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Circular I22

STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION

Climatology of Surface Fronts

by GRIFFITH M. MORGAN, JR., DAVID G. BRUNKOW, and ROBERT C. BEEBE

ILLINOIS STATE WATER SURVEY

URBANA

1975

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CLIMATOLOGY OF SURFACE FRONTS

By Griffith M. Morgan, Jr., David A. Brunkow, and Robert C. Beebe

Introduction

This report presents information on the frequency of occurrence of frontal systems (cold, warm, occluded, stationary), squall lines, and high and low pressure centers over North America. It provides maps of average frequencies for all months for the 10-year period 1961-1970, given in appendices A through G.

Surface frontal systems are idealized devices that weather forecasters find useful in simplifying an otherwise bewildering array of data to the point that a forecast of the more directly sensible weather elements can be made.

Fronts figure in various ways in climatological studies. For instance, Hiser (1956) determined the percentage of rainfalls in central Illinois which are associated with various frontal categories. Beebe and Morgan (1972) used frontal categories in investigating the synoptic factors important to the downwind enhancement of rainfall by the urban complex of St. Louis, Missouri.

The present frontal climatology is similar to, but on a much greater scale, than that of Chiang (1961) who determined the frequency of occurrence of various types of fronts in 60 × 60 n mi boxes in Illinois on the basis of the Daily Weather Map Series for the 15-year period 1945-1959. Similar tabulations on a much coarser scale were used during the 1950s in the weather summaries appearing in the *Monthly Weather Review.* Huff (1961) utilized Chiang's frontal frequencies in a study of the relationship between the distribution of Illinois hailstorms and other climatological factors.

The distribution of climate elements within Illinois can best be interpreted in relation to the pattern over a much larger area. For this reason it was decided to pursue the study of frontal climatology on the scale of the entire North American Daily Weather Map. The results of a tabulation at this scale will also be useful for studies in areas other than Illinois, and should be of use to researchers in other regions. This Circular aims to make these results available to a wide audience of users. It contains a minimum of interpretative comments.

These data are expected to find useful application in various areas of research at the Water Survey, and are available to any bonafide user in the form of punched cards or magnetic tape. The program for processing the raw data can also be made available. Initial use of the data on Project Metromex (Changnon et al., 1971) is described by Morgan, Beebe, and Brunkow (1973).

This work was carried out under the general supervision of Stanley A. Changnon, Jr., Head of Atmospheric Sciences Section, Illinois State Water Survey. Mildred Broquard accomplished the initial stages of the PLI programming. Digitizing of the maps was done by Catherine Jackson, Janet Lang, and Susan Moyer. Keypunching was done by the Water Survey Data Processing Unit. This study has been financed by the National Science Foundation under Grant GI-38371.

Tabulation Technique

The basis for this frontal climatology is the Daily Weather Map Series for the period 1 January 1961 through 31 December 1970. This was a 10-year period of apparently uniform analysis technique.

The Daily Weather Map is printed on a polar stereographic projection, true at latitude 60° N. A grid was made by dividing this into quasi-squares 60 n mi on a side created by marking off every 60 n mi along latitude circles, starting from a fixed reference longitude (100° W). This grid, printed on plastic, was overlain on each map and the squares through which fronts passed were tabulated. Squares with high and low pressure centers were also tabulated.

The total in each grid square for each frontal and pressure-center type was determined and examined in two forms: 1) printed computer output of grid-box totals, and 2) computerplotted contour maps on the original map projection. [The data presented are in the latter form. Because the contouring program examines the range of values on each map and draws contours at approximately 10 levels, the contour interval must be noted in comparing maps.]

The basic 60 X 60 n mi grid yields distributions that are quite detailed. Some of this detail may be of climatological significance and some is undoubtedly due to sampling inadequacies. For this Circular the following computer-executed smoothing operation was employed.

On each map, each 60 X 60 n mi grid square contained a *yes* or a *no* and a type code. With no smoothing employed, it was necessary only to accumulate *the yeses* over a specified time period, say one month or one month-decade, for each square and then to map the results. Smoothing was accomplished by scanning the grid square and adjacent grid squares and entering *a yes* if there was an element (front or pressure center) in any of them. This is the same as increasing the size of the basic grid square, but sliding it around by increments of 60 n mi in each direction. A sample of the effect of progressively increasing the grid size from 60 X 60 to 180 X 180 to 300 X 300 n mi is shown in figures 1,2, and 3. The maps presented in appendices A-G are based on the 300 × 300 n mi smoothing grid.

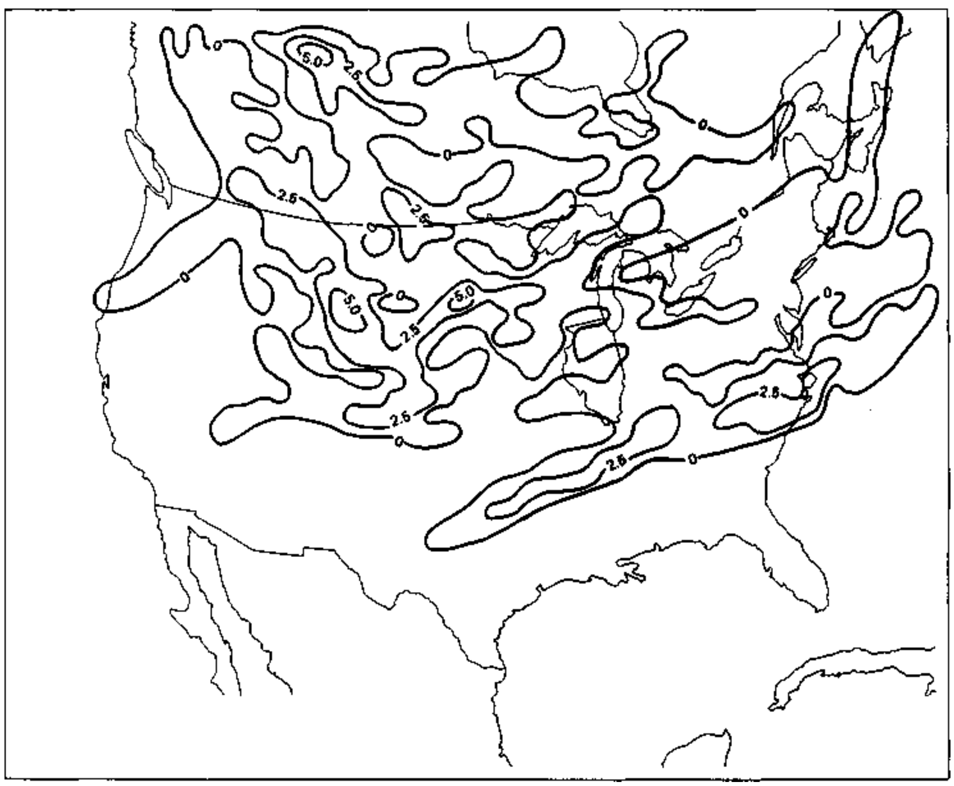

Figure 1. Frequency of stationary fronts (days), August 1971, 60 X 60 n mi grid

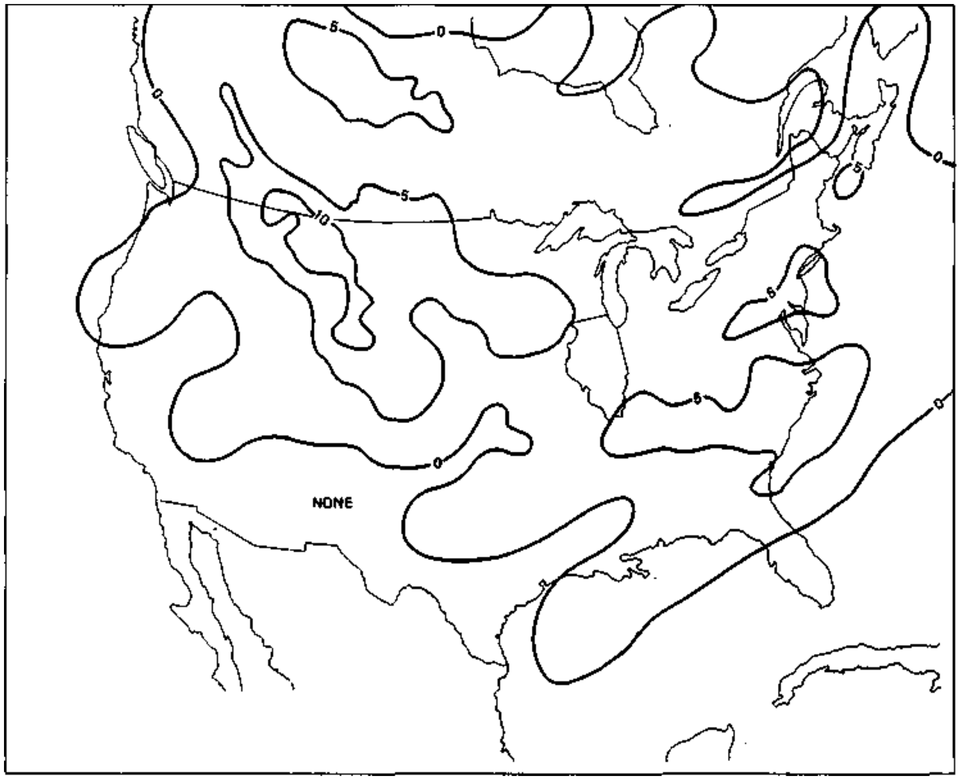

Figure 2. Frequency of stationary fronts (days), August 1971, 180 X 180 n mi grid

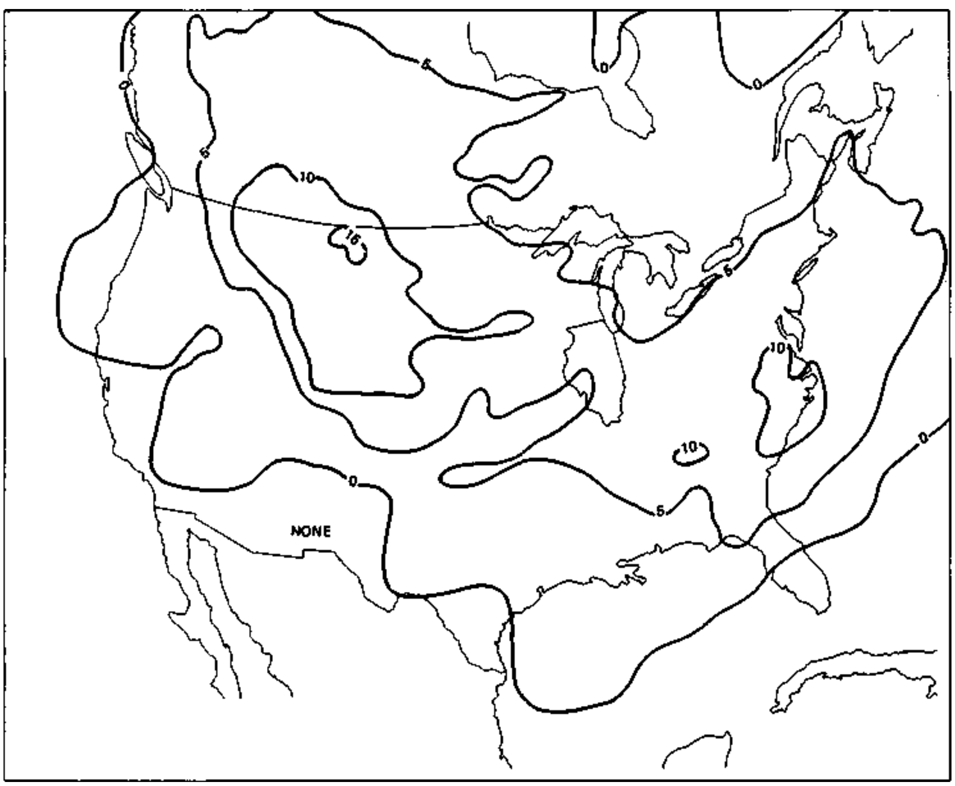

Figure 3. Frequency of stationary fronts (days), August 1971, 300 X 300 n mi grid

Comments on Interpretation

There are a number of things to be kept in mind in interpreting the maps shown here. The Daily Weather Maps are subjective synoptic analyses. Individual analysts tend to have their own emphasis, style, and degree of attention to detail. It is probable that at times fronts exist which are not indicated on the map, and the reverse may also happen. Fronts can also on occasion be improperly identified (a slow cold front may be labeled as a stationary front or even a warm front). Squall lines and cold fronts can also be confused. On occasion fronts are placed on maps just to explain some weather which shortly disappears and the front with it. An experienced analyst understands this and can make allowances for it. To undertake critical re-analysis of 10 years of weather maps is out of the question and would not really alter the situation. In spite of these subjective factors, the long series of maps employed here should provide meaningful and useful results.

The easiest maps to interpret are those of stationary fronts. In general a pronounced belt of maximum stationary front occurrence can be observed. The region of this belt can be considered as one where the leading edges of southward surges of cold air tend to 'stall out.' Most frequently cold air lies to the north of this belt and warm air to the south of it.

Squall lines are the least meaningful elements in the map series because of the morning map times, the short lifetimes of these phenomena, and the difficulty of defining squall lines with synoptic data.

Interpretation of the geographical distributions of frequency of moving frontal systems is less straightforward and requires study. High frequency of occurrence of, say, cold fronts can be due to 1) lower speed of translation through the region than through neighboring regions, 2) high frequency of frontogenesis in and near the region, and 3) analysis quirks. The inverse of 1) and 2) would apply to regions of low frequency.

References

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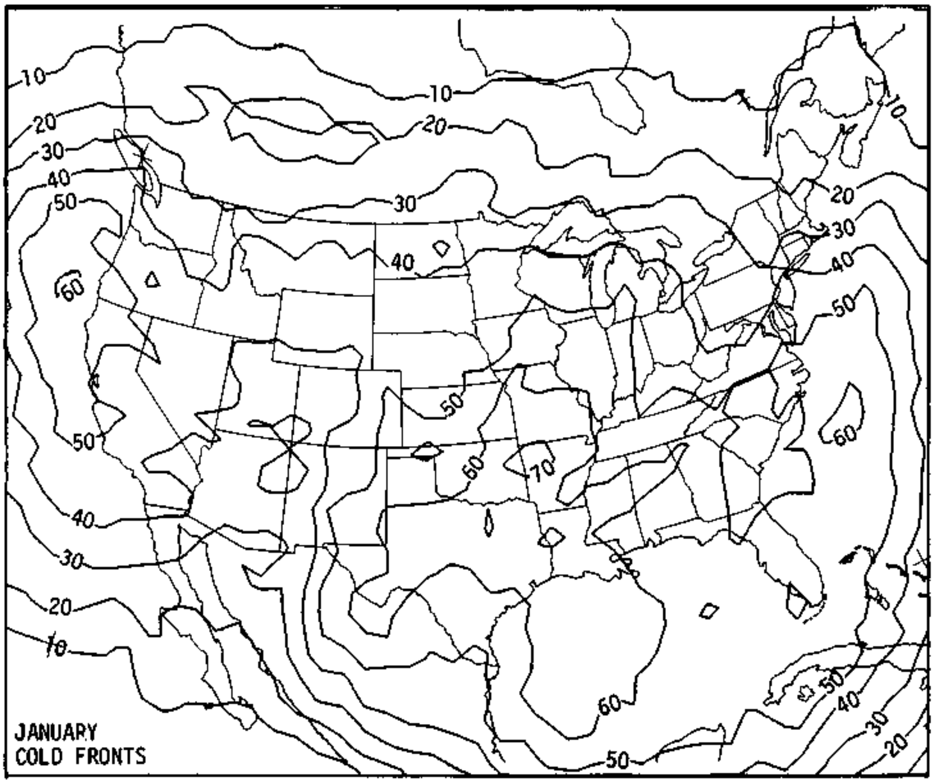
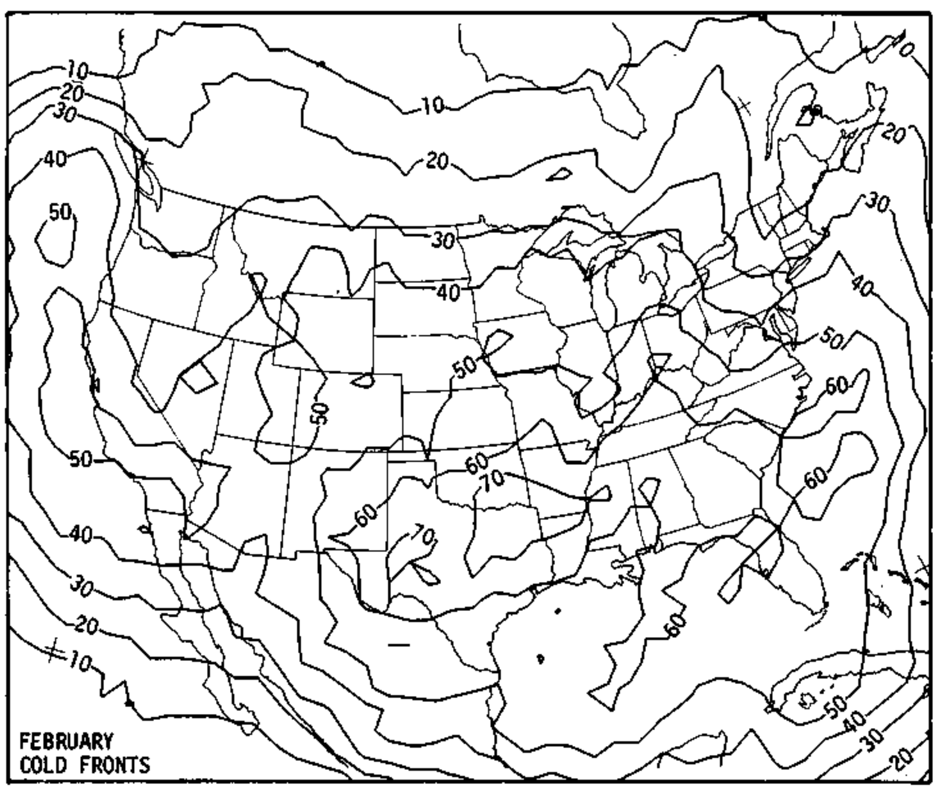
Appendix A. Frequency of Cold Fronts, in Days per 10 Years





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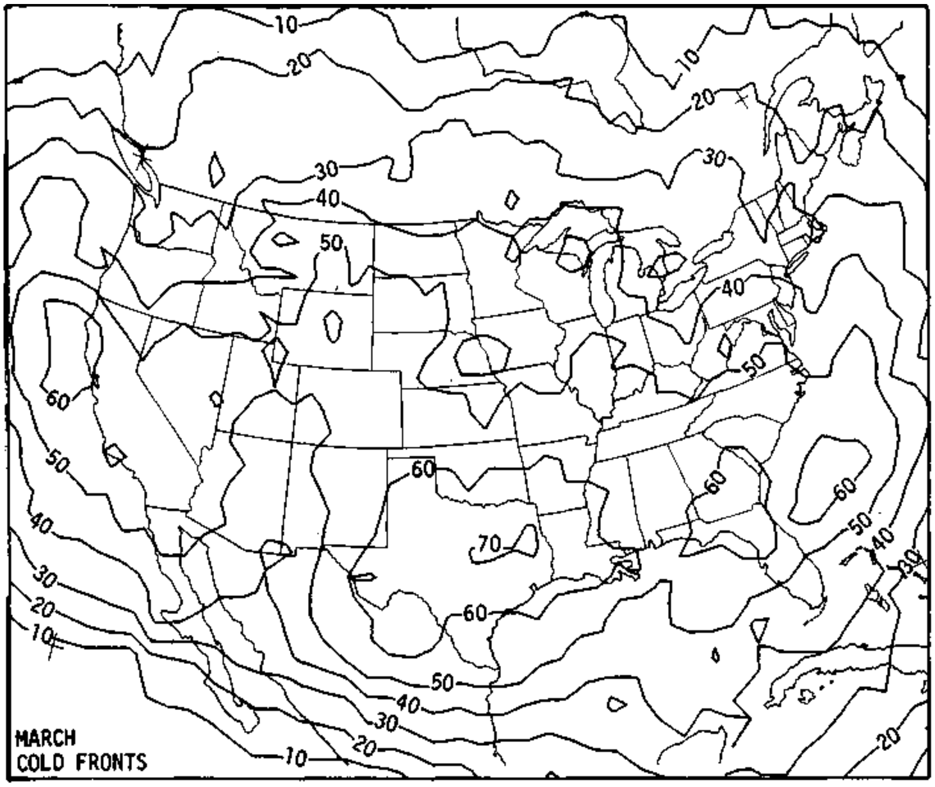

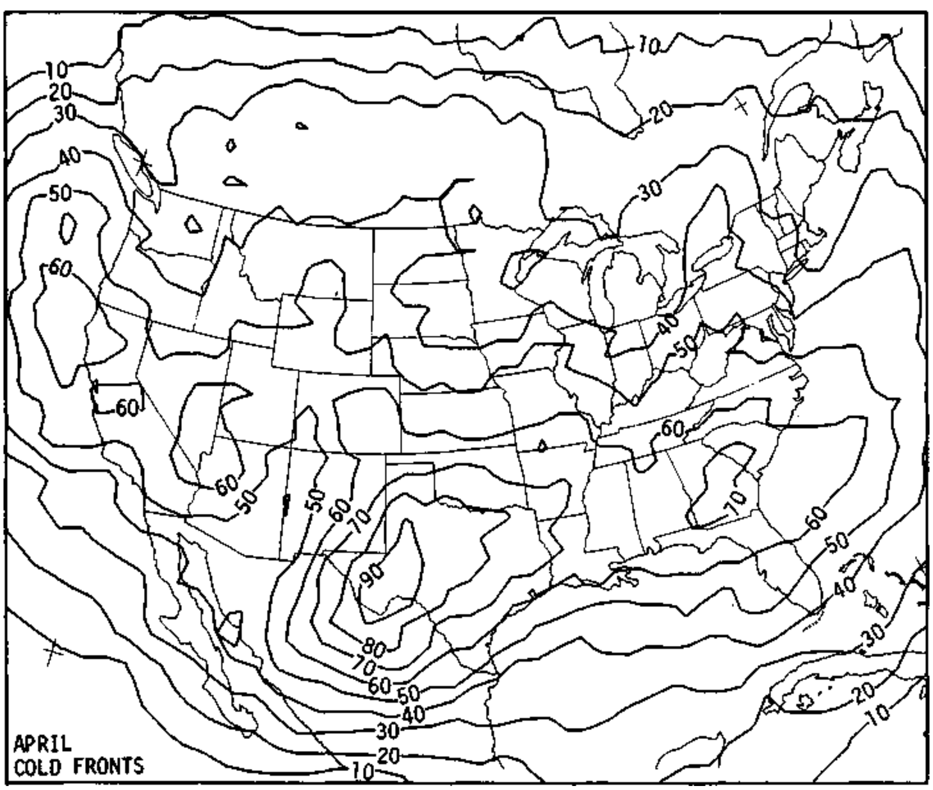

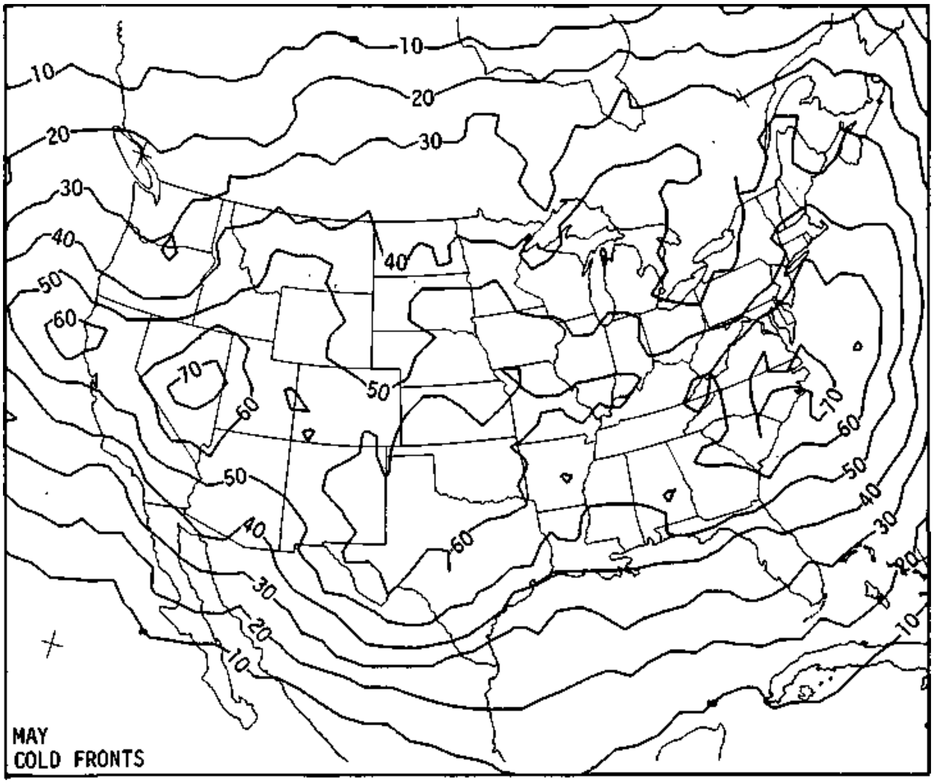
MAY
COLD FRONTS
10
20
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40
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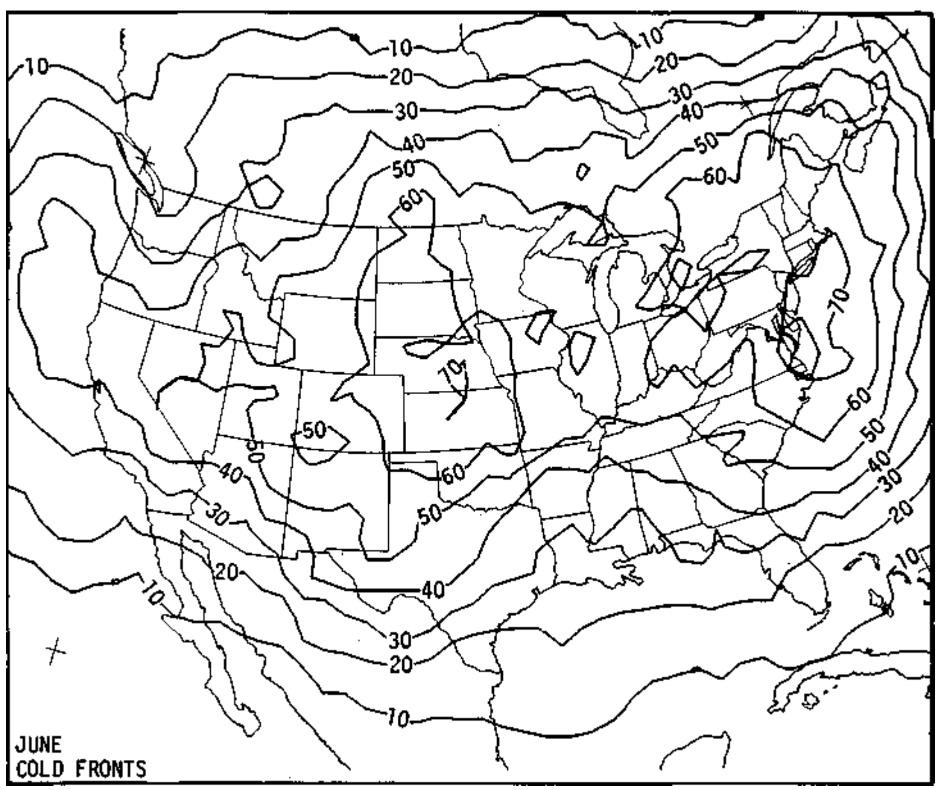
60
70


JUNE
COLD FRONTS
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20
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40
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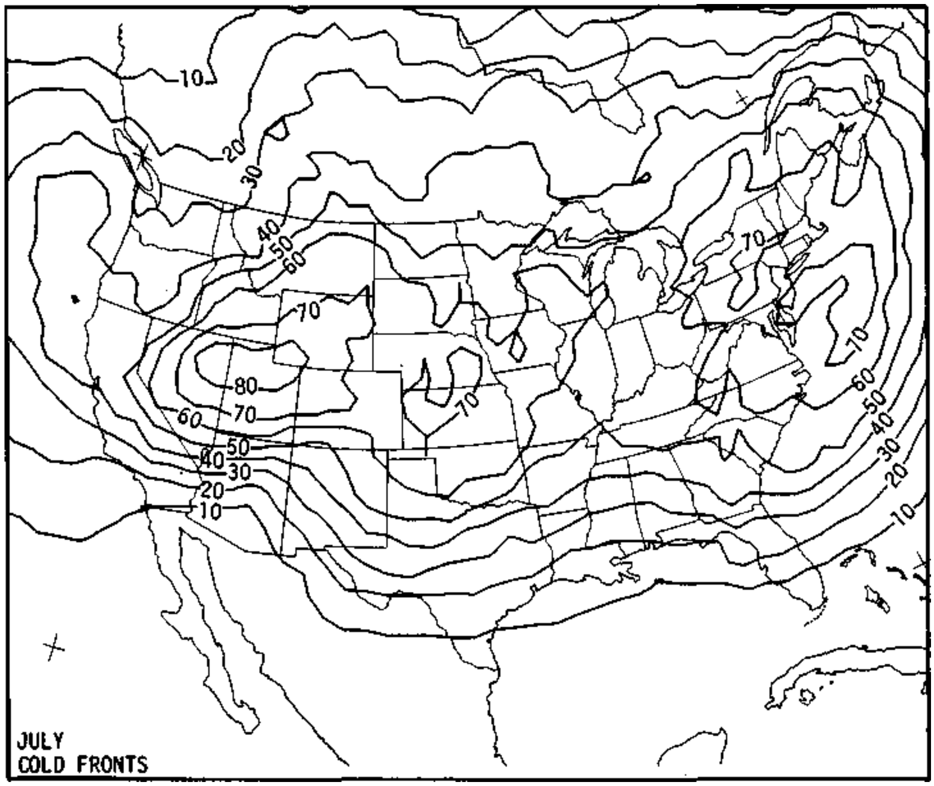
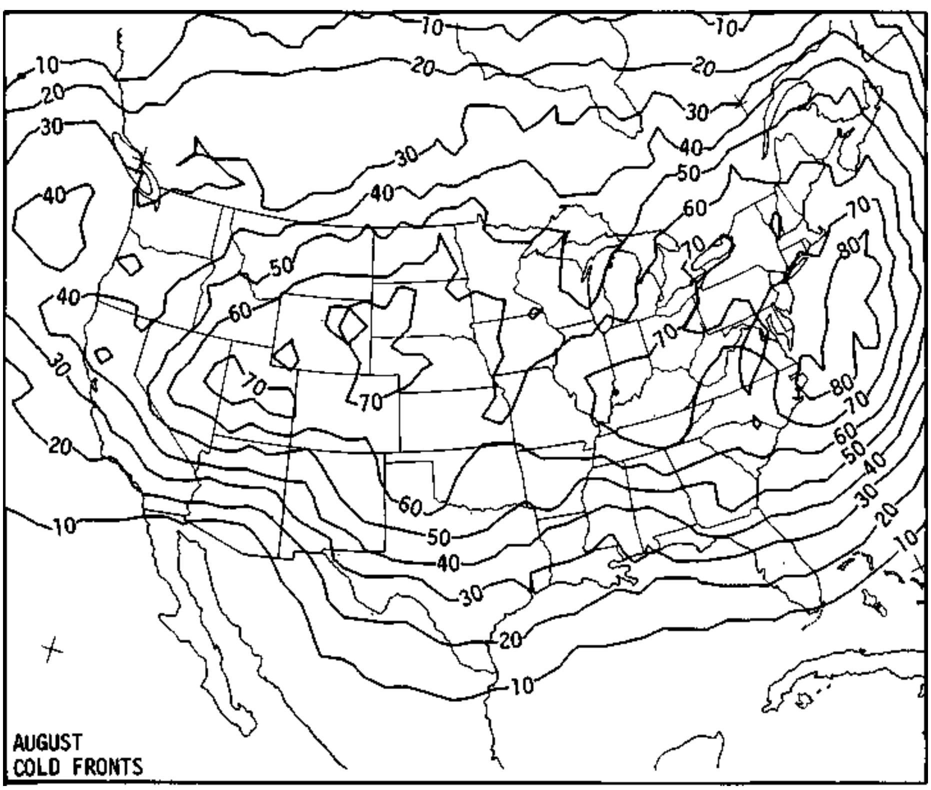
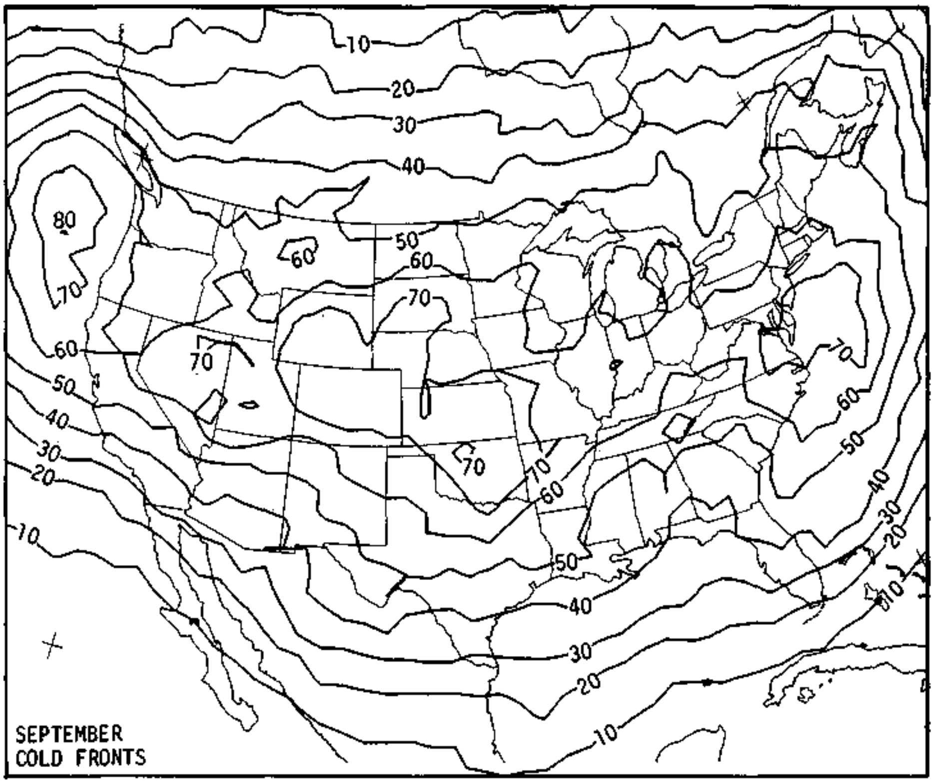
60
70

A. Cold Fronts



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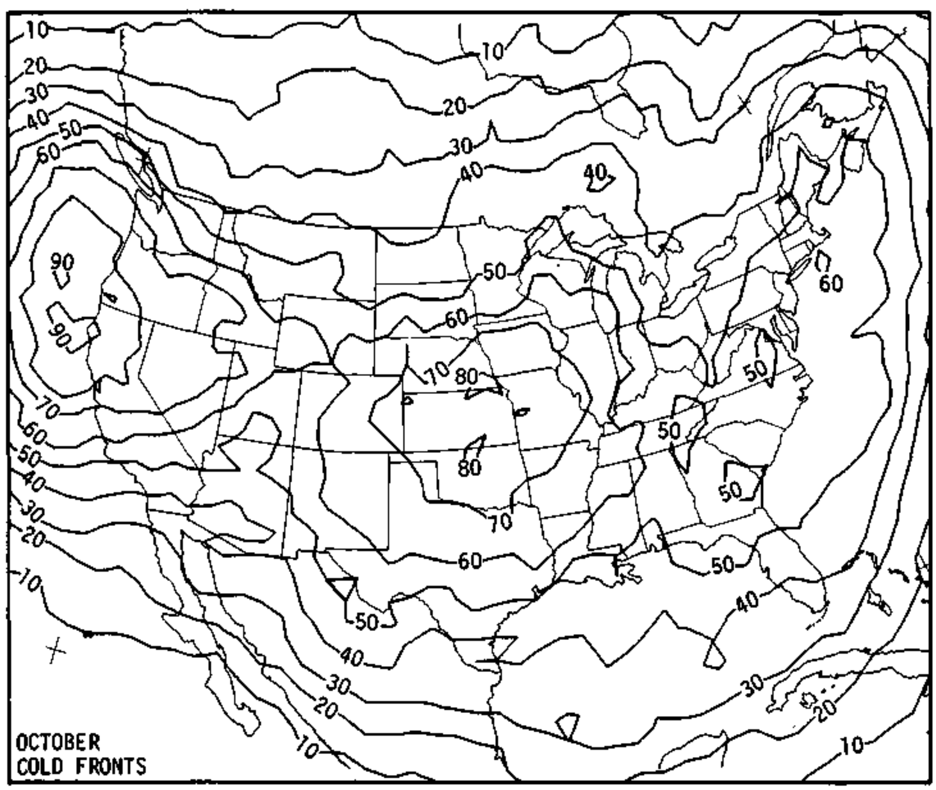
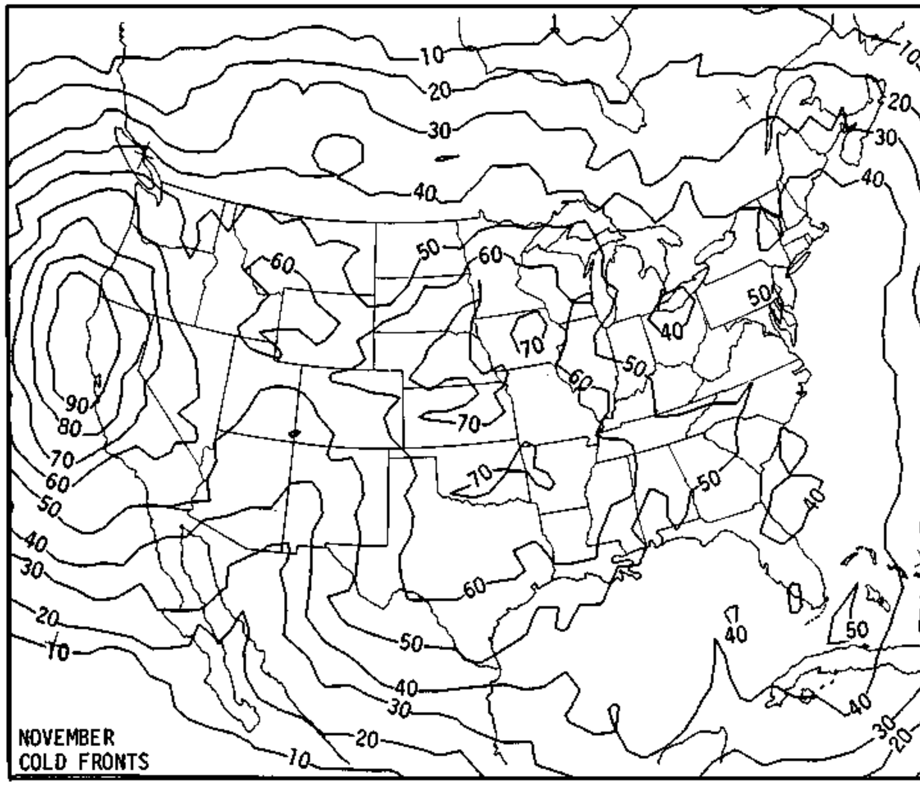
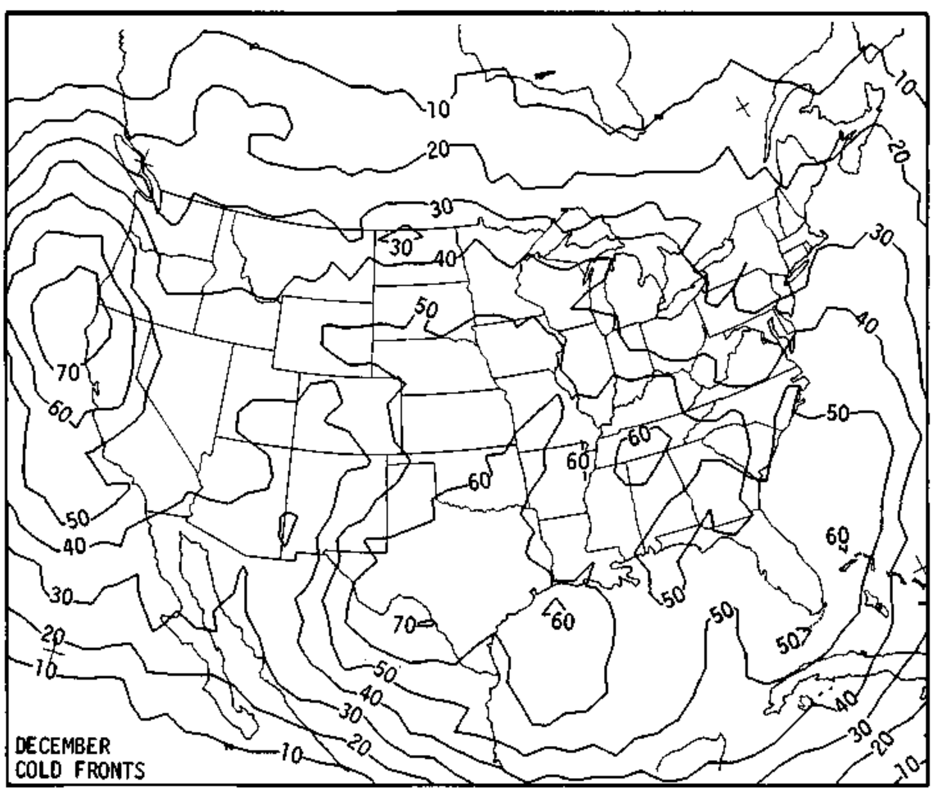
COLD FRONTS

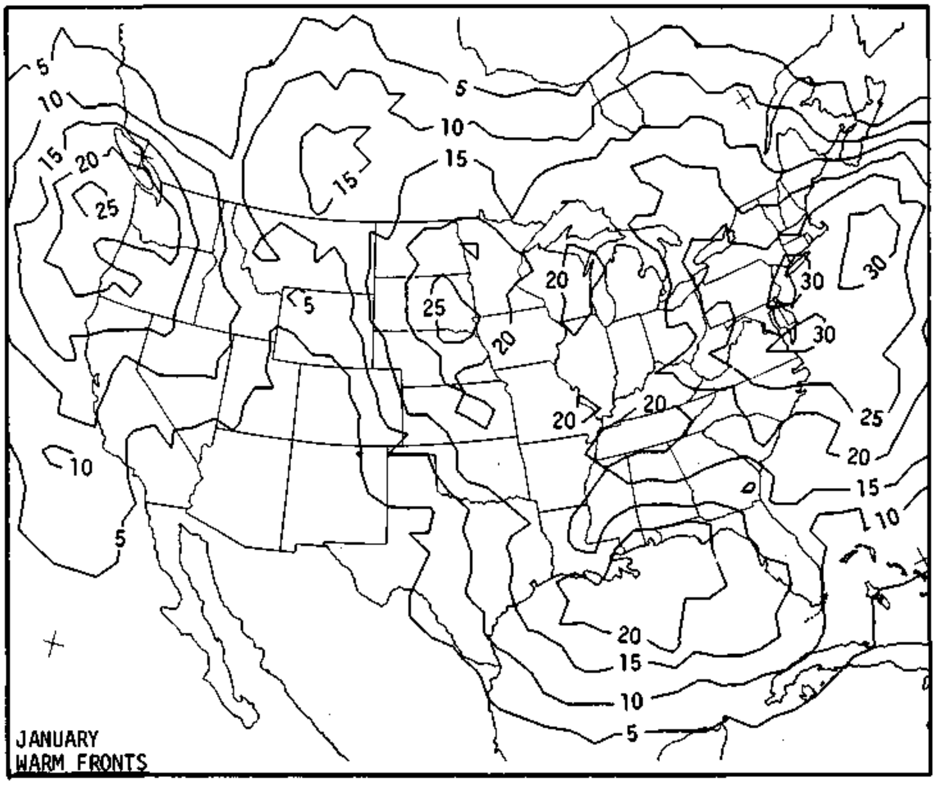

OCTOBER
COLD FRONTS

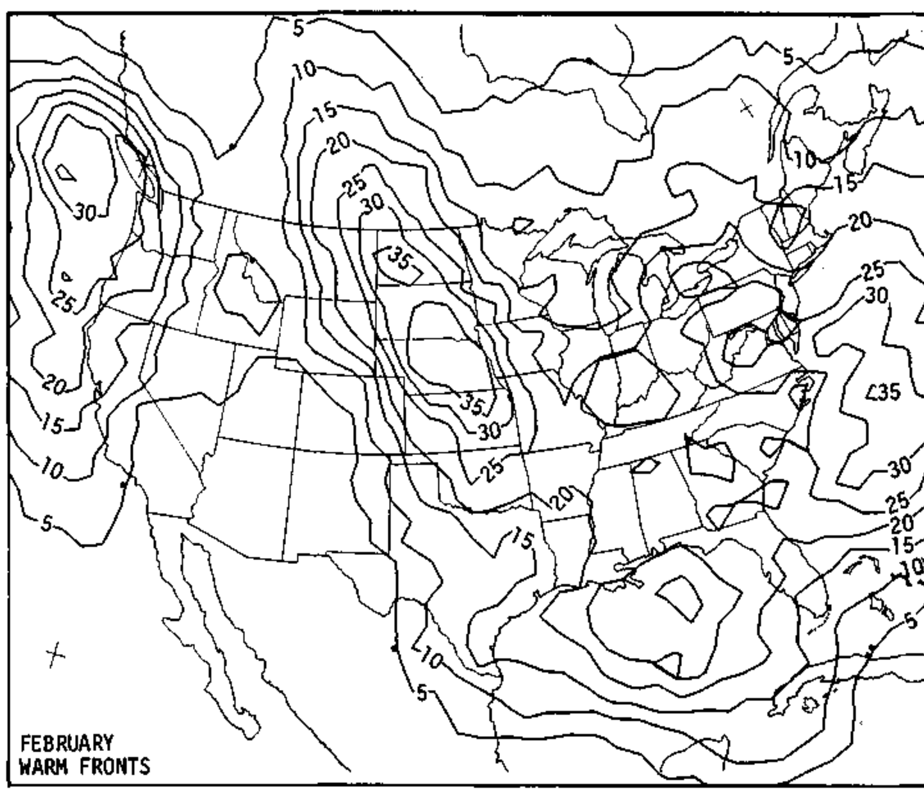
A. Cold Fronts





Appendix B. Frequency of Warm Fronts, in Days per 10 Years





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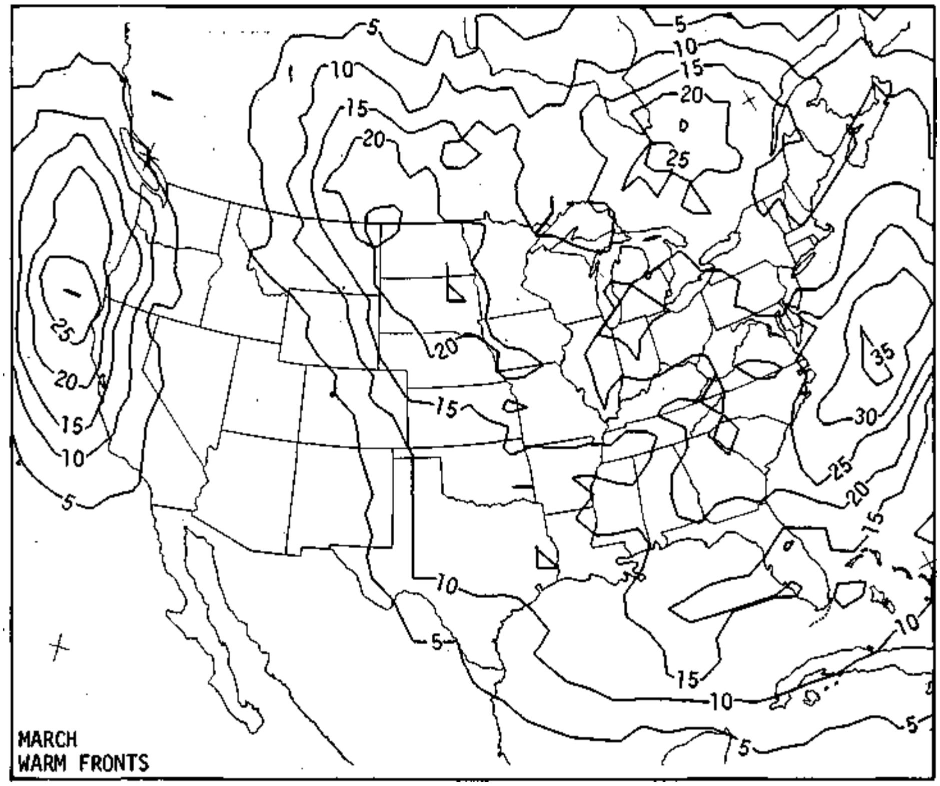

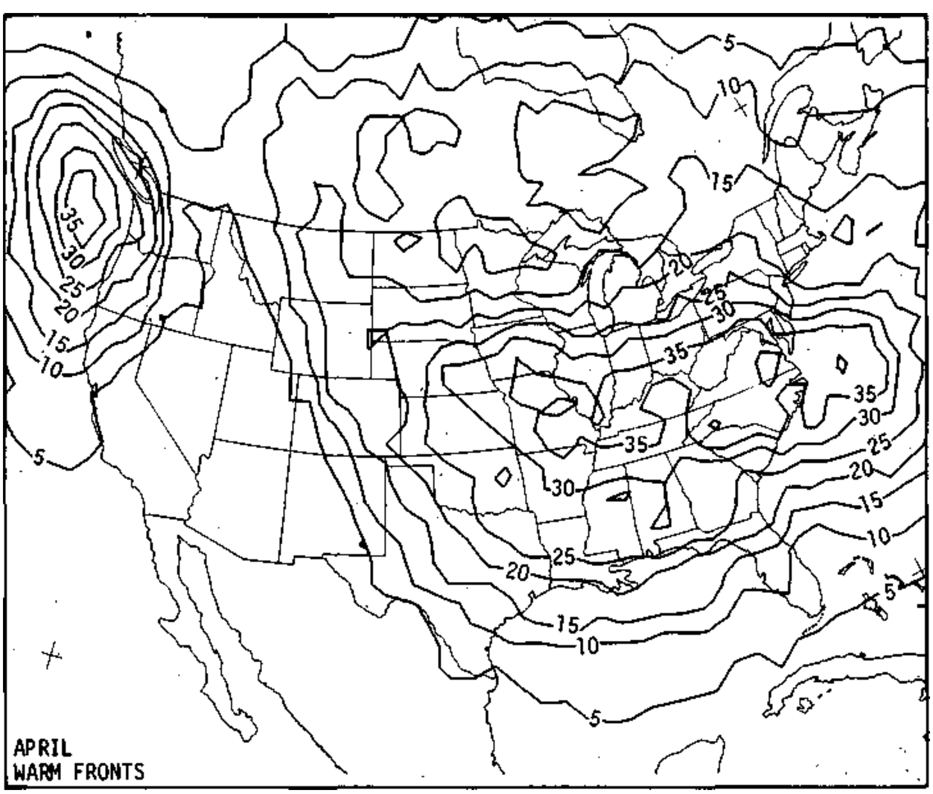

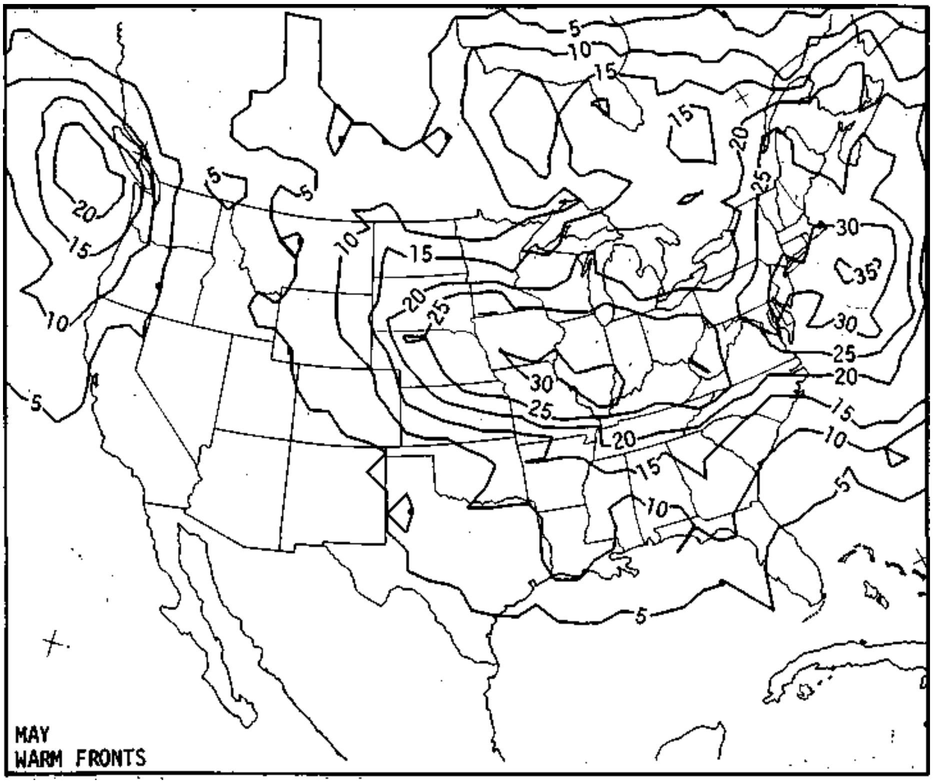
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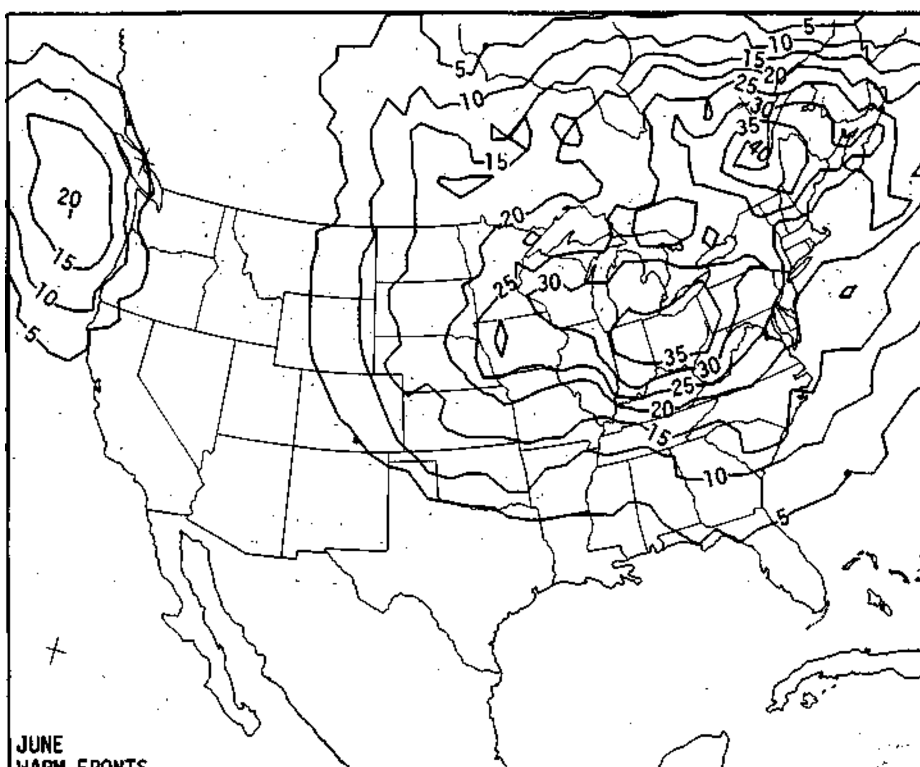
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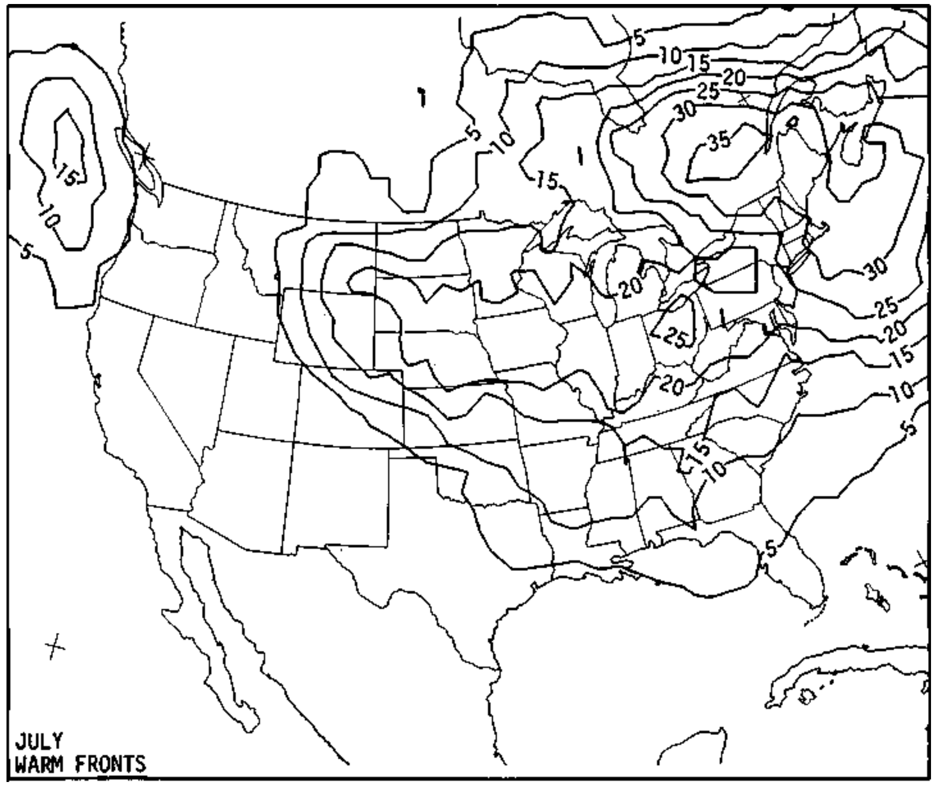
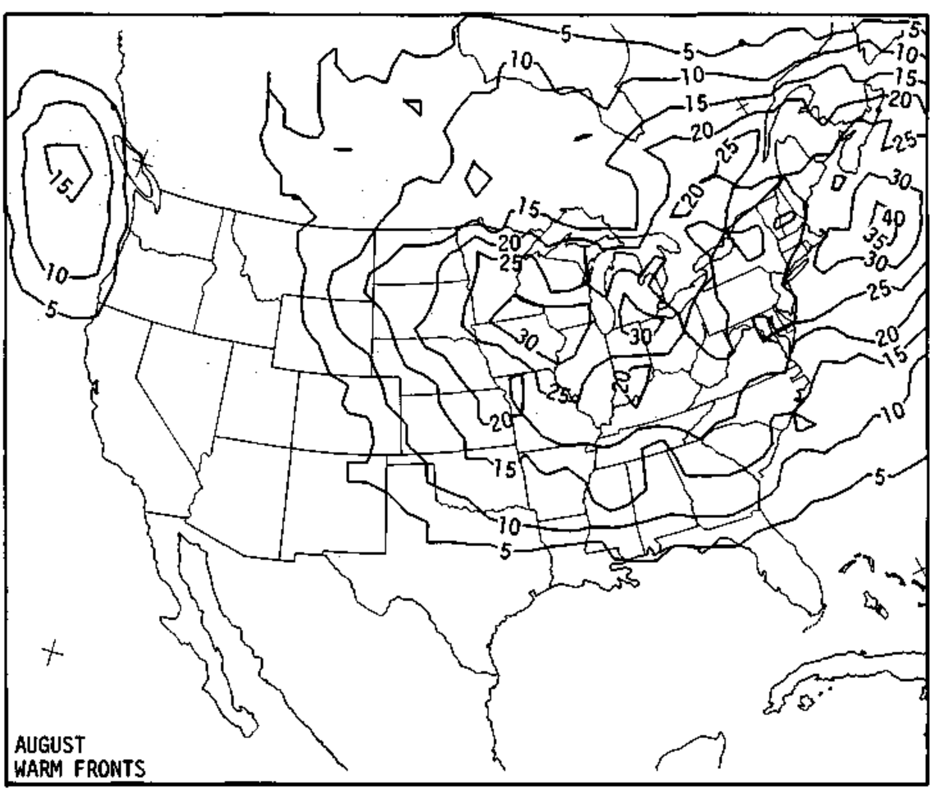
WARM FRONTS

B. Warm Fronts





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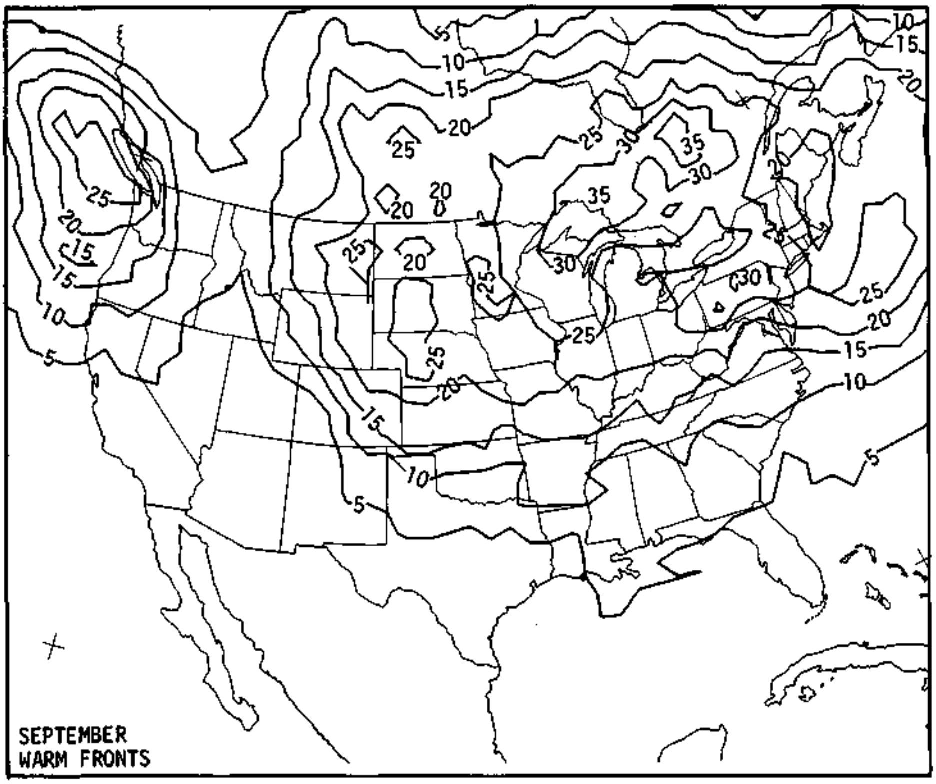

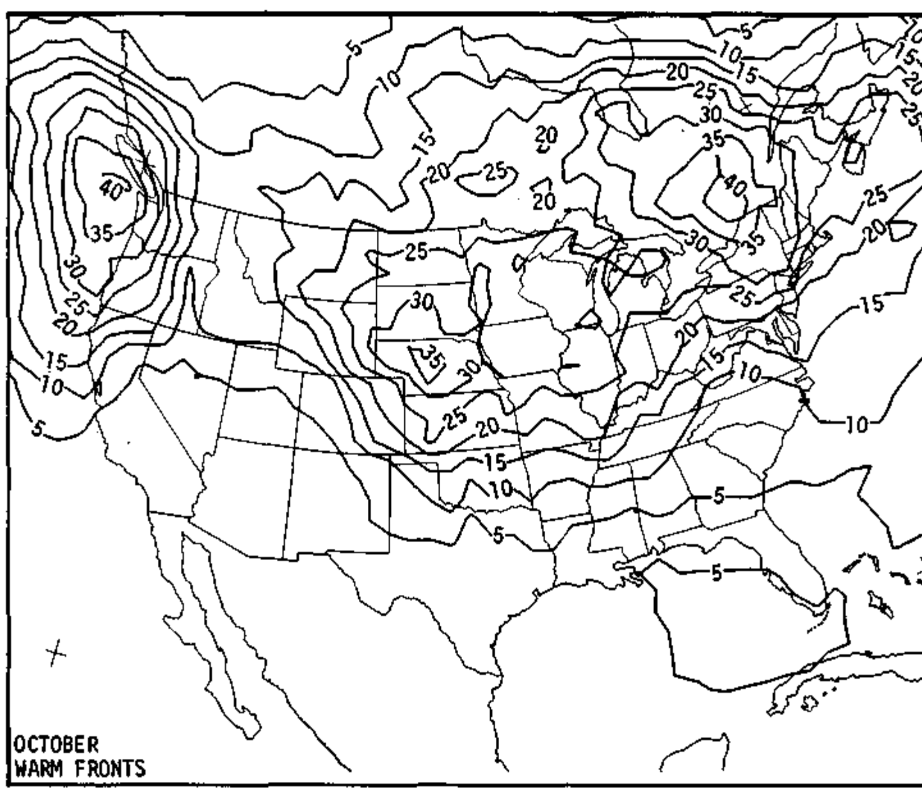

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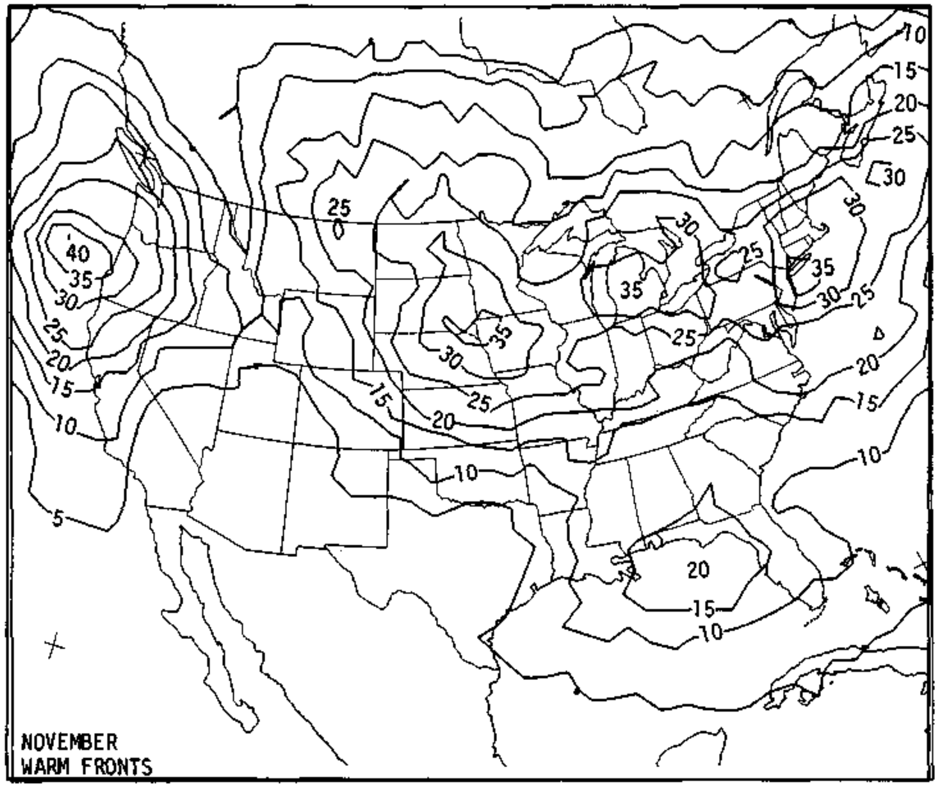
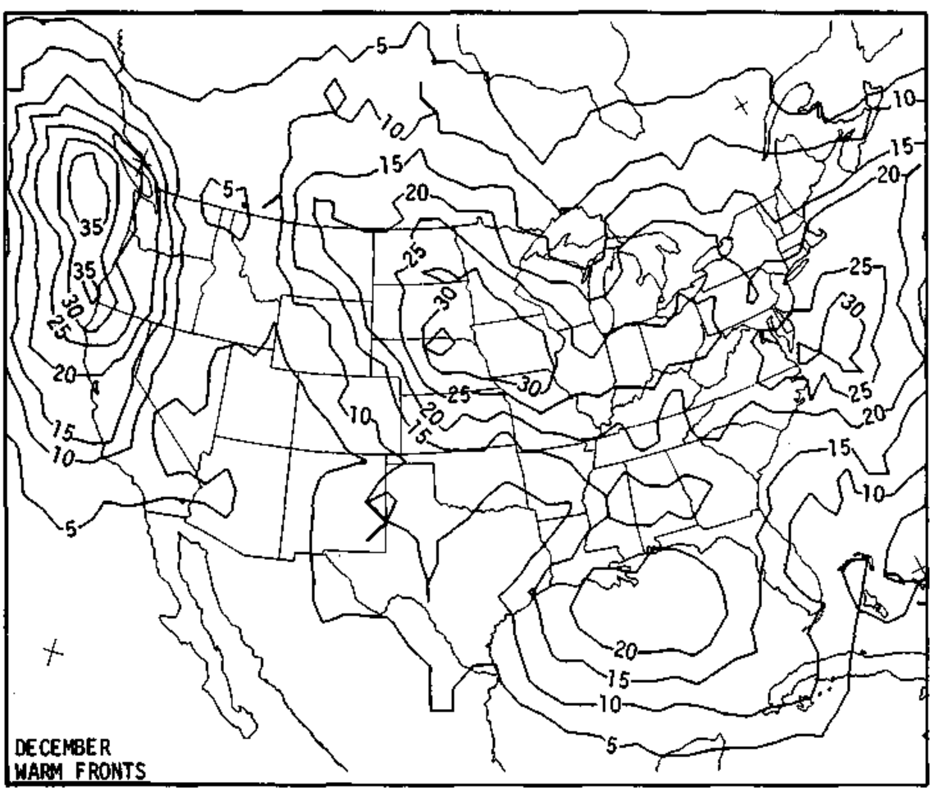
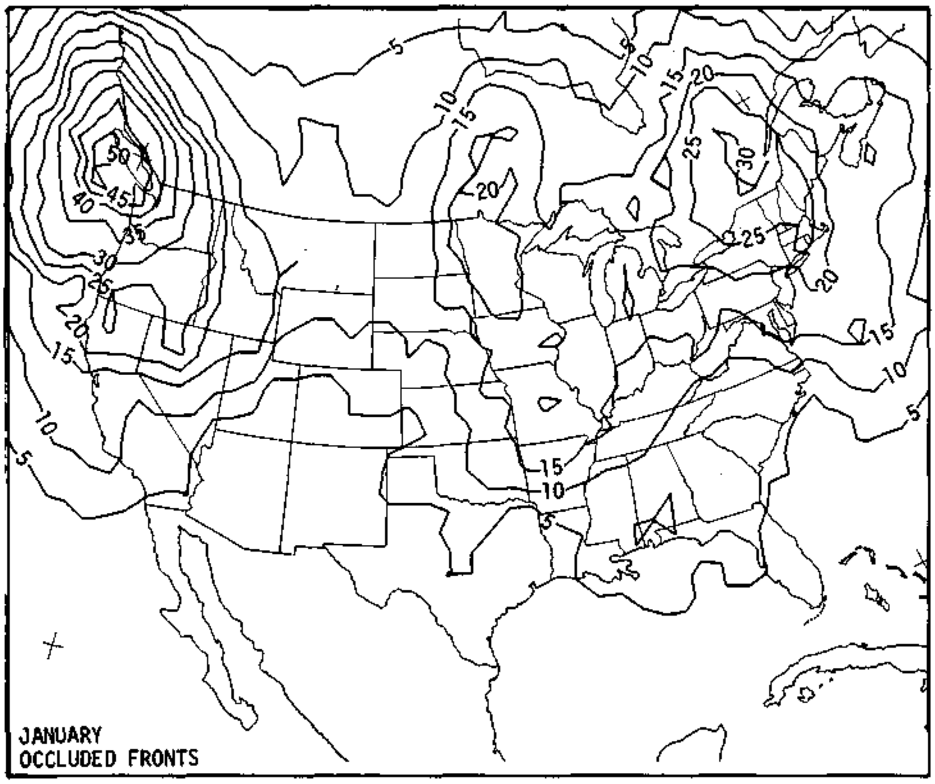
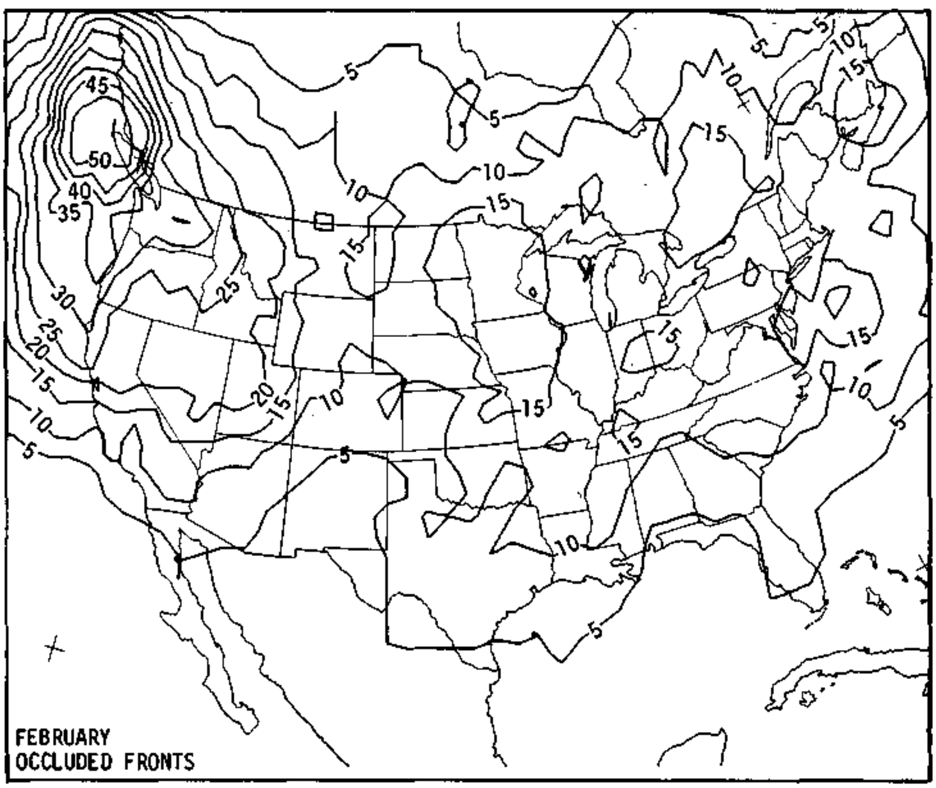




Appendix C. Frequency of Occluded Fronts, in Days per 10 Years





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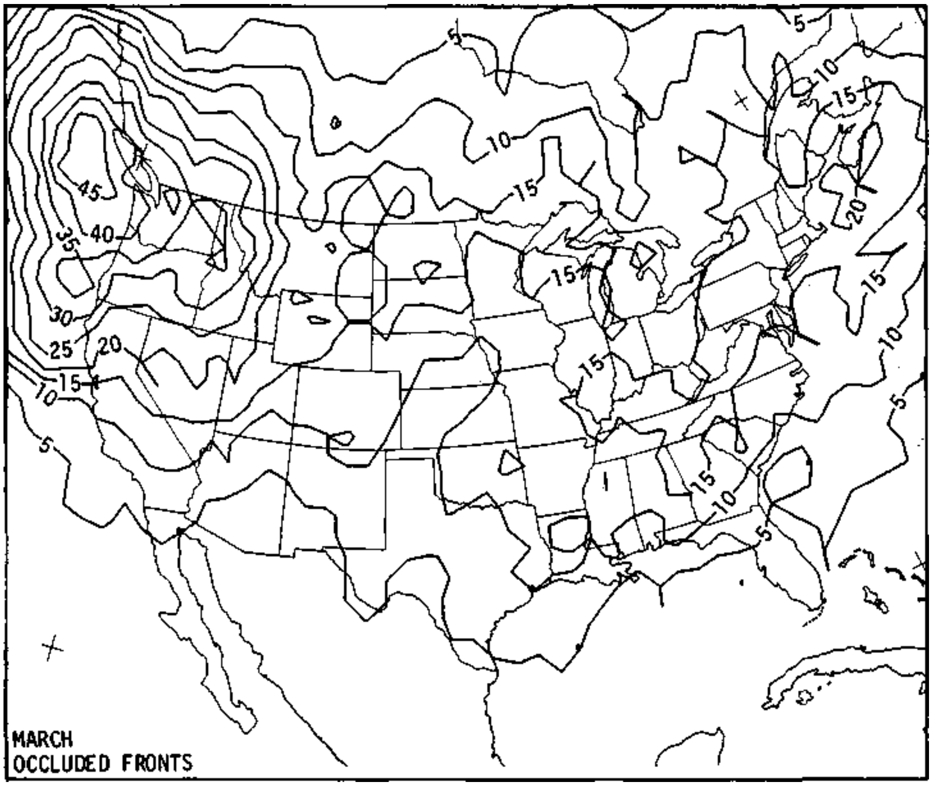

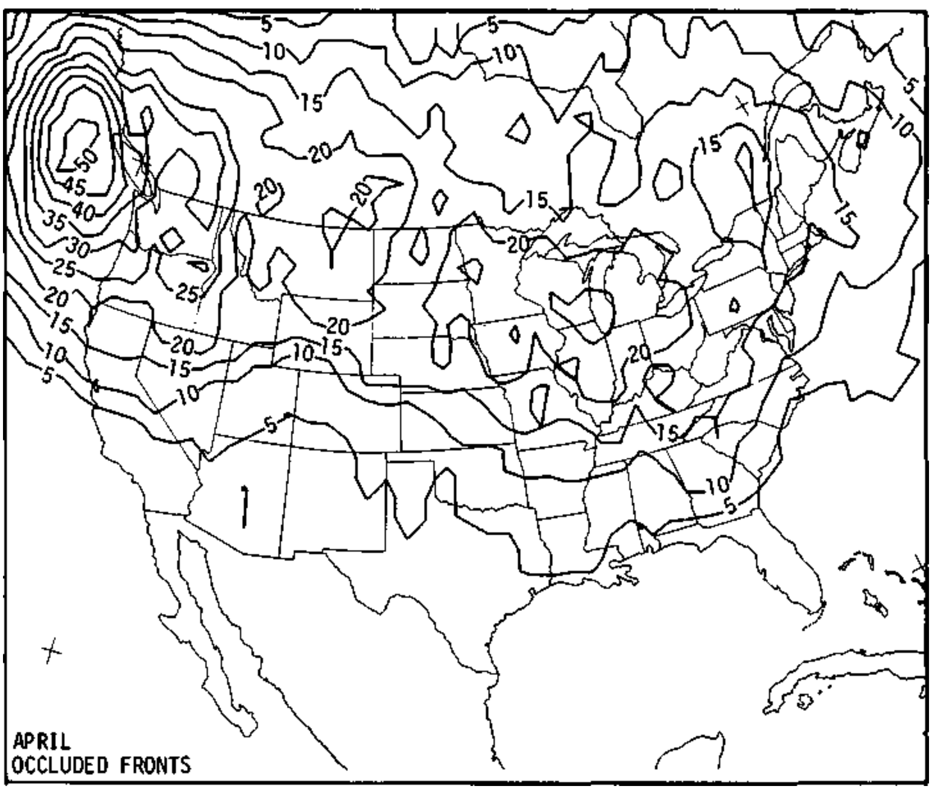

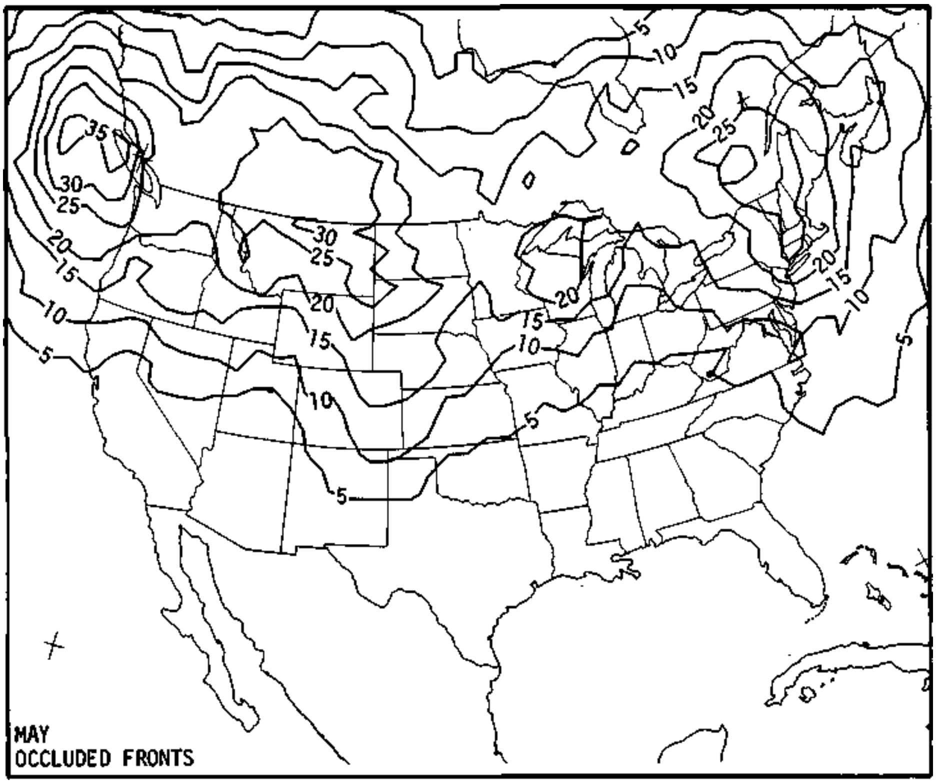
MAY
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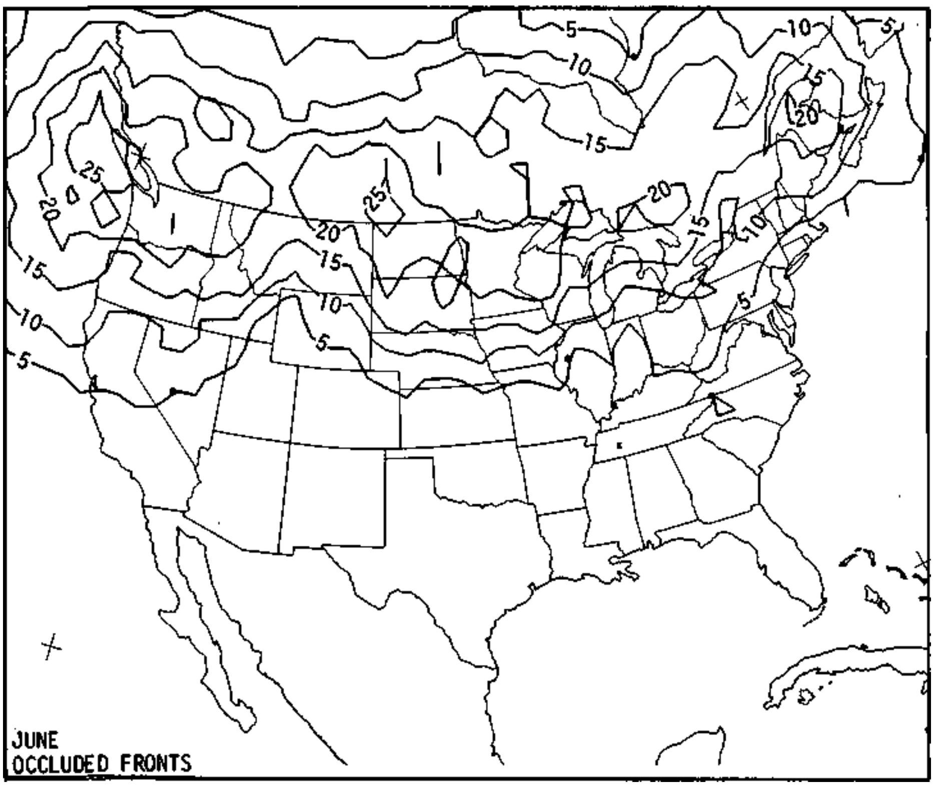
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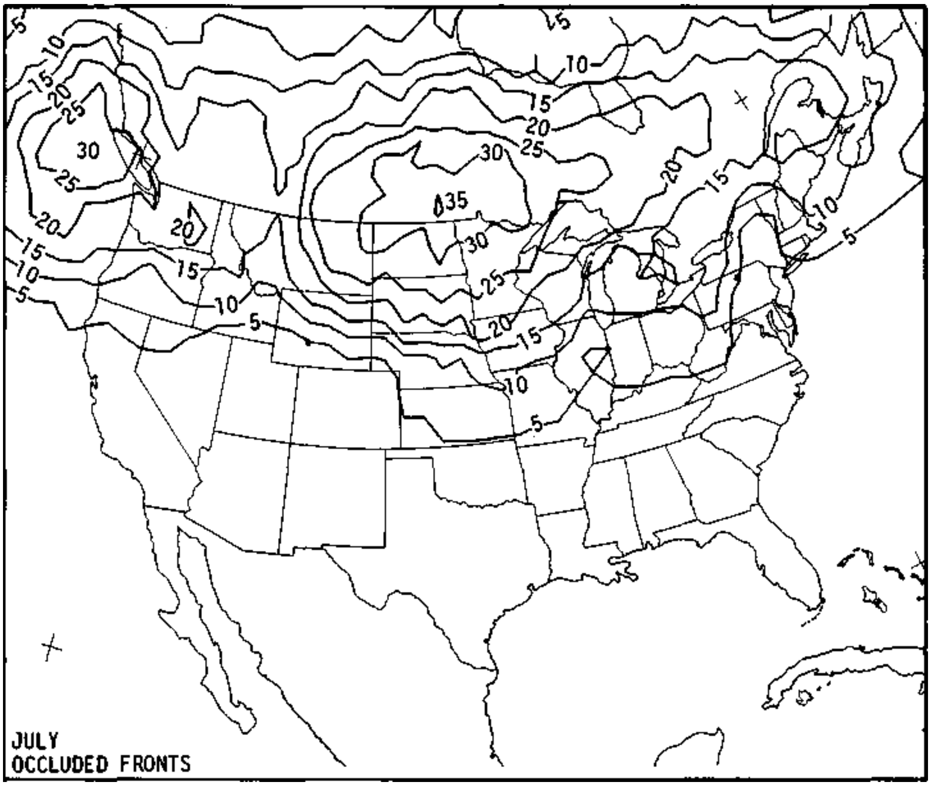
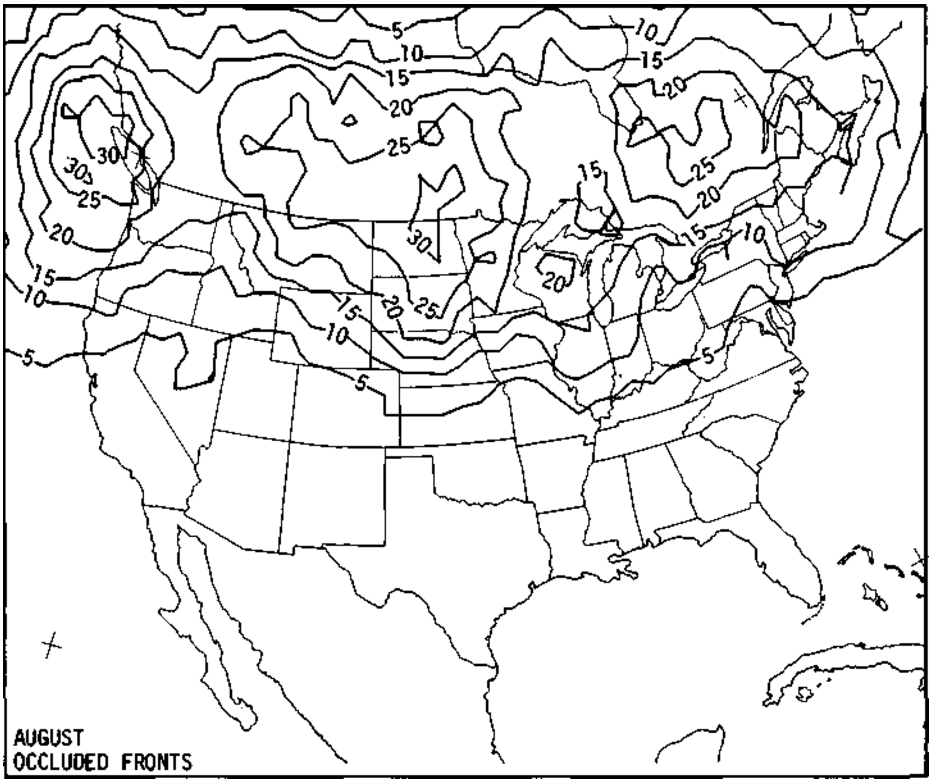
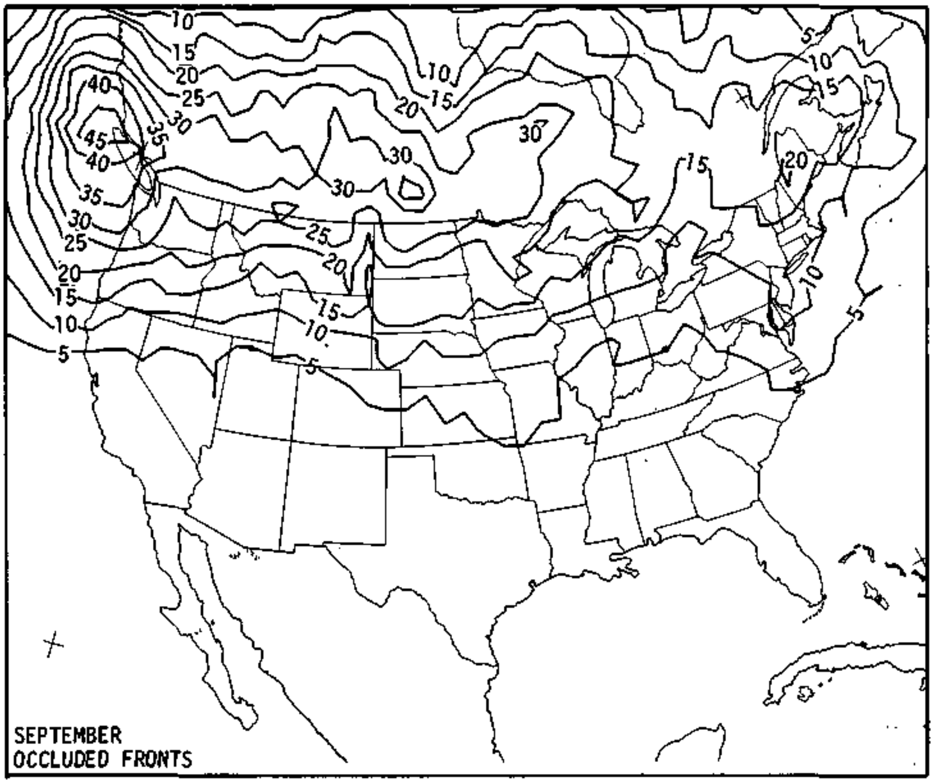
OCCLUDED FRONTS

C. Occluded Fronts






SEPTEMBER
OCCLUDED FRONTS
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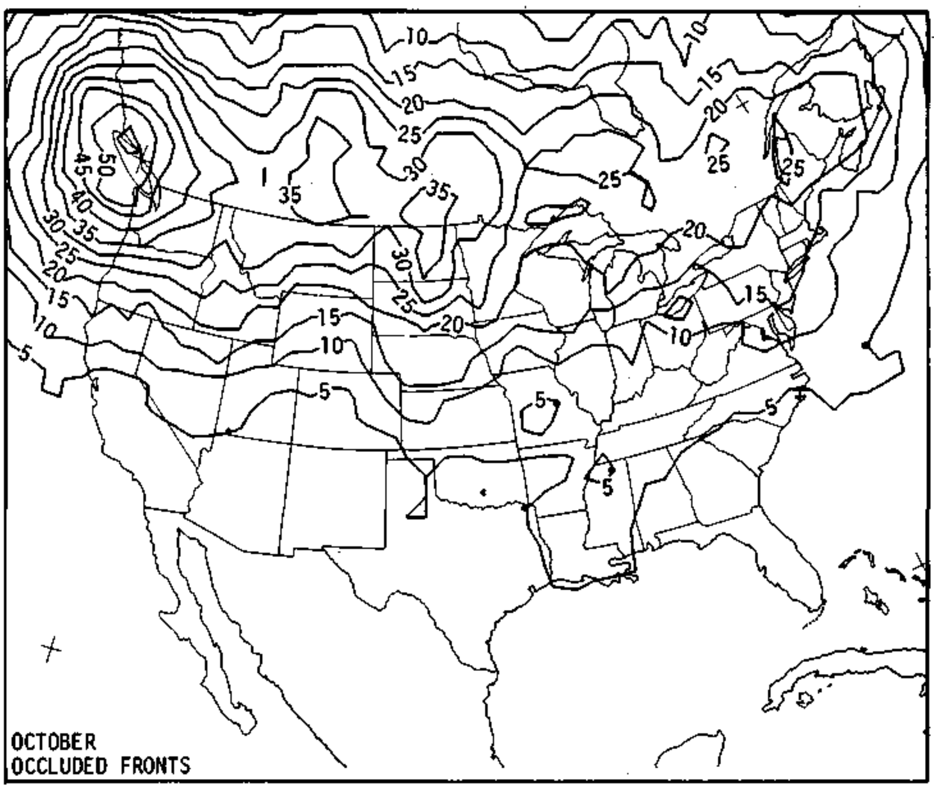
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OCCLUDED FRONTS
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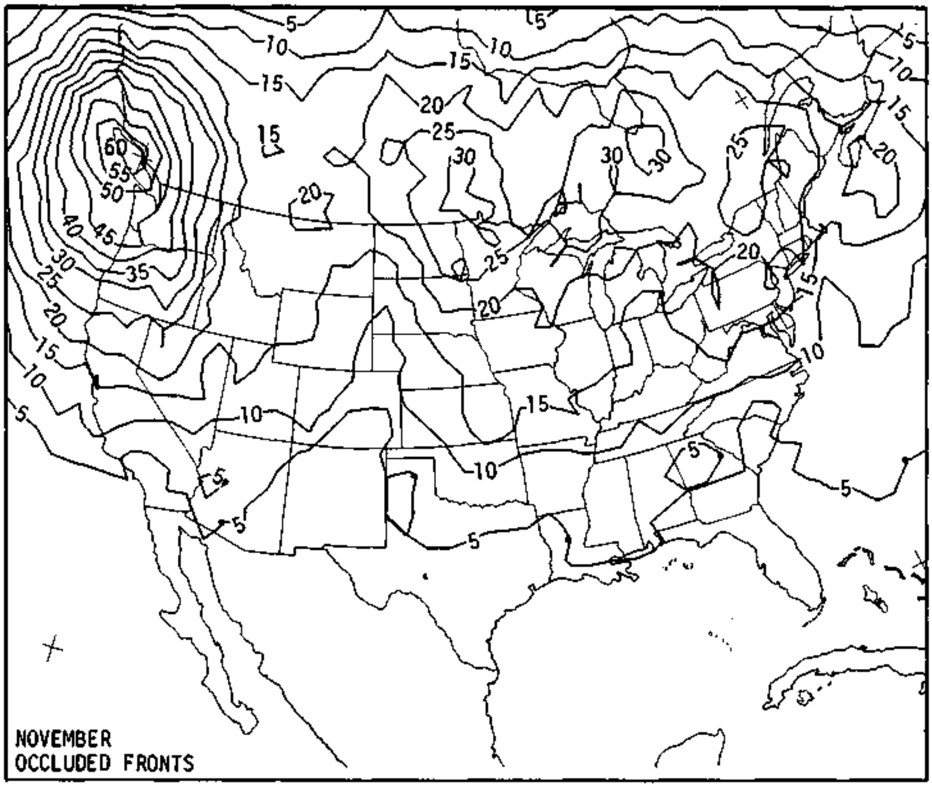
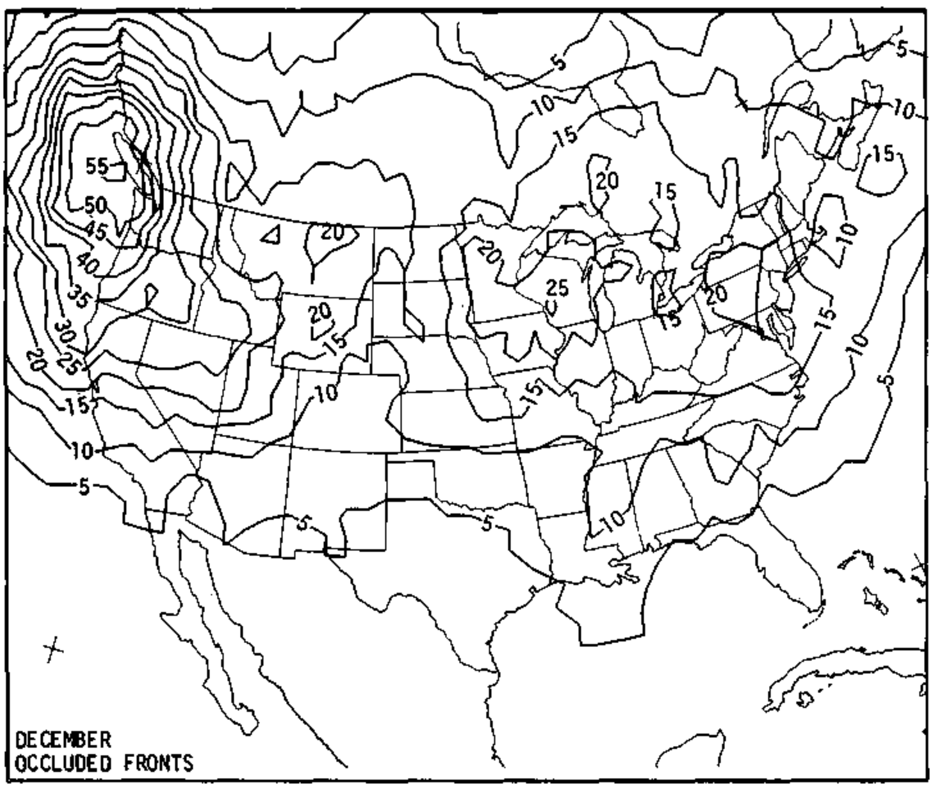
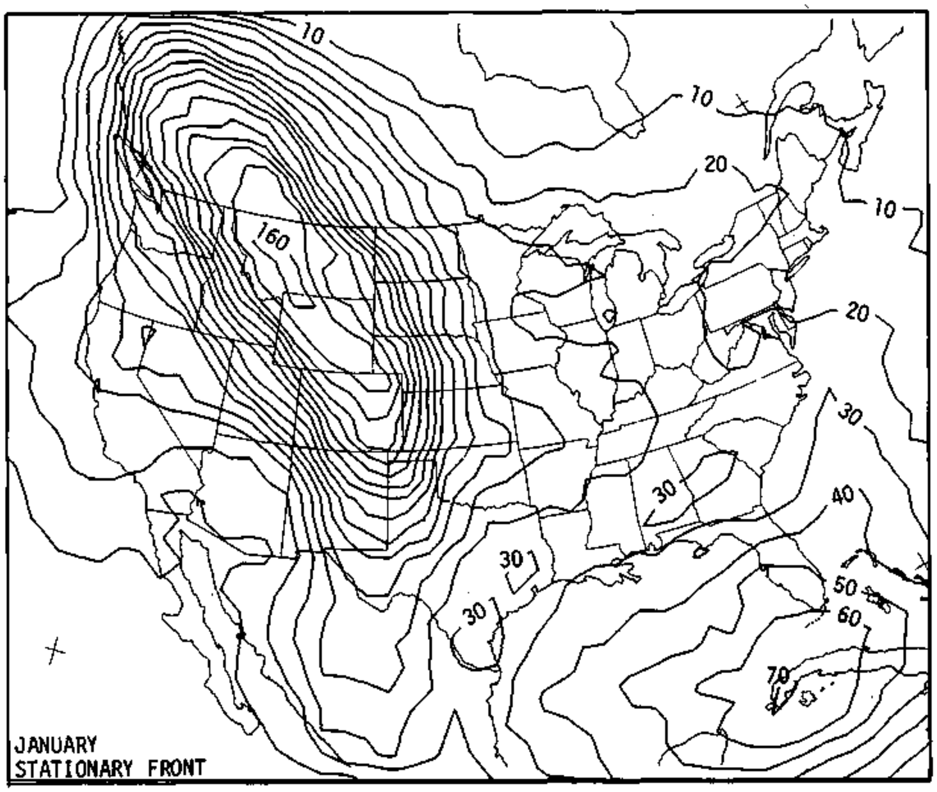
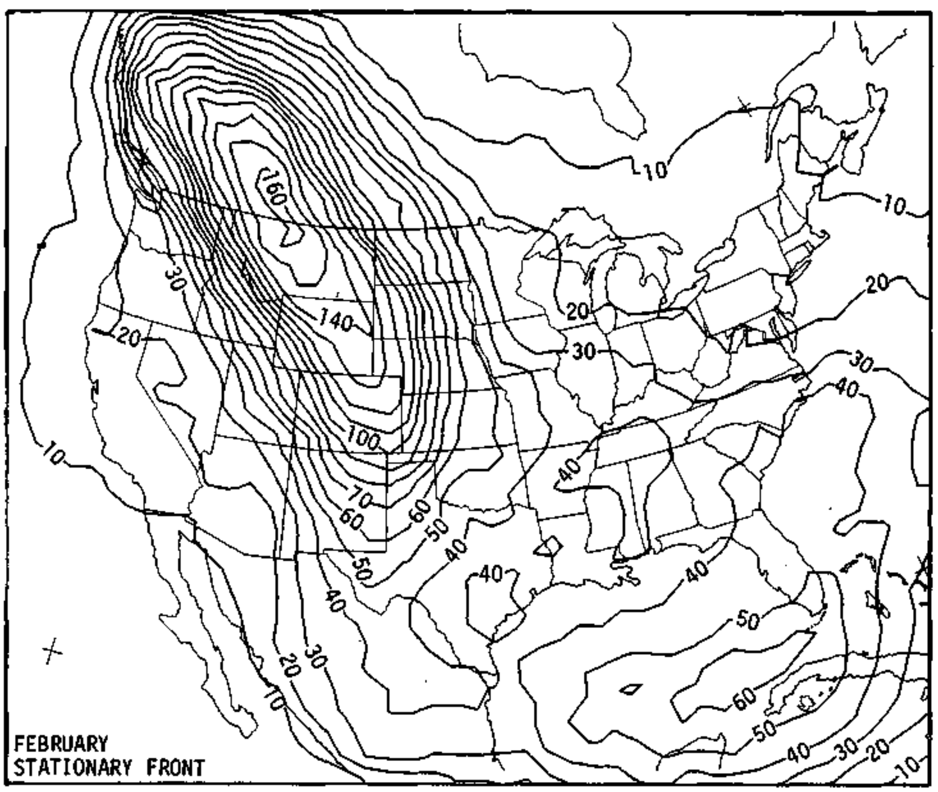
C. Occluded Fronts



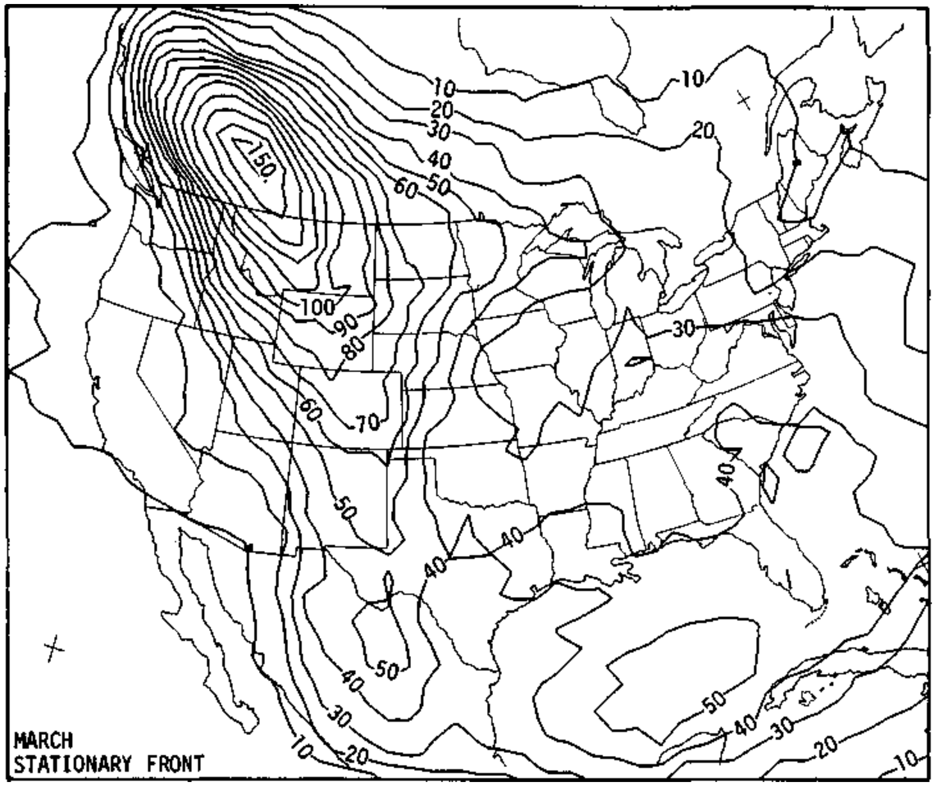


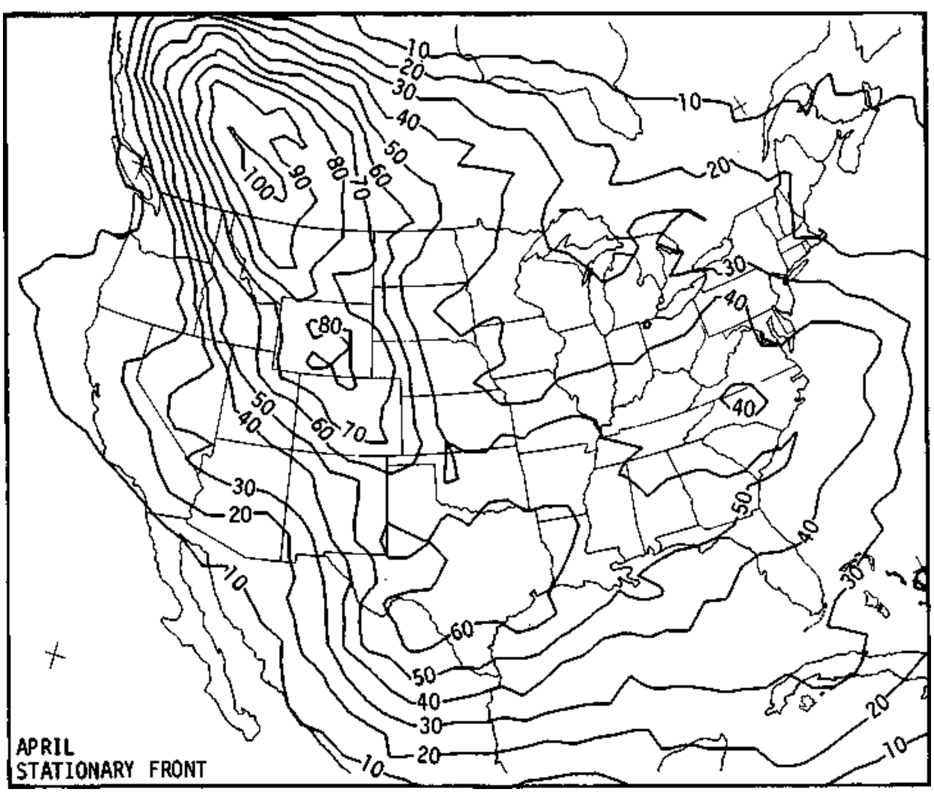
Appendix D. Frequency of Stationary Fronts, in Days per 10 Years

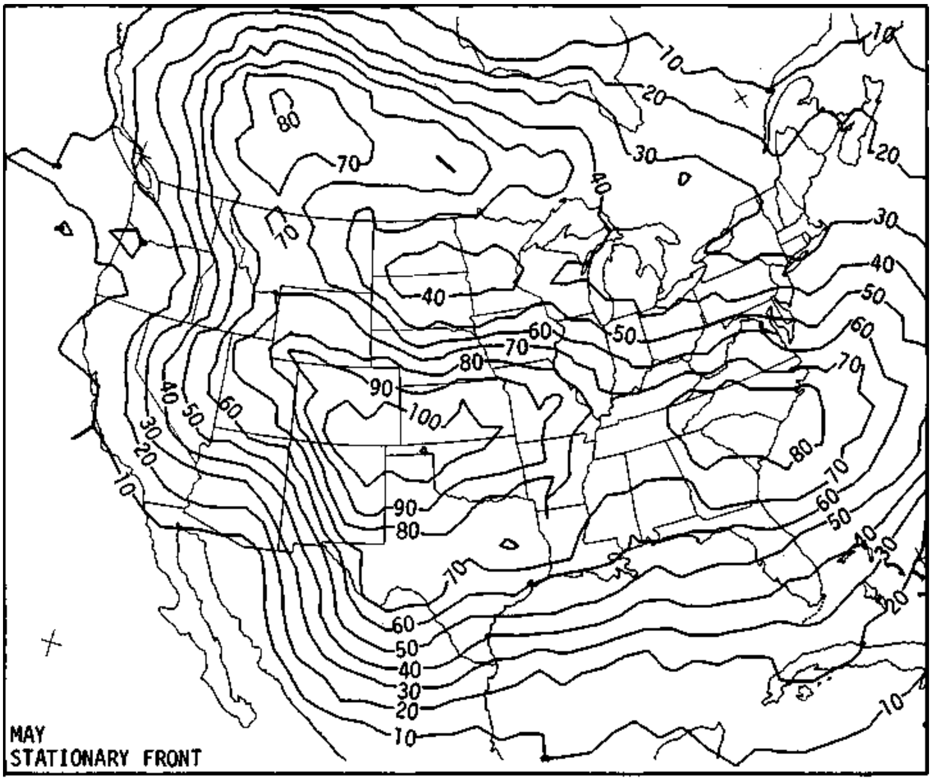




D. Stationary Fronts



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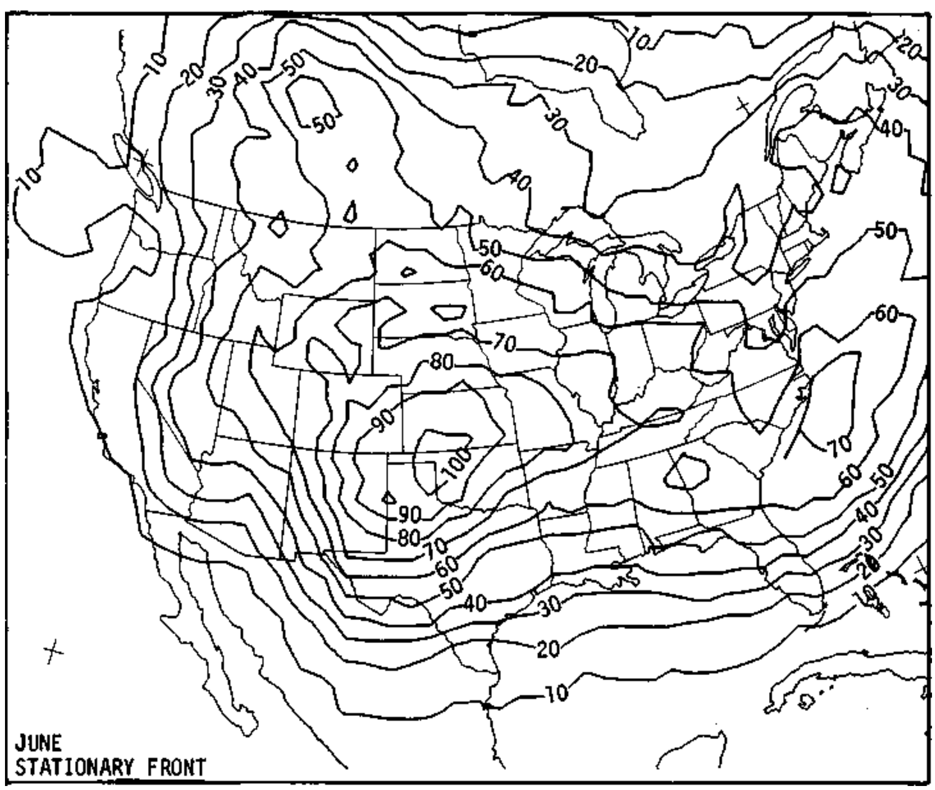
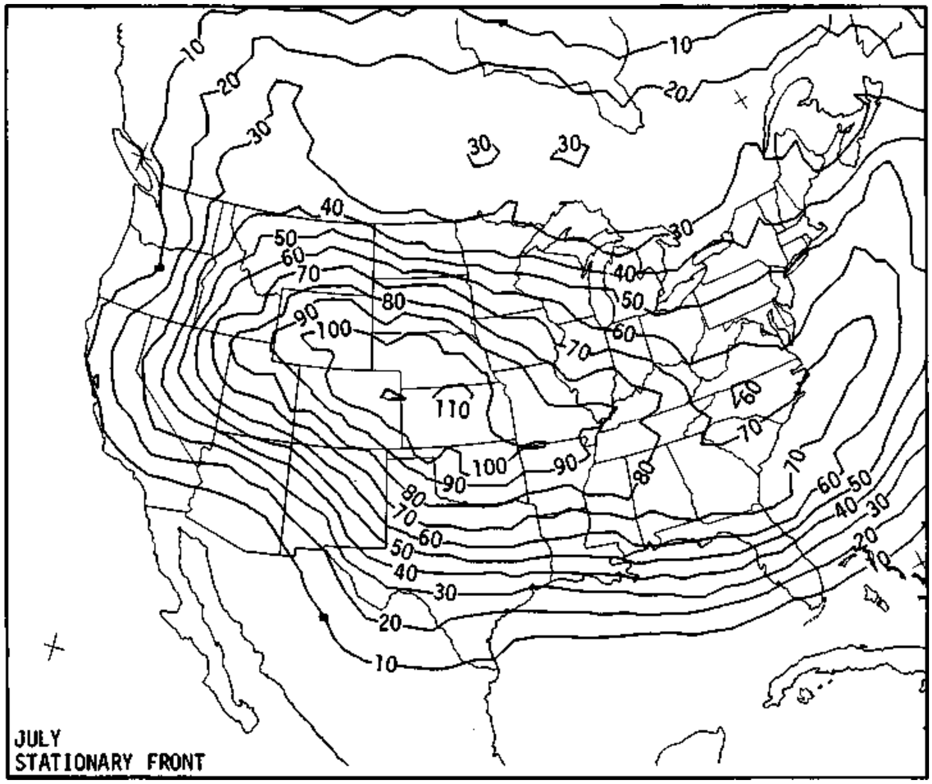
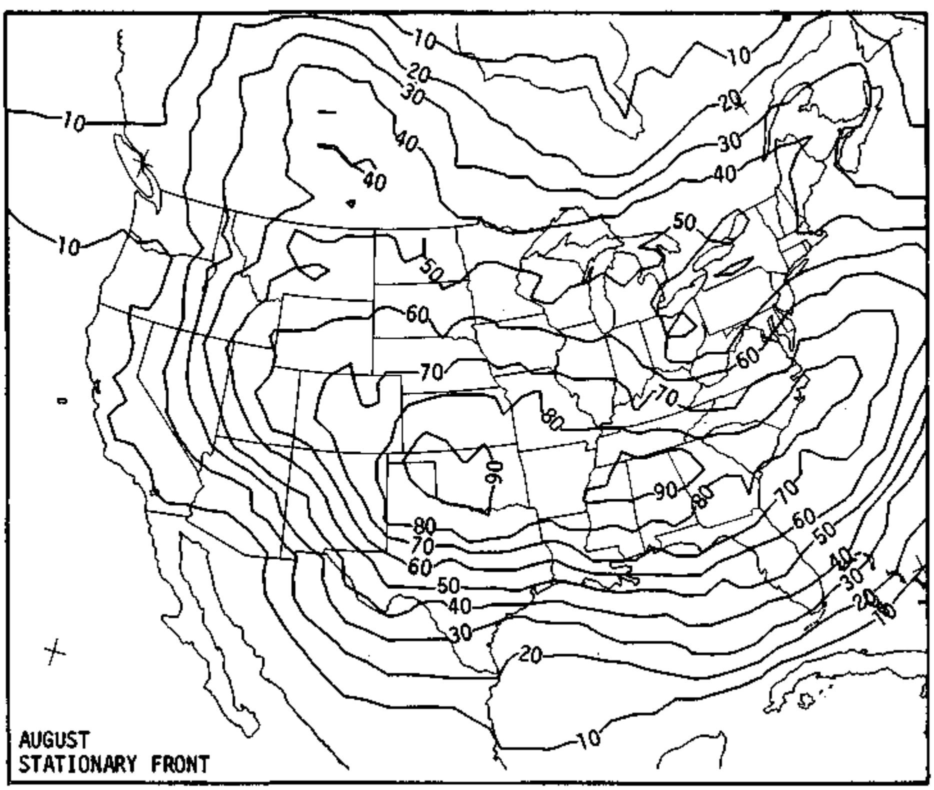
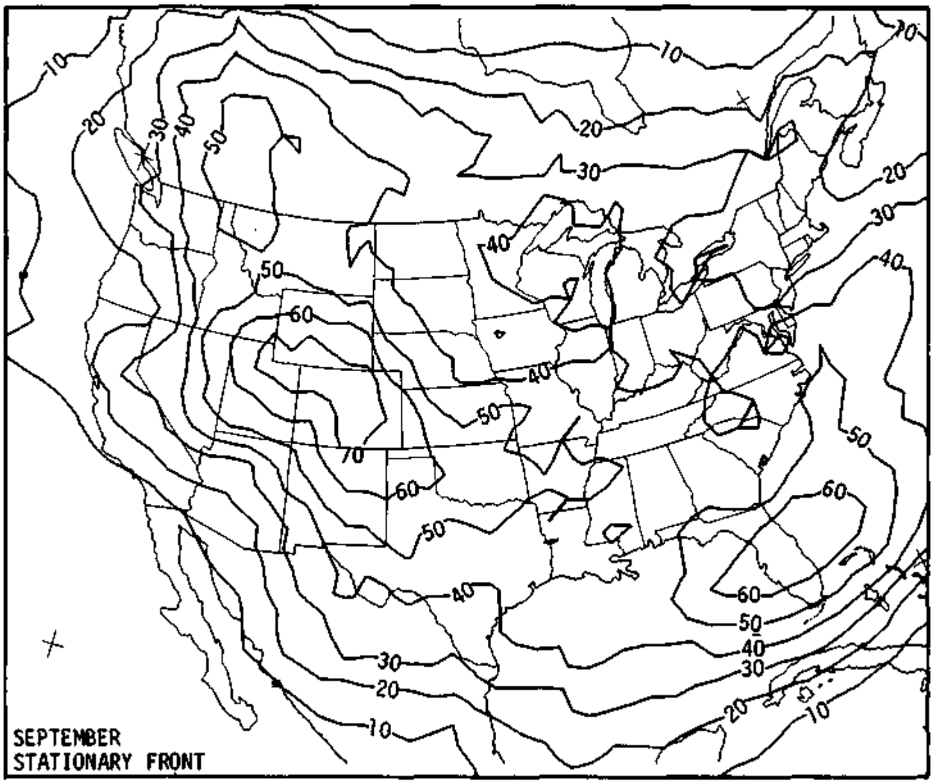

JUNE
STATIONARY FRONT

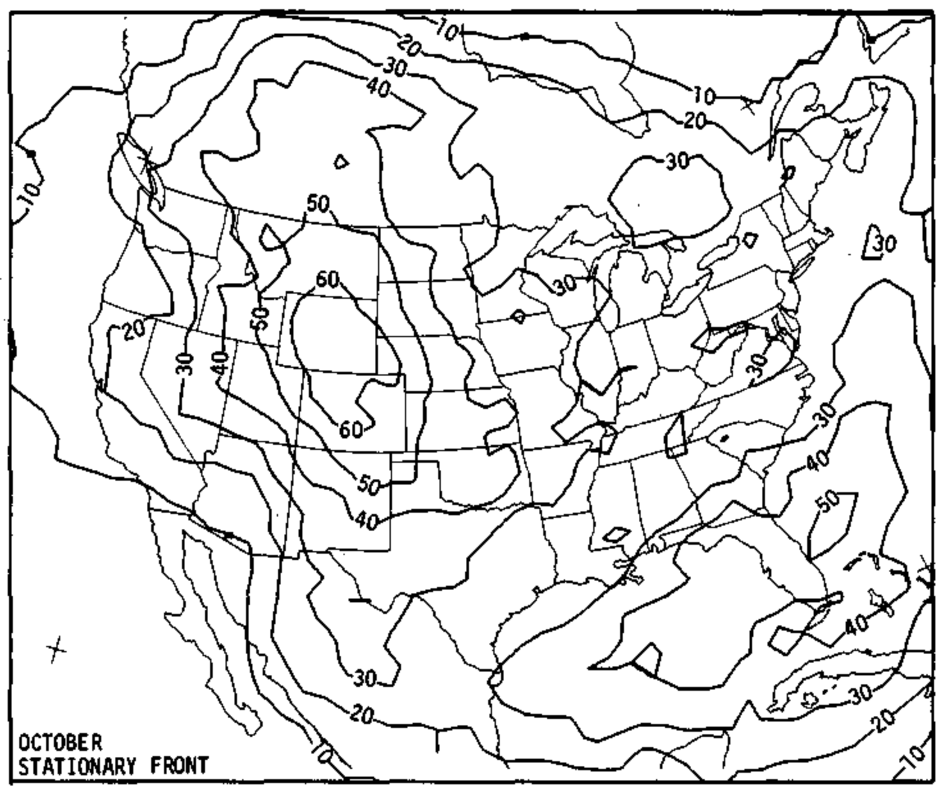
D. Stationary Fronts



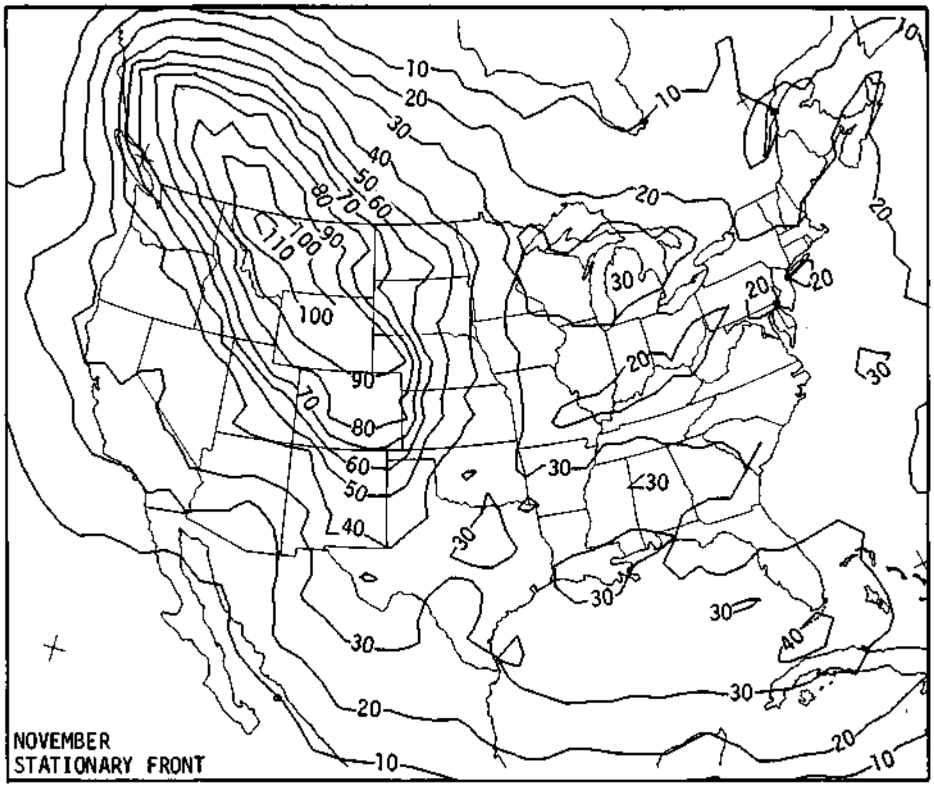


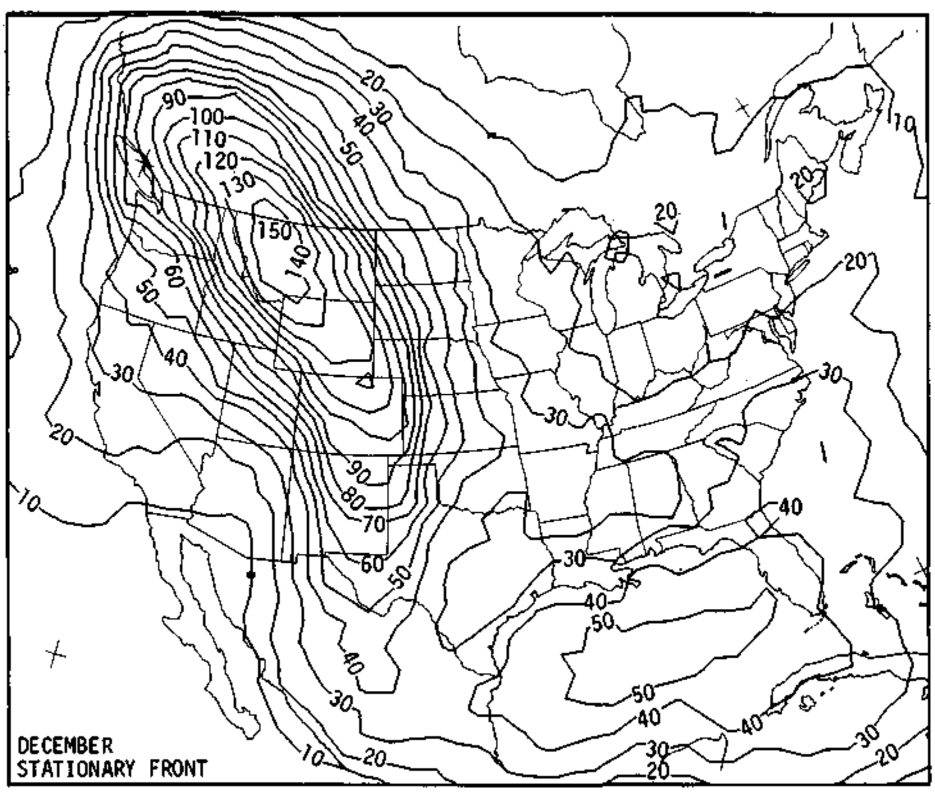
D. Stationary Fronts



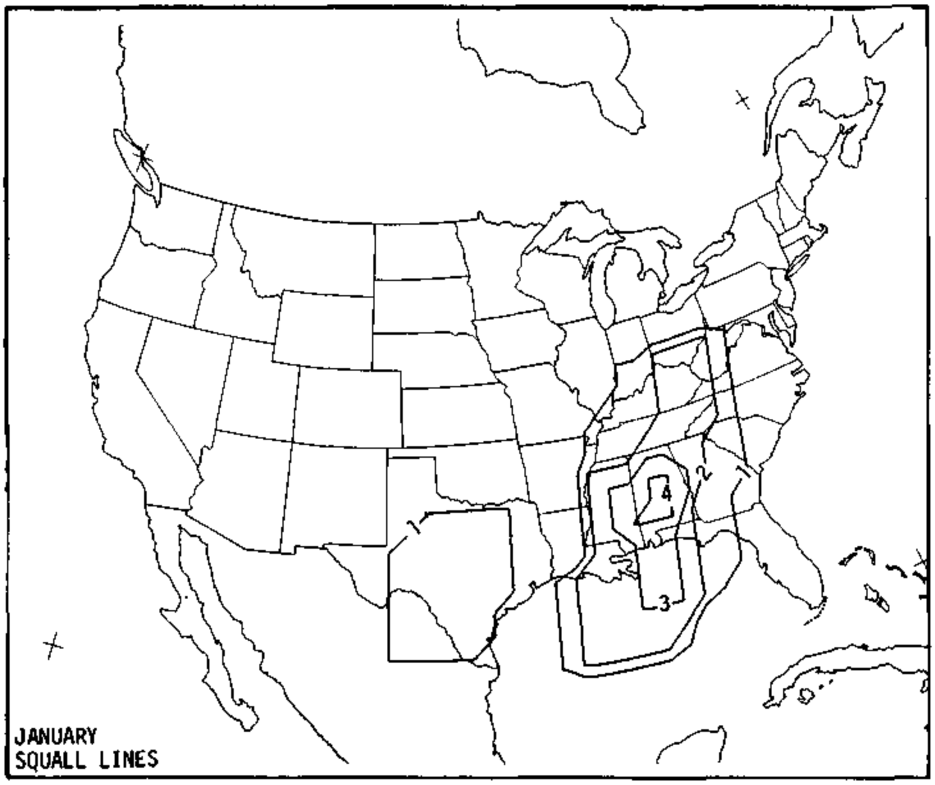


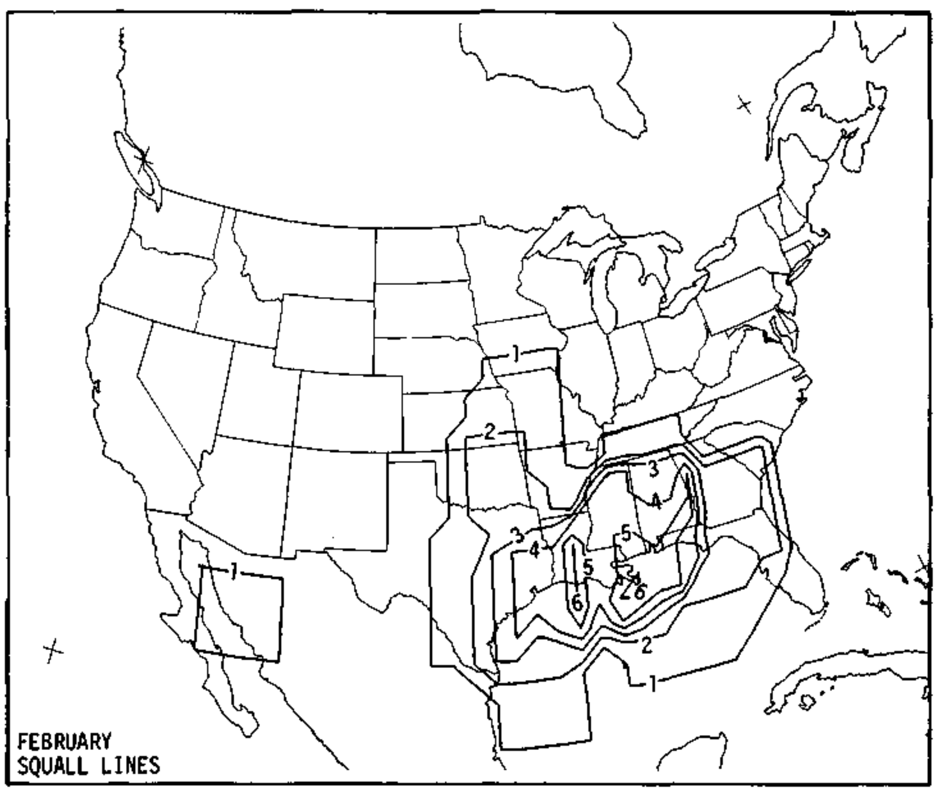
D. Stationary Fronts



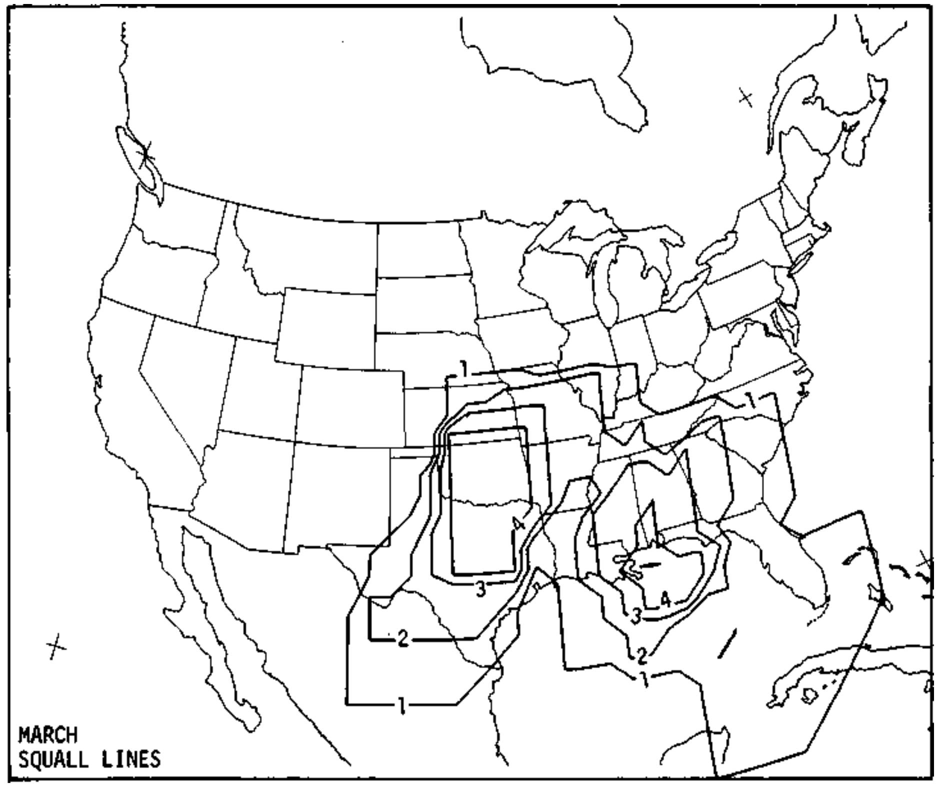


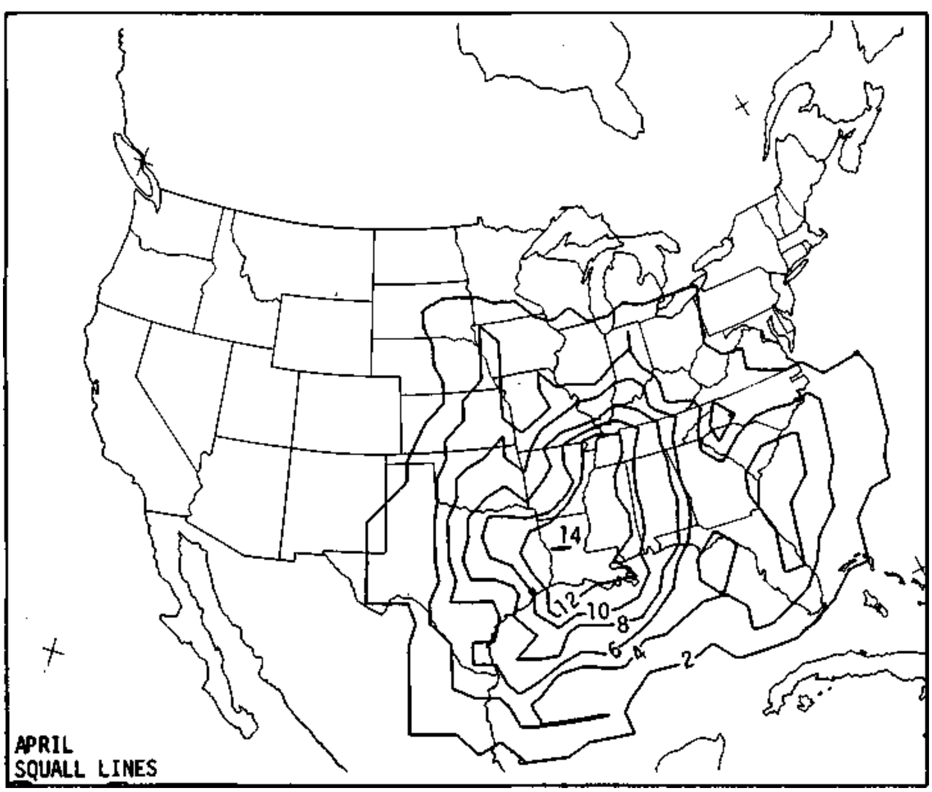
Appendix E. Frequency of Squall Lines, in Days per 10 Years

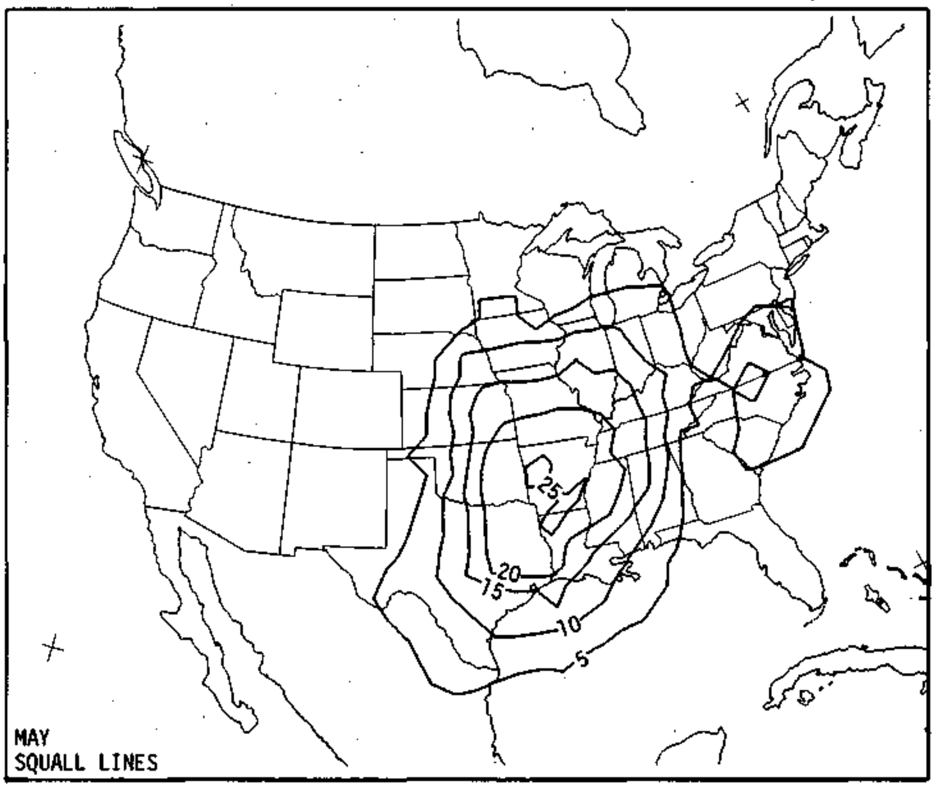


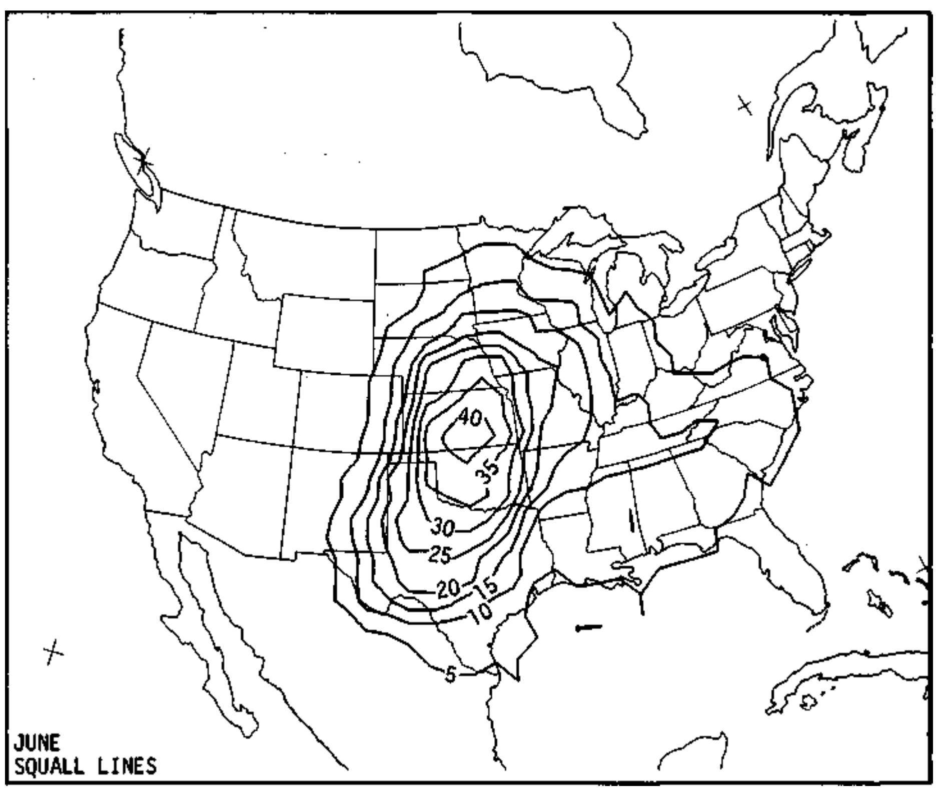


E. Squall Lines

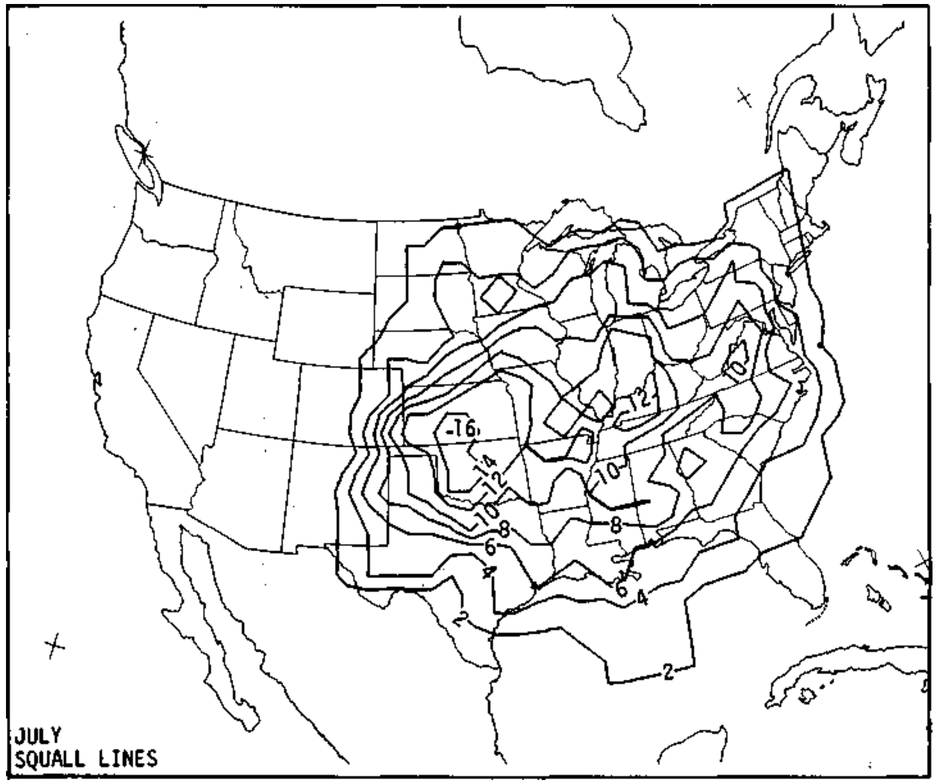


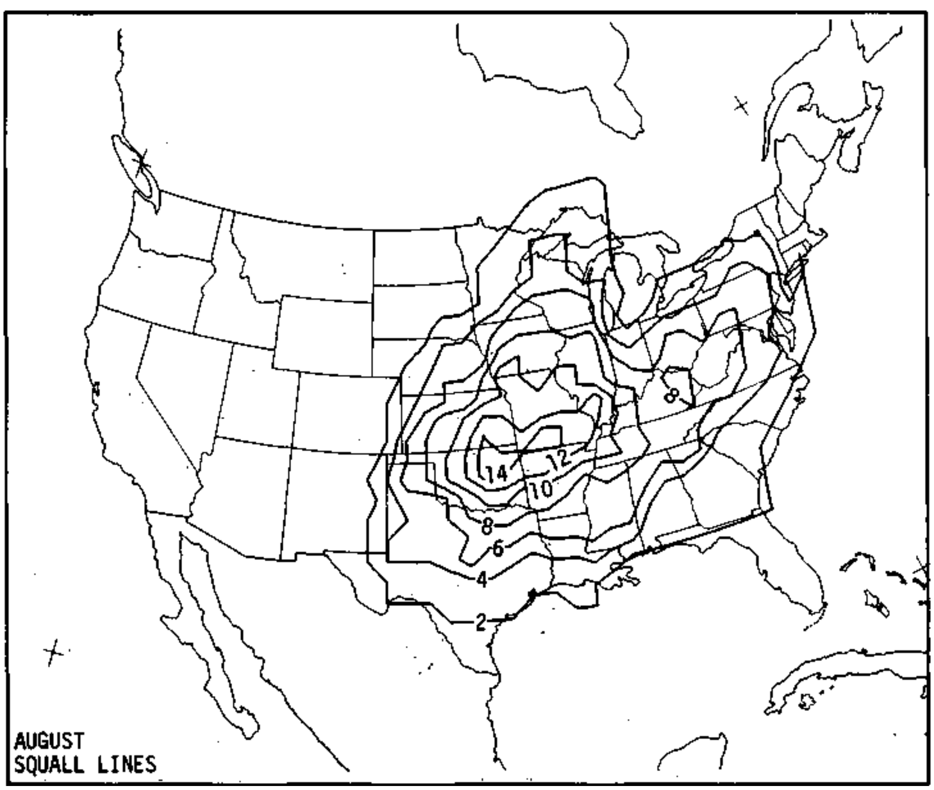


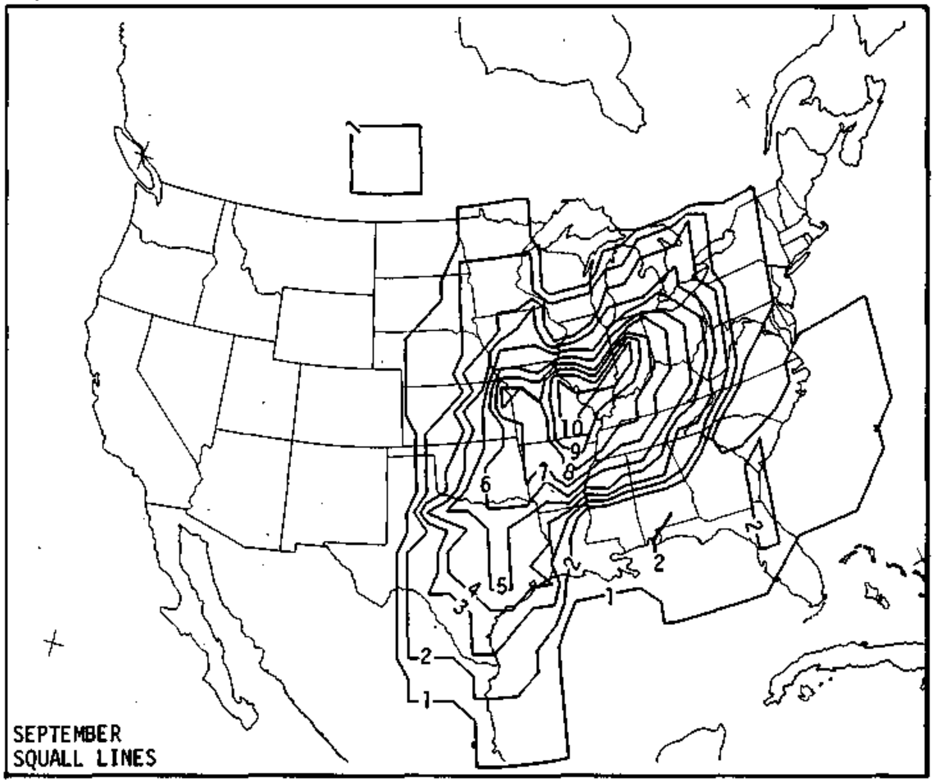

25
20
15
10
5
MAY
SQUALL LINES

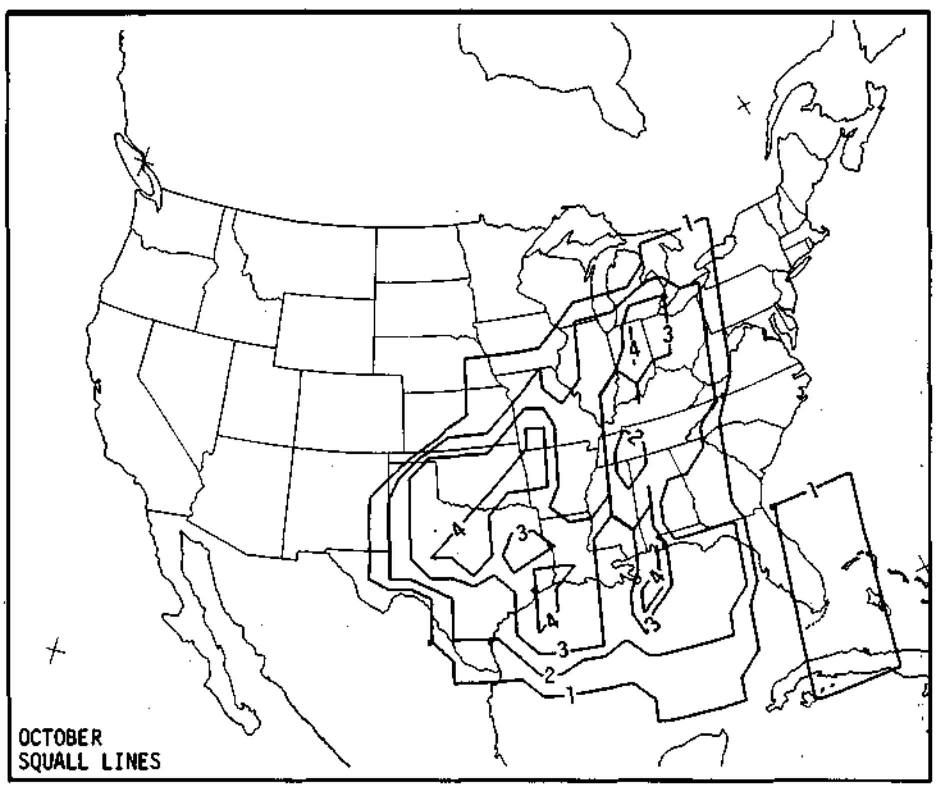

40
35
30
25
20
15
10
5
JUNE
SQUALL LINES

E. Squall Lines

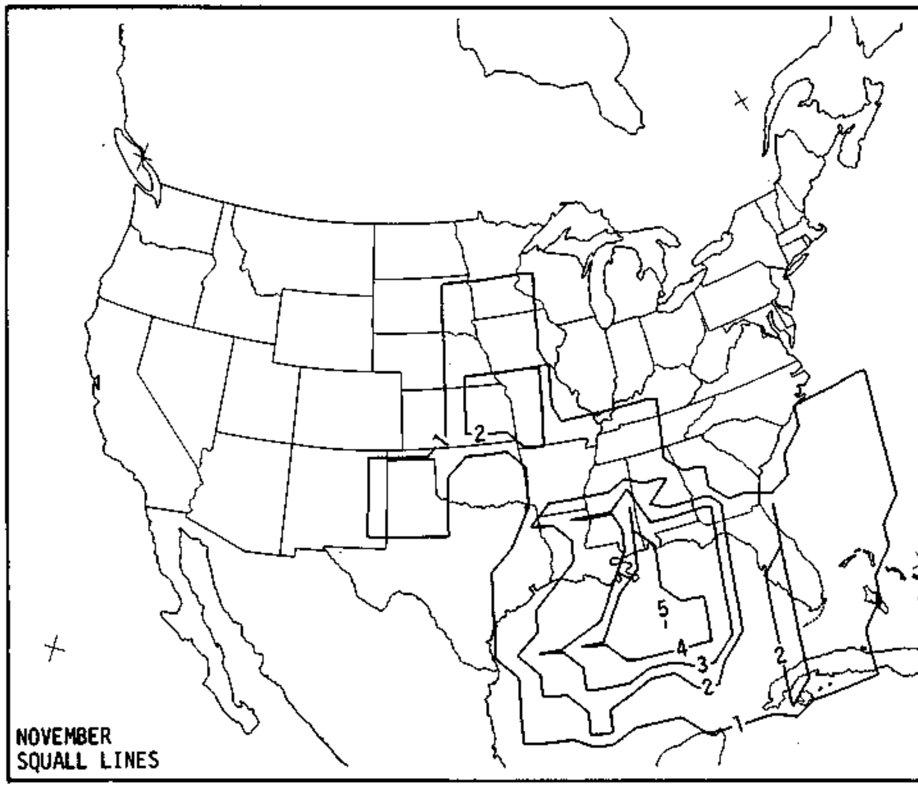


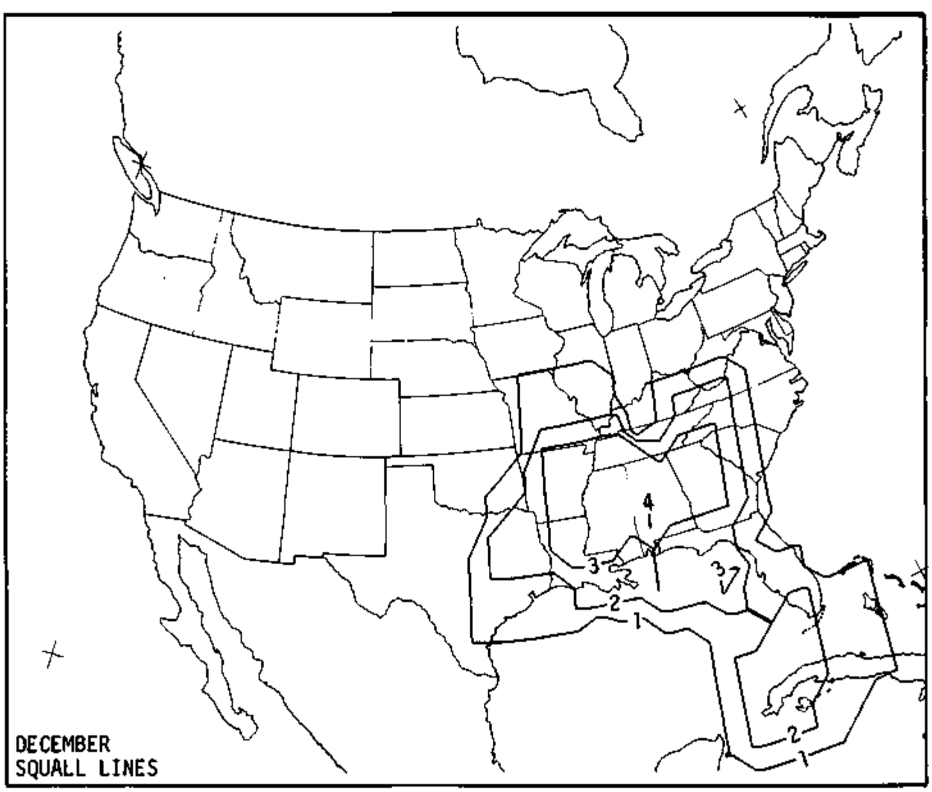



10
9
8
7
6
5
4
3
2
1
2
1
SEPTEMBER
SQUALL LINES

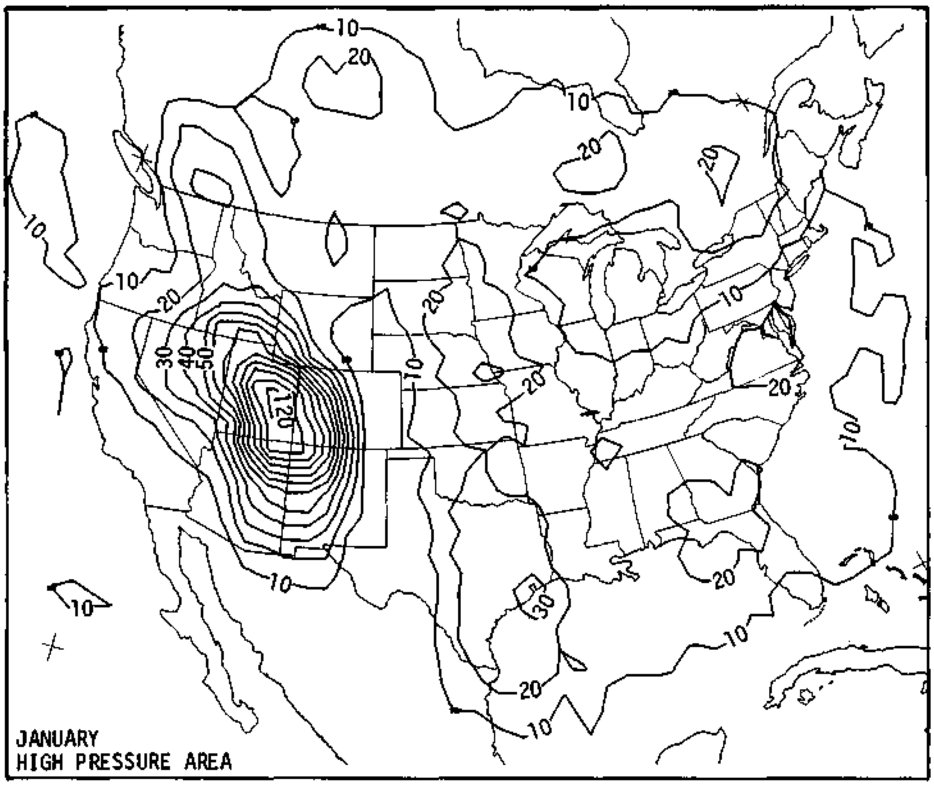

1
4
3
4
4
3
4
4
3
3
2
1
1
OCTOBER
SQUALL LINES

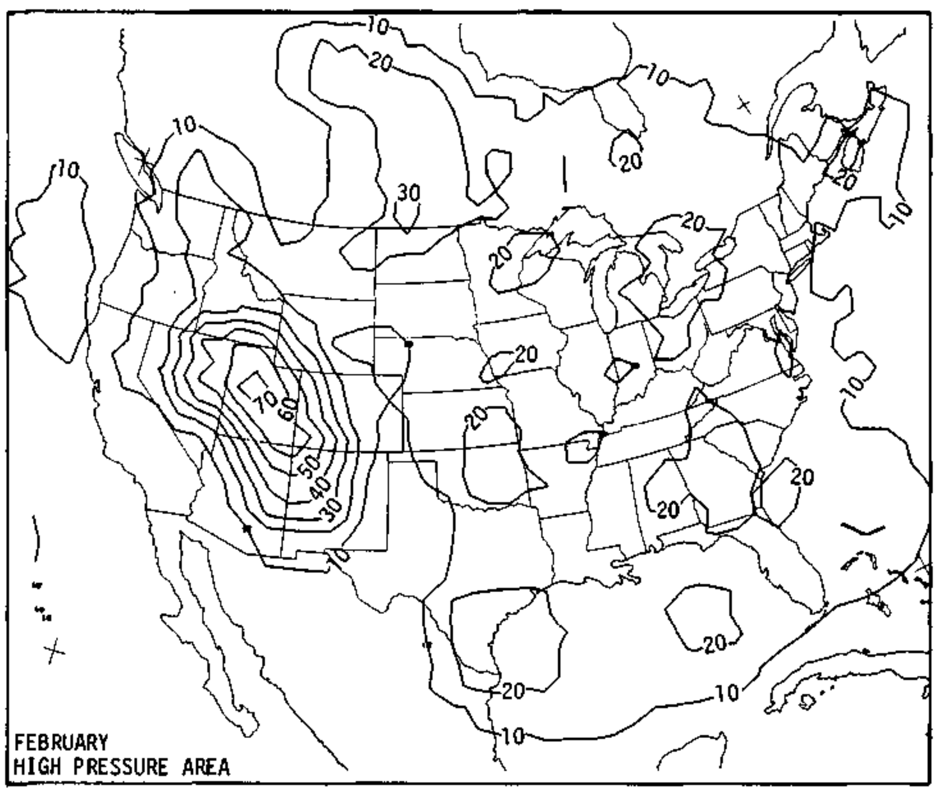
E. Squall Lines



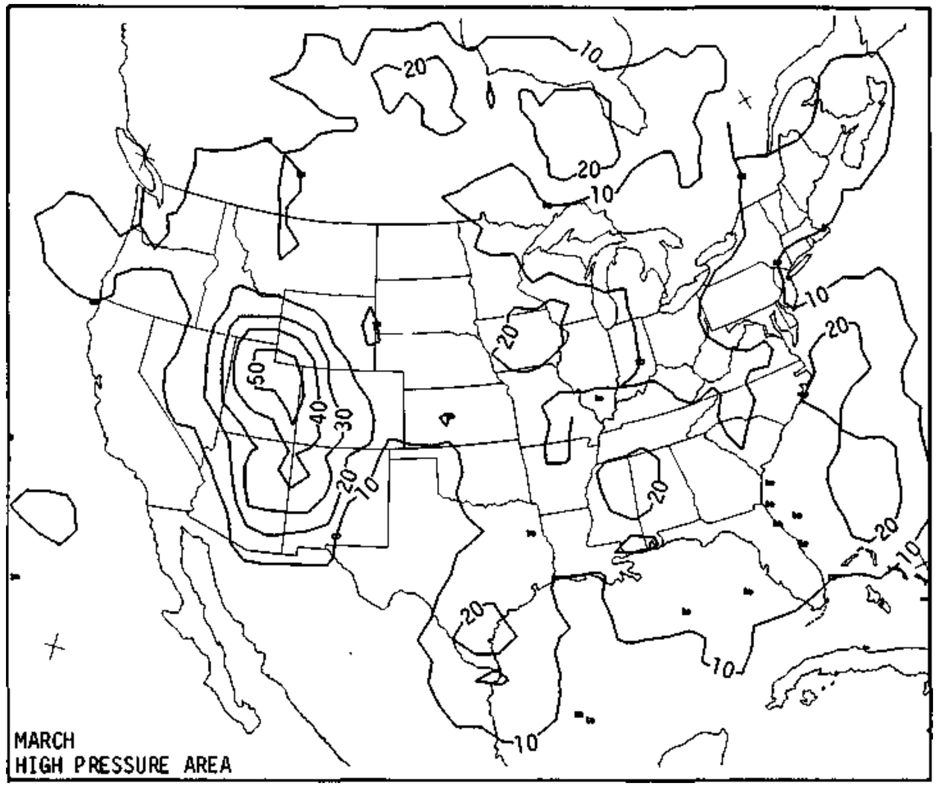


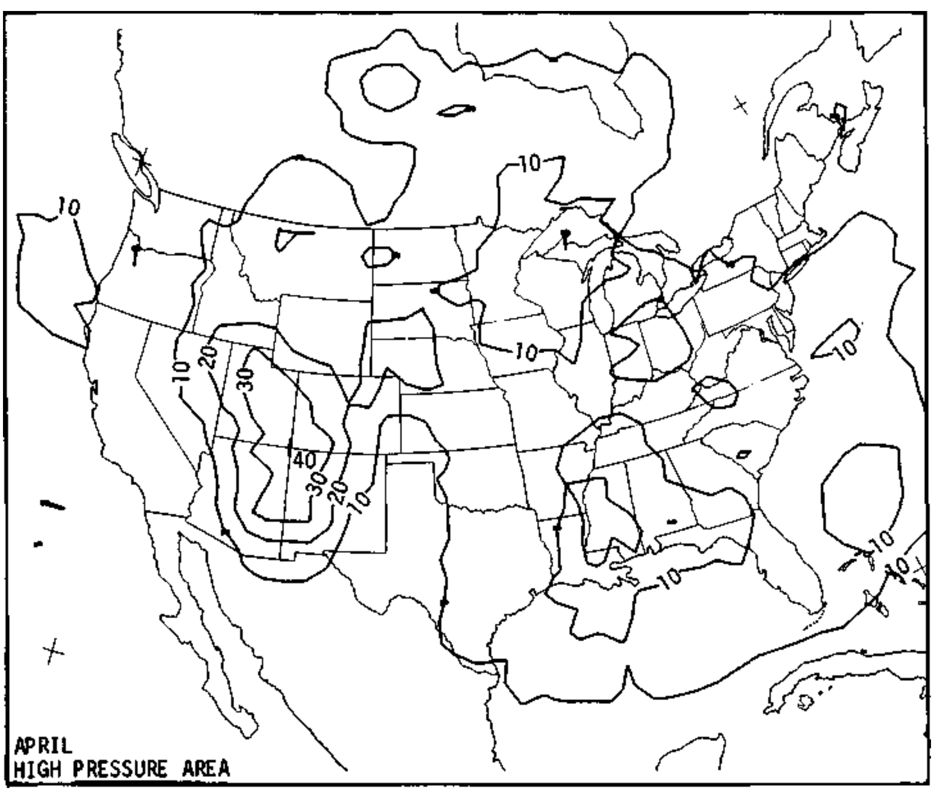
Appendix F. Frequency of High Pressure Centers, in Days per 10 Years

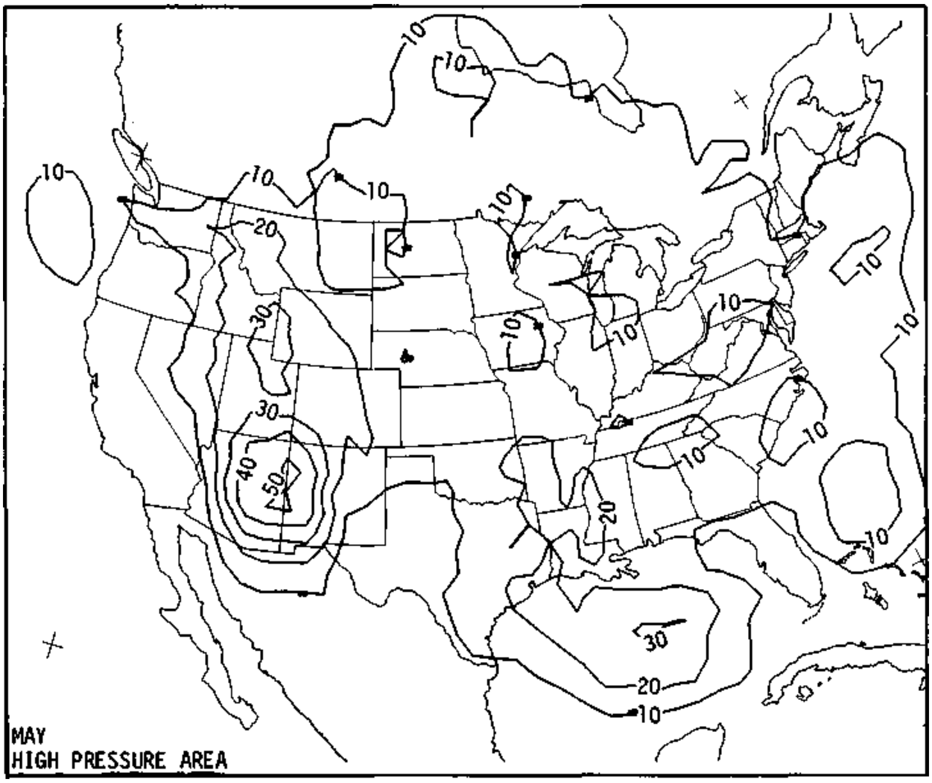


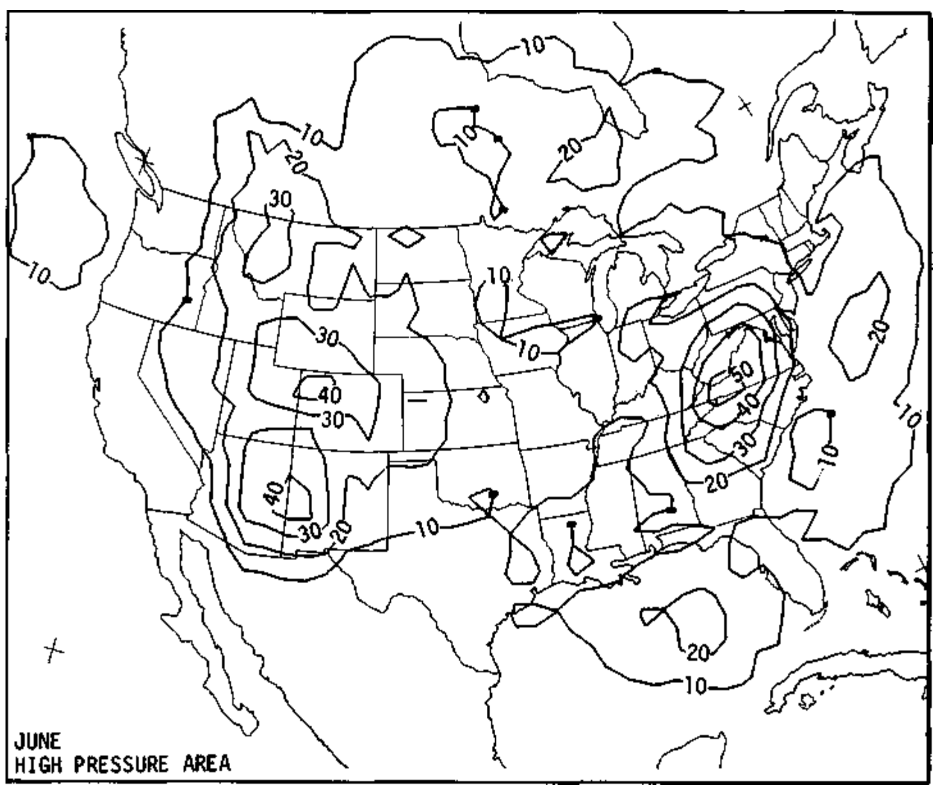


F. High Pressure Centers

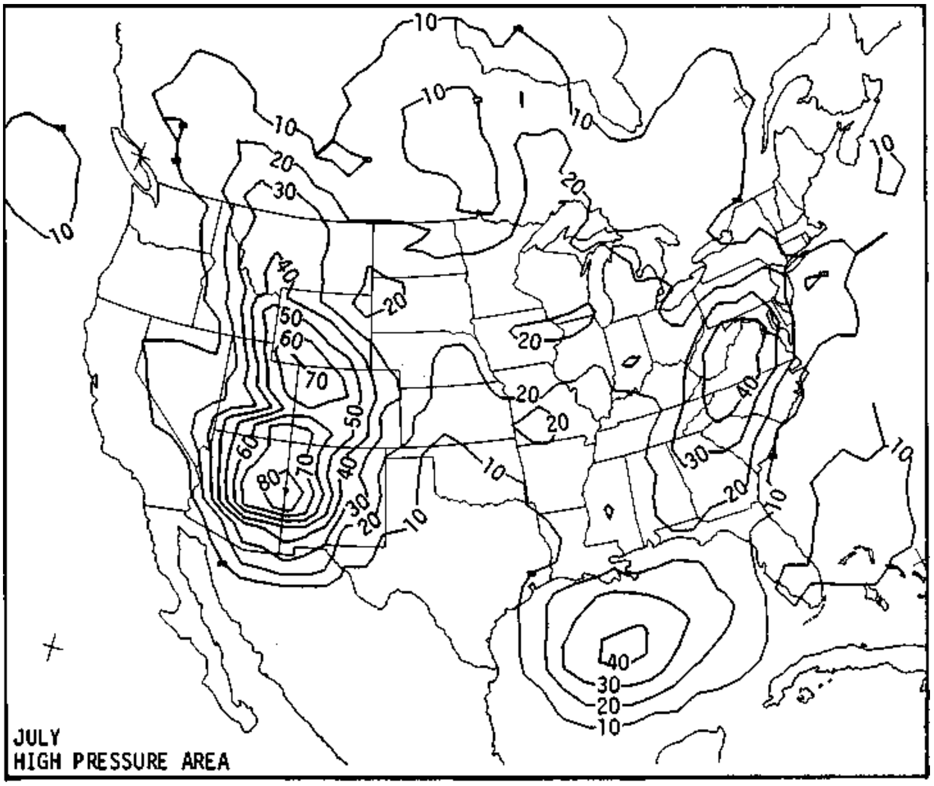


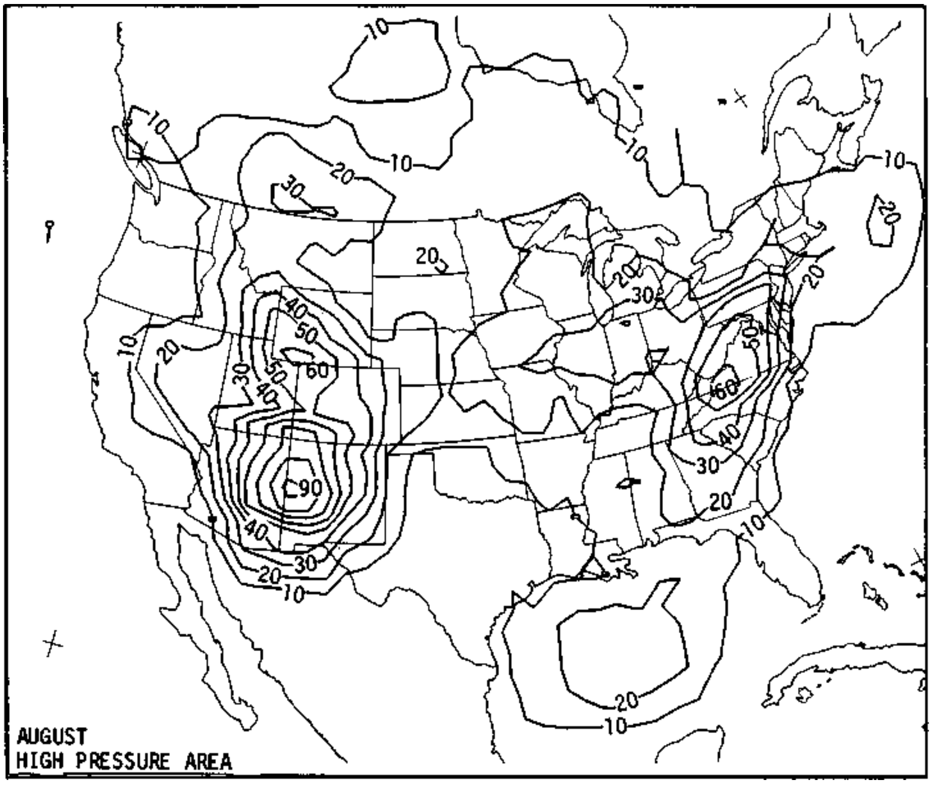


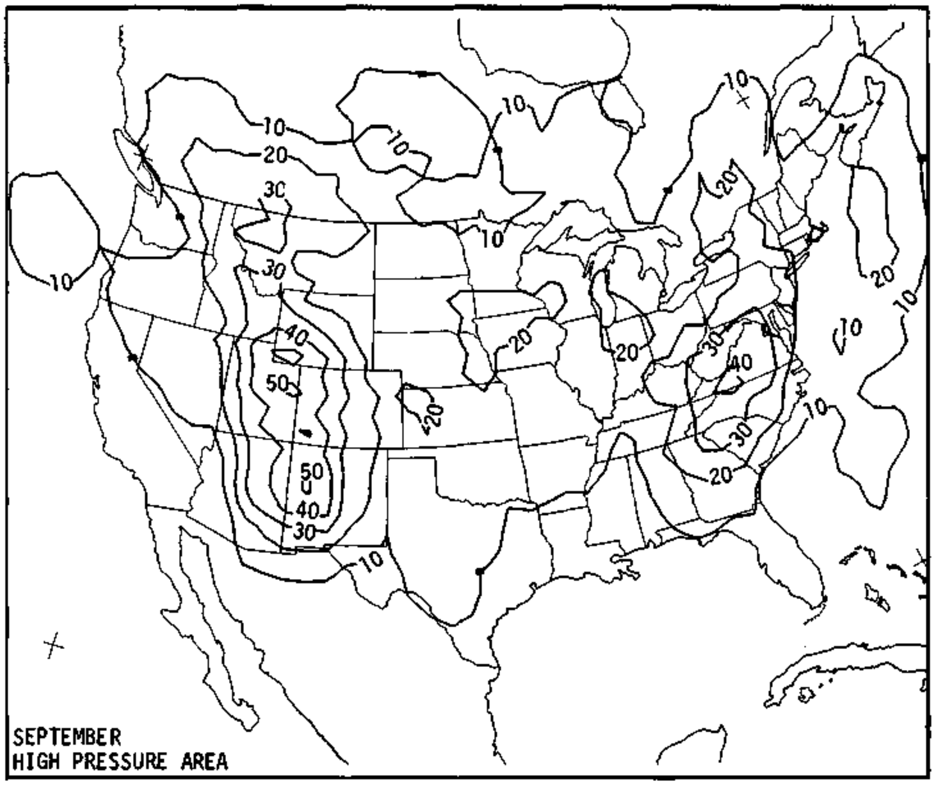

MAY
HIGH PRESSURE AREA

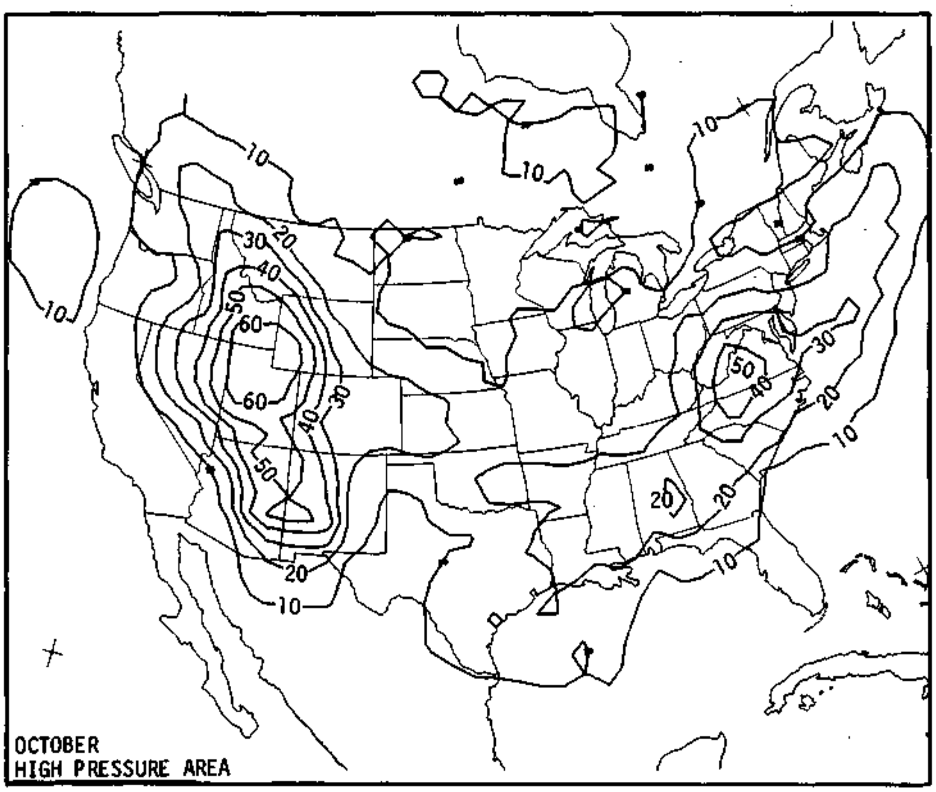

JUNE
HIGH PRESSURE AREA

F. High Pressure Centers

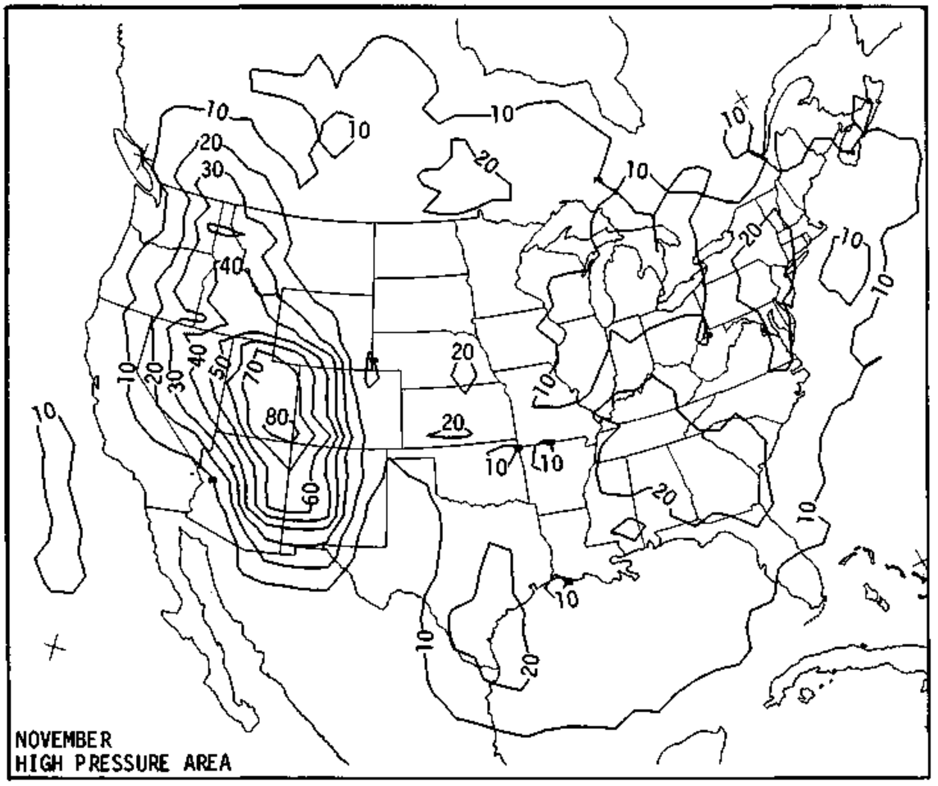


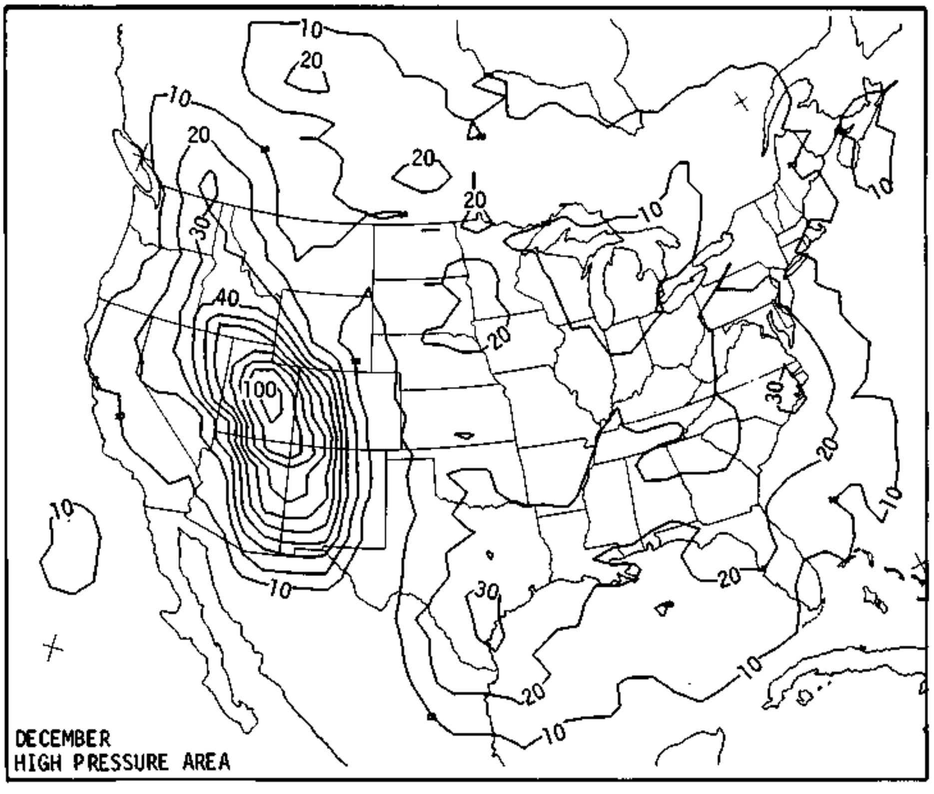



SEPTEMBER
HIGH PRESSURE AREA

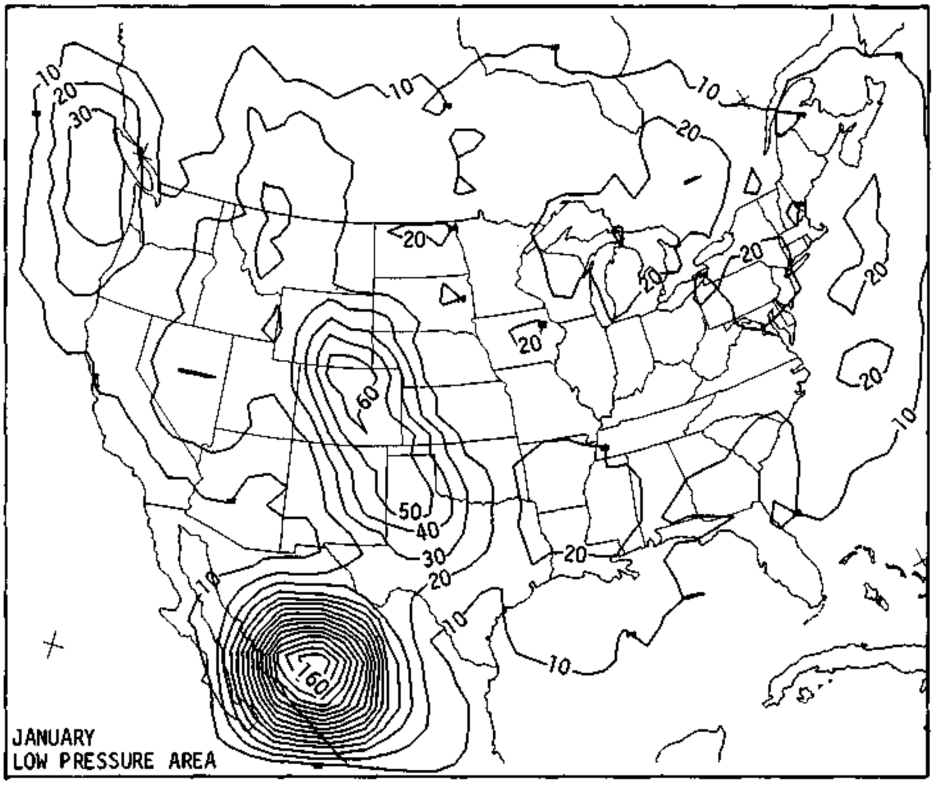

OCTOBER
HIGH PRESSURE AREA

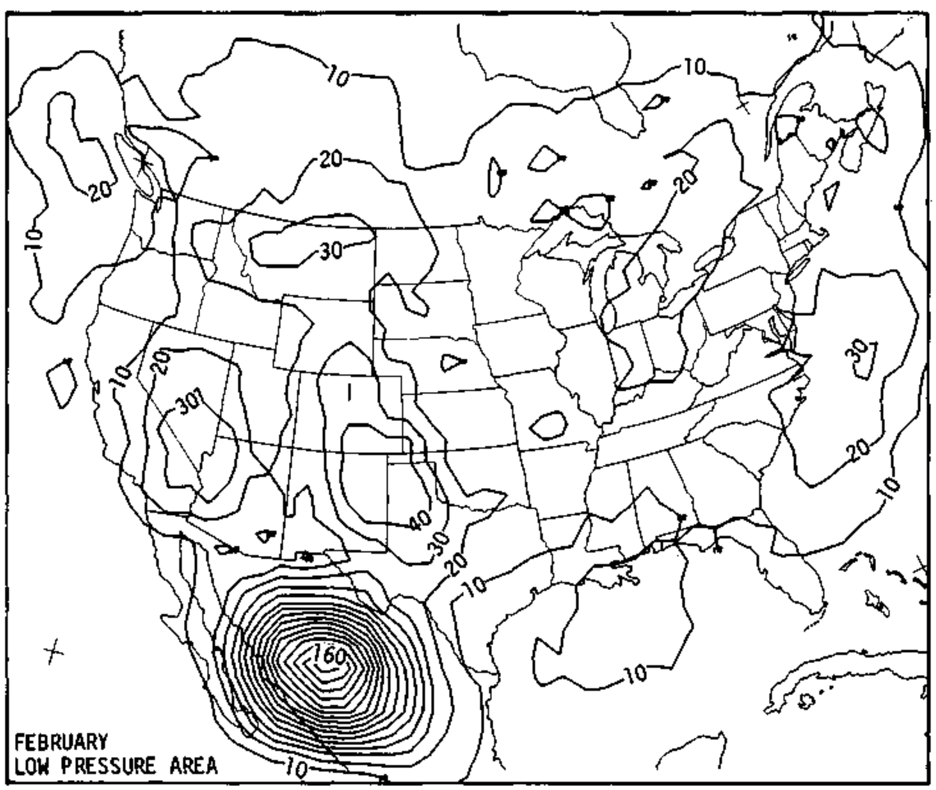
F. High Pressure Centers



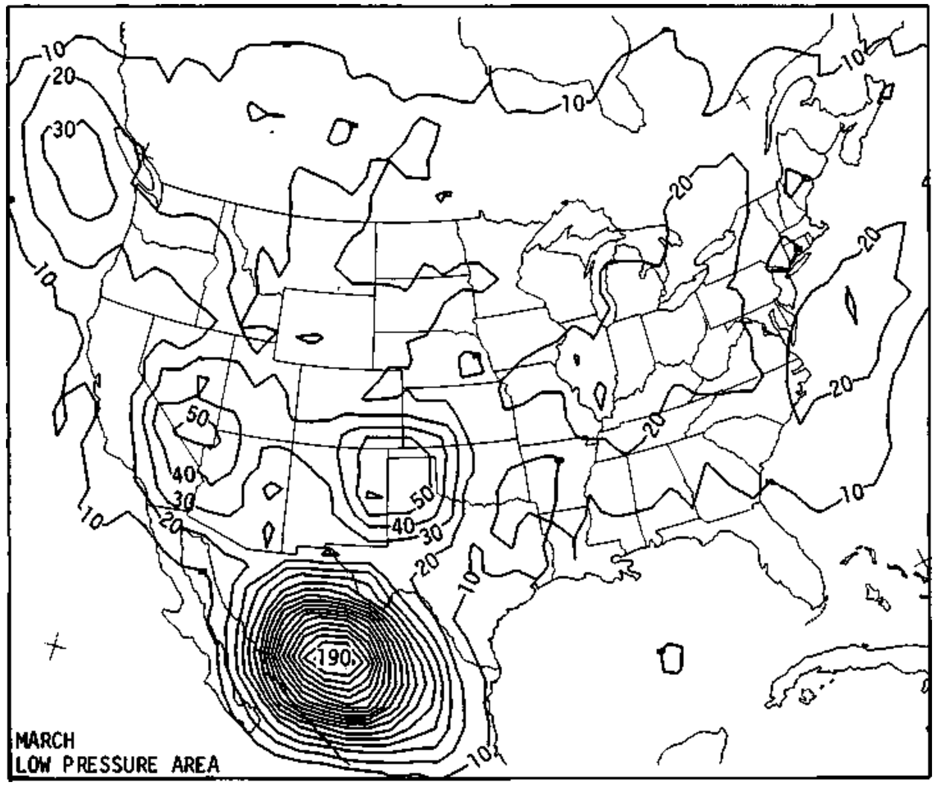


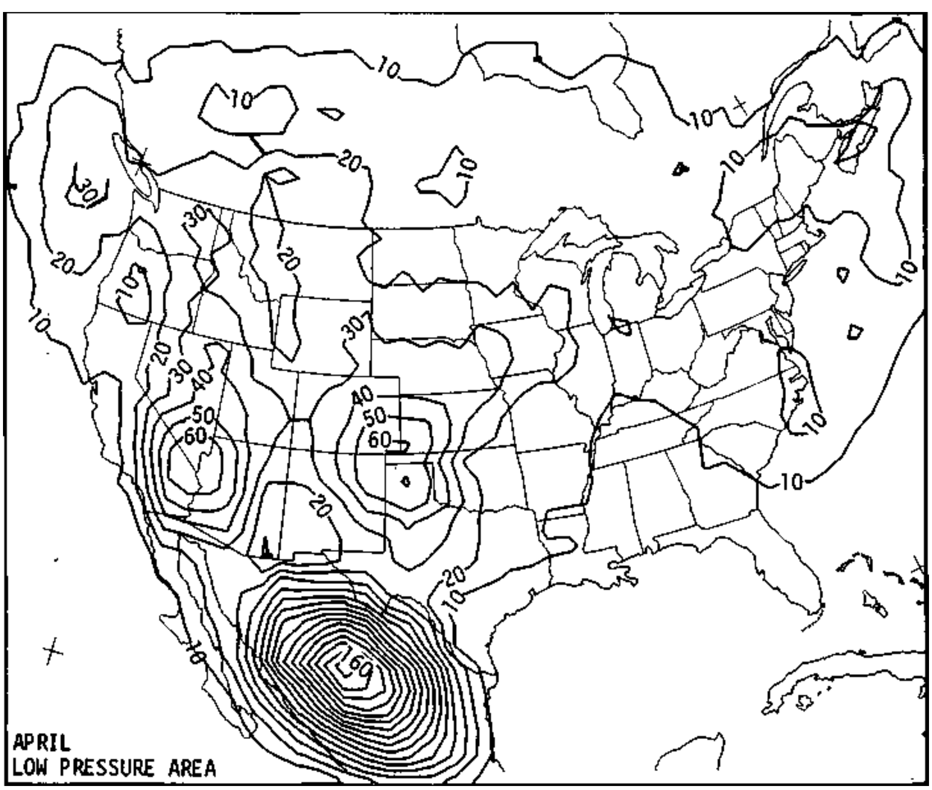
Appendix G. Frequency of Low Pressure Centers, in Days per 10 Years

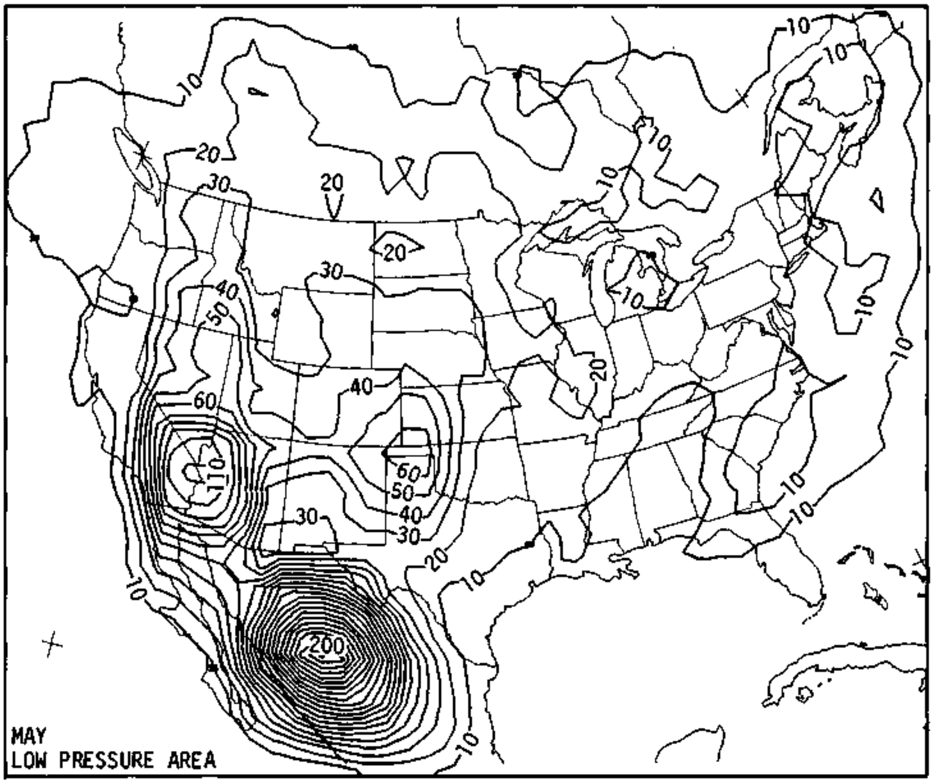


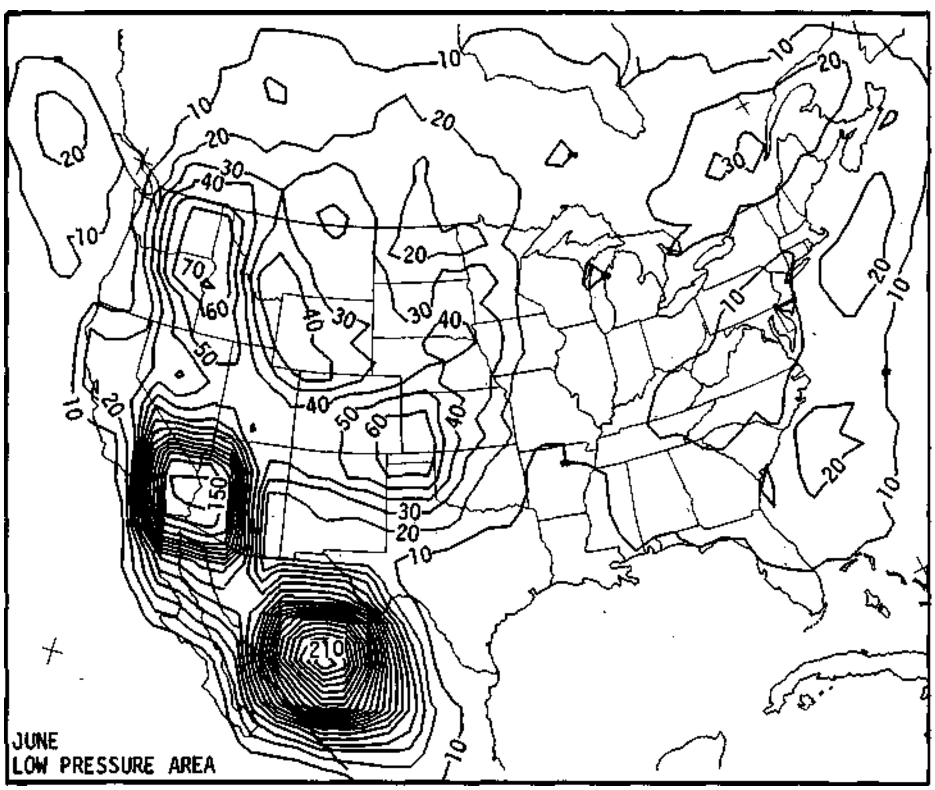


G. Low Pressure Centers

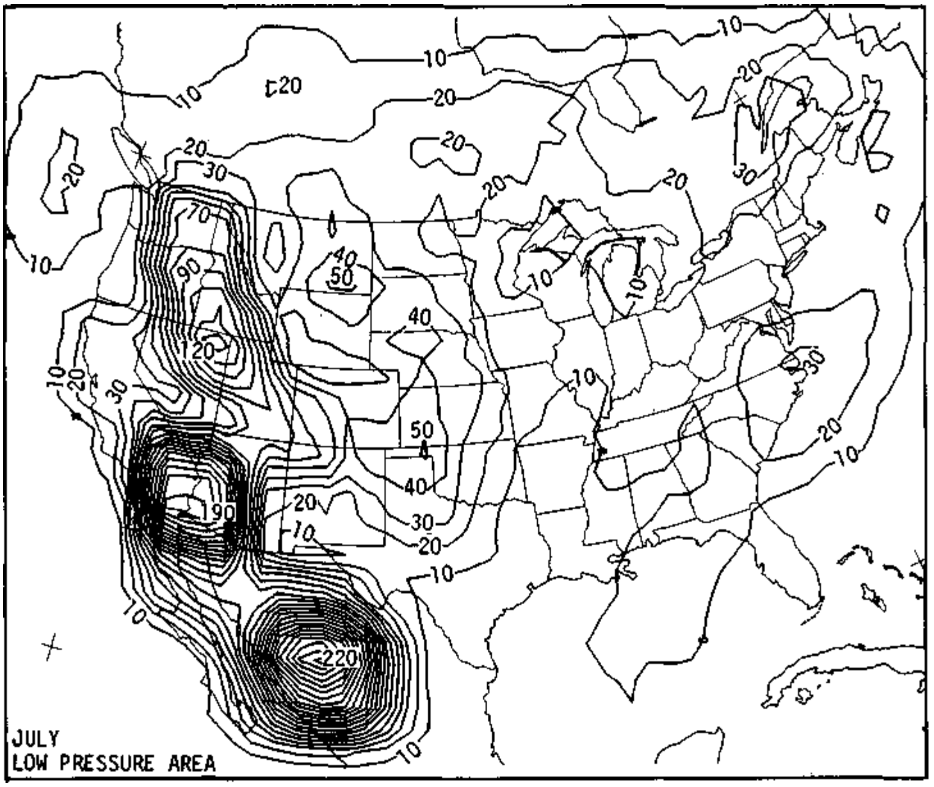


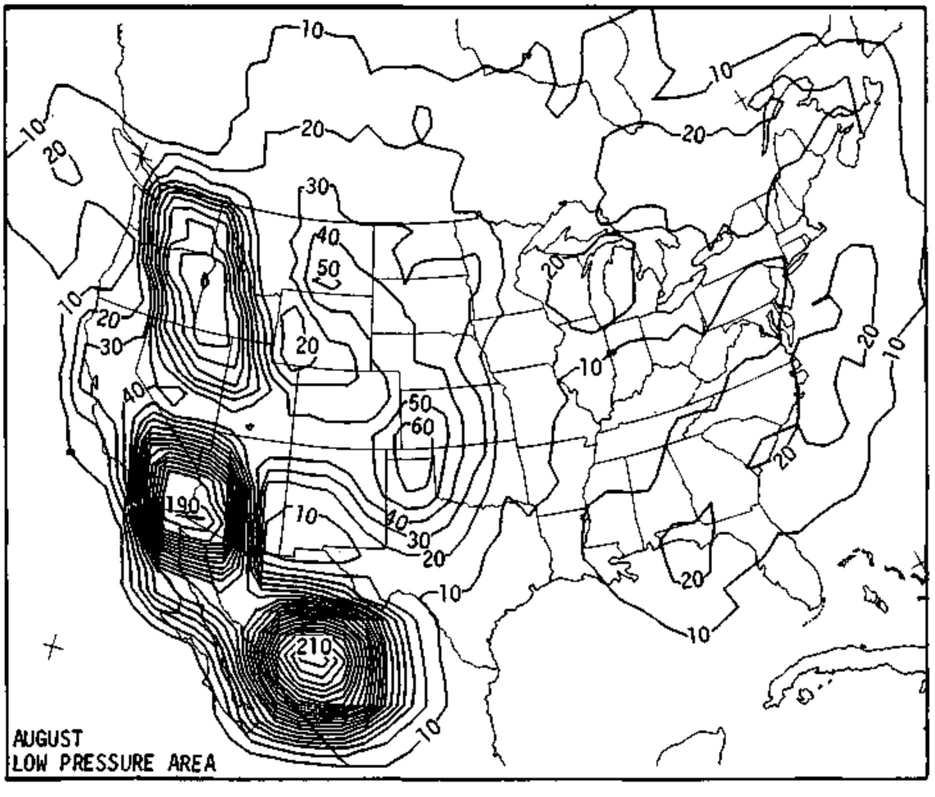


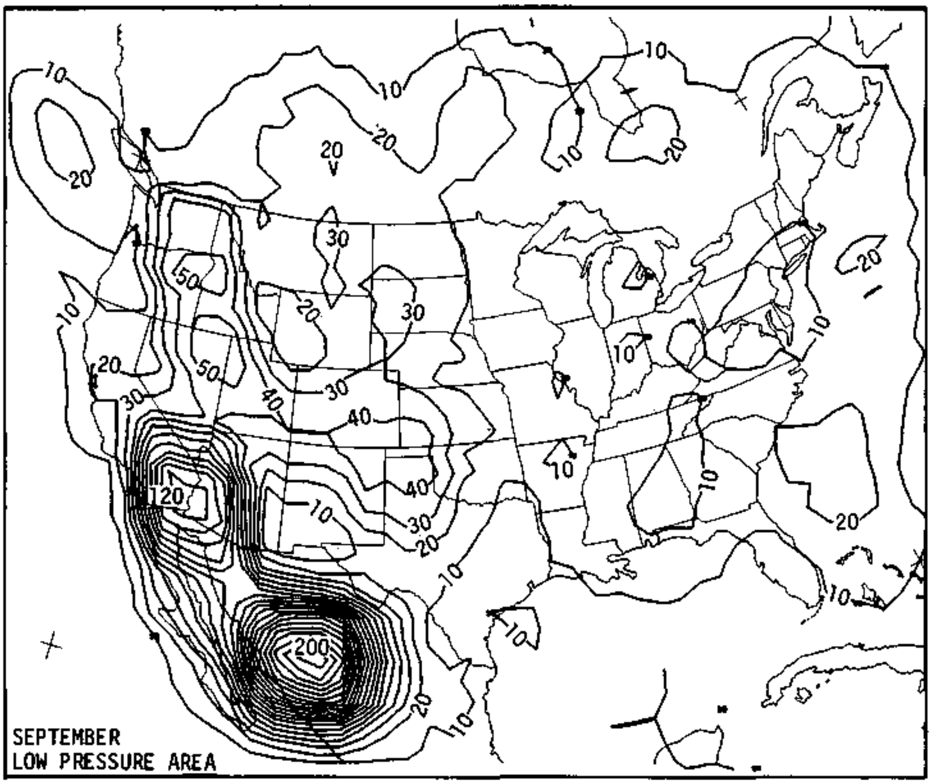

MAY
LOW PRESSURE AREA
10
20
30
40
50
60
110
200

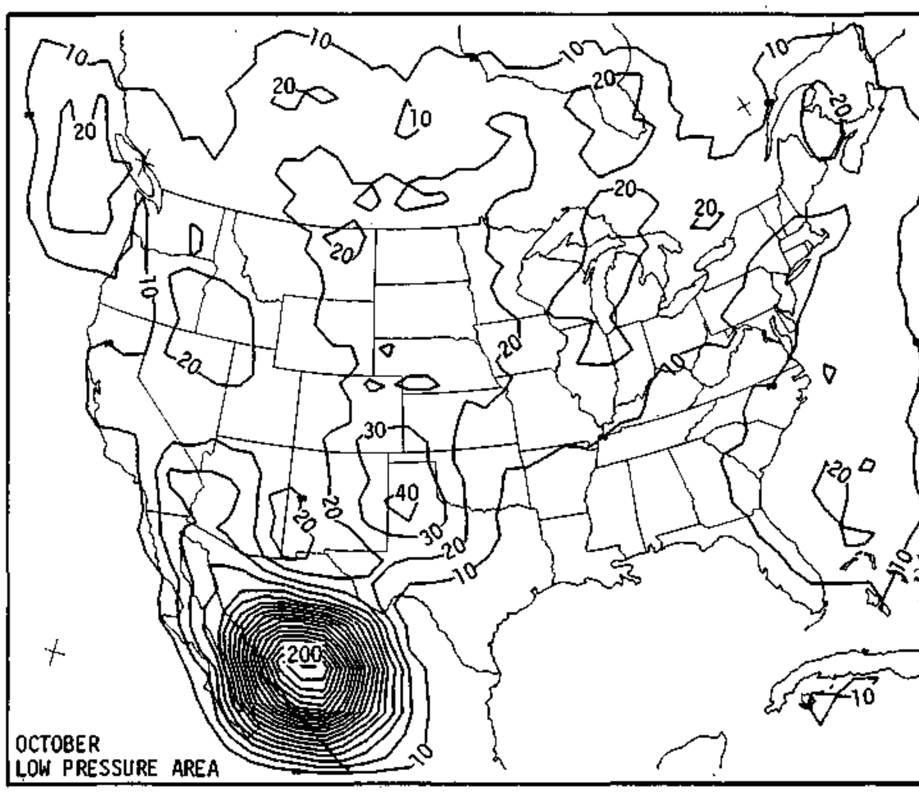

JUNE
LOW PRESSURE AREA
10
20
30
40
50
60
70
150
210

G. Low Pressure Centers






SEPTEMBER
LOW PRESSURE AREA
10
20
30
40
50
120
200


OCTOBER
LOW PRESSURE AREA
10
20
30
40
200

G. Low Pressure Centers