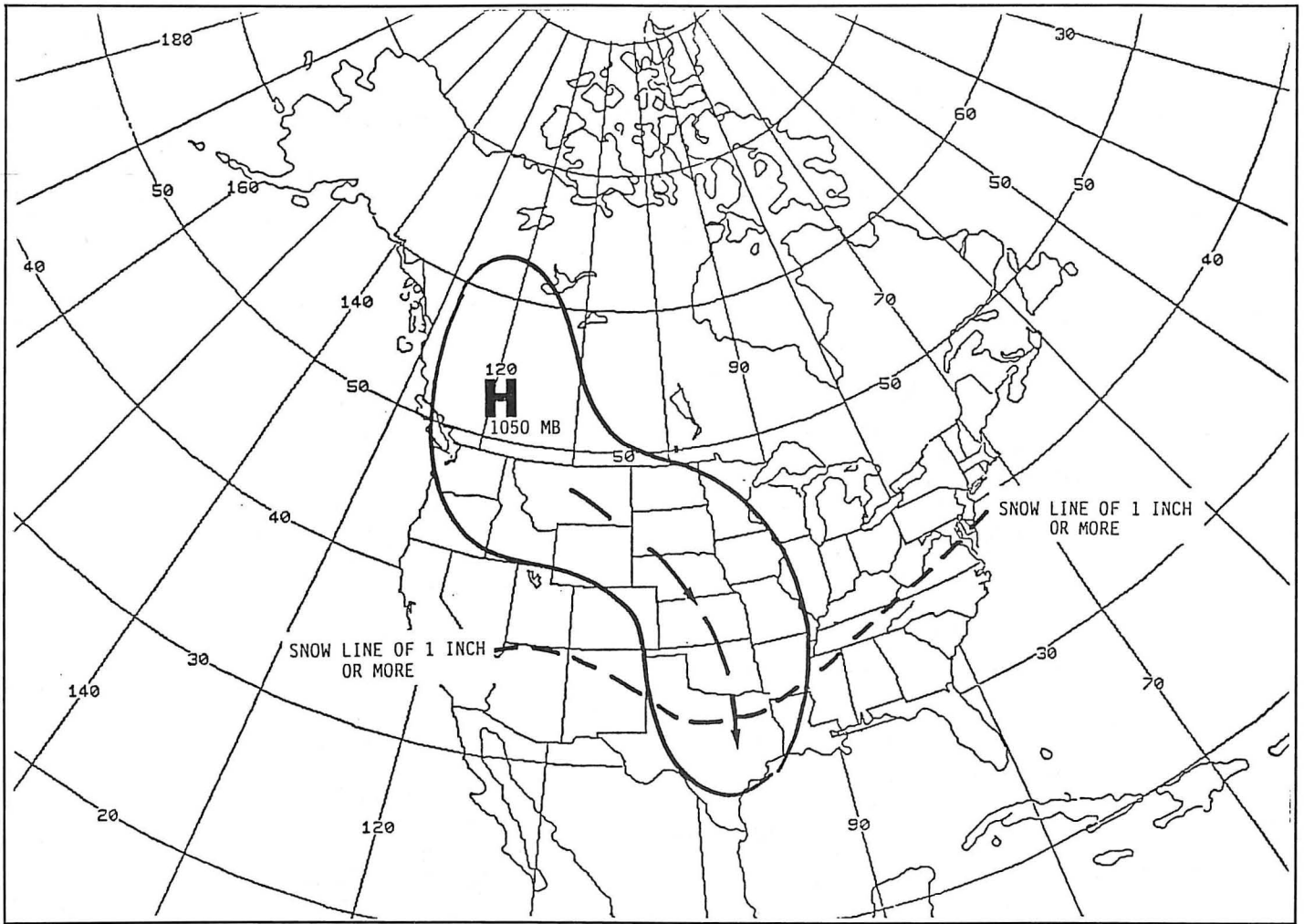


Fig. 9.—Mean surface ridge across North America during major Arctic outbreaks along with an average snow cover.

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