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LUTHER H. HODGES *Secretary*
WEATHER BUREAU
F. W. REICHELDERFER, *Chief*

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Verification of the Weather Bureau's 30-Day Outlooks

EXTENDED FORECAST SECTION, NATIONAL METEOROLOGICAL CENTER,
U.S. WEATHER BUREAU, WASHINGTON, D.C.

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VERIFICATION OF THE WEATHER BUREAU'S 30-DAY OUTLOOKS

EXTENDED FORECAST SECTION, NATIONAL METEOROLOGICAL CENTER

U.S. Weather Bureau, Washington, D.C.

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1. INTRODUCTION

This paper has been prepared to give users of the Weather Bureau's 30-day outlooks[1] a better idea of their accuracy and reliability than routine inspection would afford. For this purpose all outlooks prepared during the two years 1958 and 1959 have been reproduced alongside their corresponding observed patterns, and the resulting 48 sets of charts are printed at the end of the paper.

In addition, those verification statistics which have been routinely computed during the past 6 years are summarized and discussed in section 3. Probability tables designed especially for the general subscriber follow in section 4. The nature of the 30-day outlooks is explained in section 5, and some illustrative examples are cited in section 6. The principal findings are summarized in section 7. Before examining the material, however, the reader would do well to consider the limitations inherent in meteorological verifications treated in section 2 below.

2. LIMITATIONS OF VERIFYING PROCEDURES

The difficulties attending verification of weather forecasts stem partly from the fact that it is not possible to measure accurately the quantities being forecast. For example, in order to verify a prediction of the anomaly class of monthly mean temperature, such as above normal, much below normal, etc., one must know accurately not only the observed mean temperature, but also the long term normal for the month and the limiting values which define the classes. These latter quantities are not known precisely in many localities because the station record is too short, or the observing station or its instruments have been moved, or the environment of the observing point has changed. At first glance these considerations may appear unimportant, until it is realized that a variation of only 1° or 2° F. in monthly mean temperature may sometimes make the difference between a value falling in the above or below normal class, since class limits are computed to tenths of a degree.

Still greater difficulties arise with precipitation, whose local vagaries are well known to meteorologists and hydrologists. Sometimes, especially in summer, it is impossible to obtain an adequately detailed picture of the distribution of rainfall over an area of the size of a State. Even when the density of observing stations is increased, large variations in precipitation are found over small distances. These variations are extremely difficult to explain, let alone forecast. In addition, numerous errors arise from incorrect measurement, recording, transmission, and even summation of precipitation amounts. In short, there exists a certain indeterminacy in the very observation of precipitation patterns. For these reasons precipitation is expressed in terms of three classes (heavy, moderate, and light), but temperature in terms of five (much above, above, near normal, below, and much below).

If the errors discussed above were distributed in a random fashion, they would, in the long run, detract from the true score of the forecaster in direct proportion to his skill. Therefore a ceiling is set to the forecaster's indicated performance which is lower than 100 percent. Bearing these limitations in mind, we shall next discuss the results of actual verifications of the 30-day outlooks.

3. VERIFICATION STATISTICS

Verification scores for the 30-day outlooks issued during the initial phases of the program were published in 1953 in a monograph which also explains in detail methods used in preparing the outlooks.[2] In the present paper these scores will be brought up to date, new material added, and

[1] Published twice monthly as *Average Monthly Weather Resume and Outlook;* available from Superintendent of Documents, Government Printing Office, Washington 25, D.C. (subscription price $5.00 per year).

[2] Chapter 8 of "Thirty-Day Forecasting: A Review of a Ten-Year Experiment," by Jerome Namias, *Meteorological Monograph*, vol. 2, No. 6, American Meteorological Society, Boston, Mass., July 1953. 83 pp.

comparisons made with various controls such as climatological probability and persistence.

a. Time Graphs

The data in figures 1 and 2 give verification scores for surface temperature and precipitation for each individual 30-day outlook both for calendar months and for the 30-day periods between mid-months, for the six years 1954 through 1959. Each dot on the temperature graph (fig. 1) represents the percentage of 100 stations, evenly scattered over the contiguous United States, whose temperature was predicted in exactly the correct class or within one class of the observed. Under this criterion, for example, a forecast of above normal would be considered correct if above, much above, or near normal were observed, but incorrect if the observed temperature were in the below or much below normal classes. If the percentage of classes predicted and observed were distributed as expected climatologically, the chance score (climatological probability) with this verification system would be about 59 percent, and this score is indicated as a dashed line in figure 1.

In the case of precipitation (fig. 2), only three classes, light, moderate, and heavy, are used for predicted and observed patterns. Hence verification in terms of percent within one class would have little value. The dots in figure 2, therefore, indicate the percentage of the country which was predicted in exactly the correct class. Here the value expected by chance is 33⅓ percent, shown by the dashed line.

From these graphs it is clear that there are large oscillations in performance from one month to the next. The individual temperature scores range from a high of 97 (mid-March to mid-April 1959) to a low of 23 (February 1958), while the precipitation scores range from 67 (October 1959) to 15 (mid-January to mid-February 1956).[3] In order to damp these fluctuations and facilitate overall evaluation, means of six scores (two a month) have been computed for consecutive 3-month periods defining the four seasons (December, January, and February; March, April, and May; June, July, and August; September, October, and November). The resulting seasonal averages are connected by solid straight lines in figures 1 and 2. Although the mean scores computed in this fashion retain considerable variability (ranging from 85 to 61 for temperature and from 41 to 30 for precipitation), they make it clear that on the average the 30-day outlooks have skill but are far from perfect. Not once during the 6-year period portrayed in figures 1 and 2 was the seasonal mean score for temperature less than that expected by chance, while the precipitation score was less than chance for only two seasons. The fact that precipitation is more difficult to forecast than temperature is not surprising in view of the greater complexity of its physics.

Figure 3 is similar to figures 1 and 2 but pertains to the mean contour pattern of the 700-mb. surface, a fundamental part of the 30-day prognosis which more or less represents the prevailing upper-air winds and thereby largely determines the prediction of prevailing weather. The verification system involves first subtracting the appropriate month's long-term normal value from both prognostic and observed charts at each point of a suitable grid. The resulting "anomaly" patterns may then be considered as surfaces whose degree of parallelism we wish to know. This is given by the correlation coefficient; perfect agreement in the location and strength of positive and negative anomalies gives a correlation of +1.00, diametric opposition gives −1.00, and lack of relationship, 0.00.

The dots in figure 3 show the correlations obtained for the United States (North America since 1958) and for the Atlantic for individual months. As in figures 1 and 2, seasonal averages are shown by solid lines, and chance (zero skill) by the dashed lines. Despite large fluctuations, the averages indicate predominantly positive, though small, skill. Only a few seasons have scored below chance, none since 1957.

b. Skill Interrelationship

It is interesting to compare the scores for prediction of 700-mb. pattern (fig. 3) with the scores for weather prediction (fig. 1). This has been done in figure 4, where the verification of all temperature outlooks made for the United States during 1958 and 1959 is plotted against the verification of the corresponding forecasts for 700-mb. anomaly pattern over North America. This is the same 2-year period illustrated by charts at the back of this booklet. Figure 4 shows that there is a tendency for good forecasts of 700-mb. pattern to be accom-

[3] The reader may wish to compare predicted and observed patterns using the maps at the end of this paper.

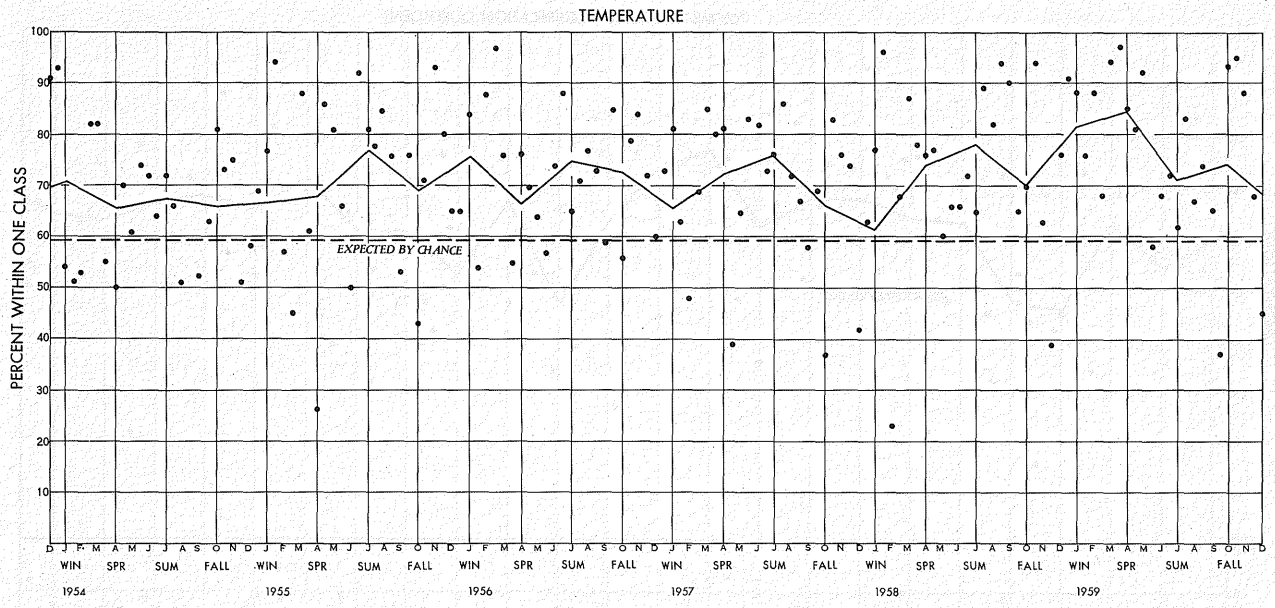

FIGURE 1.—Percent of 100 stations evenly situated across the contiguous United States with mean temperature anomaly predicted in either the correct class or within one class of the observed, December 1953 to December 1959. Each dot represents one 30-day outlook; the solid line connects averages of seasons. The dashed line is the score expected by chance (climatological probability).

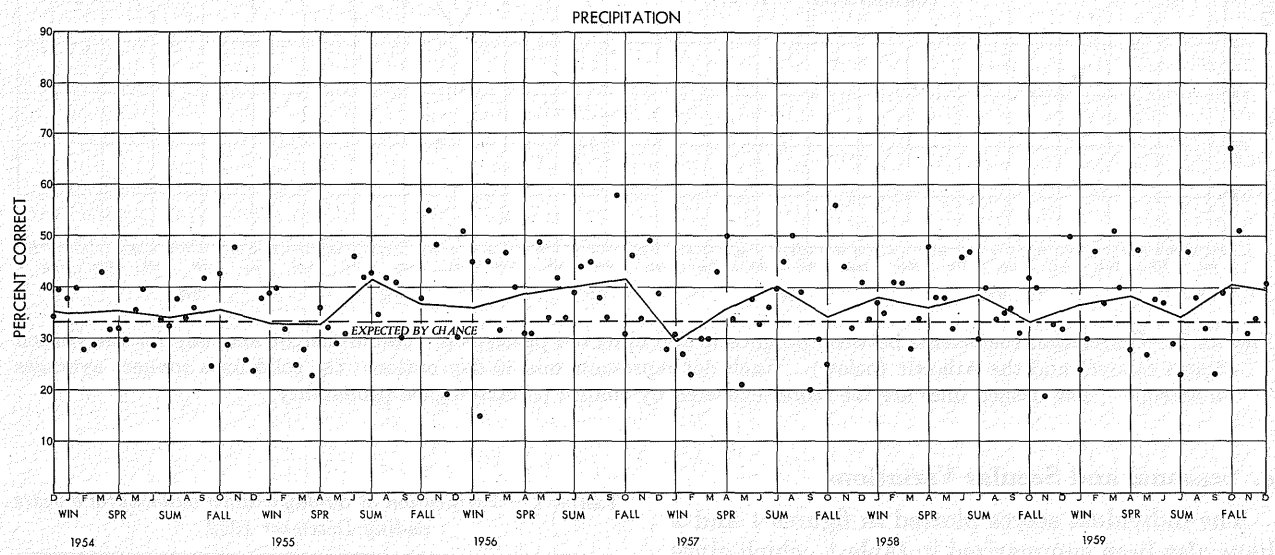

FIGURE 2.—Percent of 100 evenly spaced stations in the contiguous United States with total precipitation predicted in exactly the correct class (out of three), December 1953 to December 1959. Each dot represents one 30-day outlook; the solid line connects averages of seasons. The dashed line is the score expected by chance (climatological probability).

panied by good forecasts of surface temperature, and vice versa. Theoretically this should be the case, since temperature estimates are made largely from the prognostic contour patterns. However, the simple linear correlation coefficient between the two sets of scores is only +0.53. This correlation is not perfect (+1.00) because there are times when surface temperature is not uniquely defined by the wind circulation or when other factors influence the forecaster.

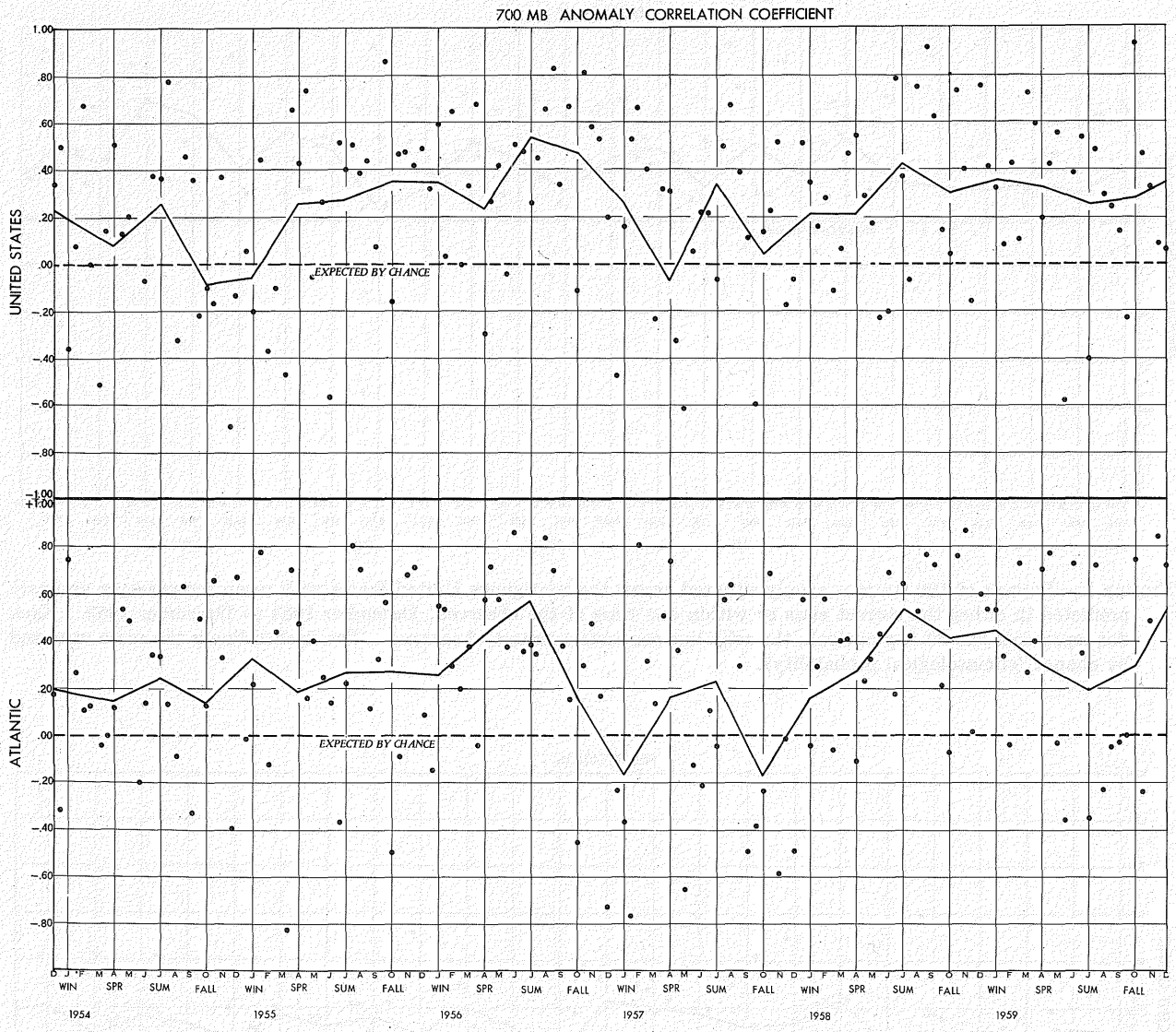

FIGURE 3.—Correlation coefficients between prognostic and observed patterns of 700-mb. height anomaly for the United States (above) and the Atlantic (below). Each dot represents one 30-day outlook; the solid lines connect averages of seasons. The dashed lines are the scores expected by chance (climatological probability).

c. Seasonal and Secular Variations

The individual scores plotted in figures 1 and 2 have also been summarized in table 1, which gives the average verification by seasons for the same 6-year period. For comparison, the scores expected by chance from the distribution of classes actually observed during each season are shown in columns 2 and 5. The scores for forecasts of both temperature and precipitation have been consistently higher than these chance scores. In a third column, comparative scores are given for forecasts made by considering the average weather of one month as possessing the same degree of

TABLE 1.—*Verification of 30-day weather outlooks for 6 years ending December 1959*

	Temperature (percent)			Precipitation (percent)		
	Forecast	Chance	Persistence	Forecast	Chance	Persistence
Winter	70.2	59.9	64.1	34.8	33.3	36.8
Spring	71.7	59.7	63.7	36.3	33.3	37.8
Summer	74.0	58.8	65.6	38.2	33.3	35.7
Fall	69.7	60.1	66.5	37.2	33.3	33.5
Year	71.4	59.6	65.0	36.6	33.3	35.9

abnormality as the preceding month. Such a prediction is referred to as "persistence." From table 1, it is clear that the outlooks are superior to persistence (given in columns 3 and 6) in all cases except those of precipitation during winter and spring. Another noteworthy feature of table 1 is the fact that the scores for both temperature and precipitation have averaged higher in summer than at any other time of year.[4]

Table 2 presents a summary by seasons of the individual scores for the 700-mb. anomaly verifications which were plotted in figure 3. With this element, as with surface weather, the 30-day outlooks have enjoyed greatest success during summer. Furthermore, the forecasts of 700-mb. circulation pattern have been superior to climatological probability (last column) during all seasons in both the Atlantic and the United States. Unfortunately, comparable scores are not available either for persistence or for the Pacific section.

There is a suggestion in figures 1, 2, and 3 that the 30-day outlooks have shown some improvement over the years. Some indication of this is provided by table 3, which contains verification statistics not only for the 6-year period summarized in tables 1 and 2 (1954–1959), but also for the 6 years immediately preceding (1948–1953) and for the last 2 years (1958–1959). The table shows that the most marked improvement of the past decade has come about during the past 2 years, when all scores except those for precipitation were higher than in previous periods. It is hoped that these differences represent a real advance, but the period of 2 years is too short to provide statistical significance. There are, however, a number of factors which may have contributed to this improvement, among them use of high speed computers for data processing and analysis, and incorporation of some new, objective forecasting procedures.

TABLE 2.—*Verification of 30-day circulation outlooks for 6 years ending Dec. 1959, 700-mb. correlation coefficients (normal removed)*

	United States	Atlantic	Chance
Winter	0.22	0.21	0.00
Spring	.18	.26	.00
Summer	.35	.35	.00
Fall	.23	.20	.00
Year	.24	.25	.00

TABLE 3.—*Verification of 30-day outlooks during various periods*

	Winter	Spring	Summer	Fall	Year
Temperature (percent within 1 class):					
1948–1953	65.5	70.6	71.9	70.5	69.6
1954–1959	70.2	71.7	74.0	69.7	71.4
1958–1959	71.4	79.3	74.5	72.3	74.4
Precipitation (percent correct):					
1948–1953	40.1	35.9	36.1	38.4	37.6
1954–1959	34.8	36.3	38.2	37.2	36.6
1958–1959	37.5	37.6	36.5	37.2	37.2
700-mb. correlation (United States):					
1948–1953	.23	.28	.25	.18	.24
1954–1959	.22	.18	.35	.23	.24
1958–1959	.28	.27	.34	.29	.29
700-mb. correlation (Atlantic):					
1948–1953	.19	.23	.31	.20	.23
1954–1959	.21	.26	.35	.20	.25
1958–1959	.31	.29	.37	.36	.33

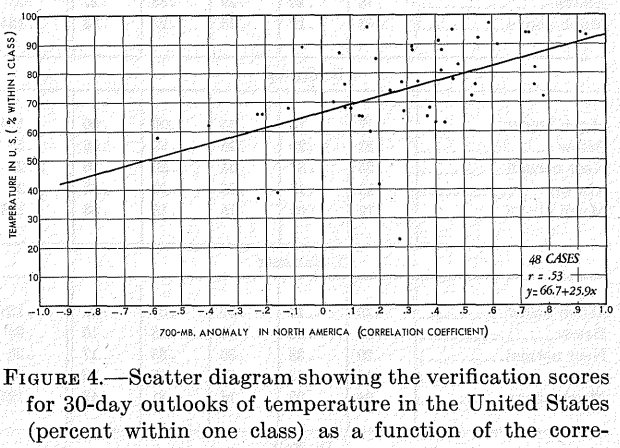

FIGURE 4.—Scatter diagram showing the verification scores for 30-day outlooks of temperature in the United States (percent within one class) as a function of the corresponding scores for pattern of 700-mb. height anomaly in North America (correlation coefficients). Each dot represents one 30-day outlook during the two years, 1958–59 (48 cases). The heavy line (of regression) was derived by the method of least squares. Its equation and the simple linear correlation coefficient between the two variables are given in the legend at lower right.

[4] It might be objected that the type of temperature verification used here allows a forecaster to obtain an artificially high score by "playing the system." For example, a forecast of near normal over the entire country would, in the long run, verify 75 percent of the time. In practice the forecasters do tend to be cautious about predicting the extreme classes (much above, much below). These were, during the 6 years summarized in table 1, actually chosen 14 percent but observed 25 percent of the time. The effect of this hedging can be estimated by recomputing the chance control as one expected from a random reshuffling of the actual forecasts. The result, an annual average of 62.8 percent, instead of the value 59.6 percent given in table 1, does not affect any of the conclusions drawn above.

An alternate method of verification is to count only those stations forecast in exactly the correct temperature class. For the 6-year period under consideration, this computation gives an annual average score of 28.1 percent correct for the 30-day outlooks, compared to 25.3 percent for persistence and 21.9 percent for chance. These figures also support the conclusions reached previously on the basis of the percentages within one class.

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4. ACCURACY IN TERMS OF PROBABILITIES

In order to help the subscriber judge the degree of usefulness of the 30-day outlooks in his special field, be it agriculture, industry, commerce, or whatever, values of the probability of occurrence of the various forecast categories have been computed (tables 4 and 5). These tables, which contain material derived from the 6 years of forecast verifications discussed in section 3, do not differentiate between areas of the United States. They have been split into four parts (A, B, C, D), one for each season.

The main columns of the tables are headed by the names of the forecast categories or classes. (The exact numerical definitions are presented in geographical detail on every published outlook.) The numbers in each column represent the estimated probabilities of actual occurrence of the various classes, given the forecast at the top of the column. The last column in each table contains, for comparison, the climatological (or chance) probabilities of occurrence of the classes.

TABLE 4.—*Probabilities of occurrence of 30-day forecast temperatures. Data from the 6 years ending December 1959*

Probability of occurrence of— \ Forecast	Much below	Below	Near normal	Above	Much above	Chance
A. Winter						
Much below	.11	.10	.10	.04	.00	.125
Below	.33	.31	.21	.17	.13	.25
Near normal	.35	.27	.25	.24	.27	.25
Above	.18	.20	.29	.33	.27	.25
Much above	.03	.12	.15	.22	.33	.125
B. Spring						
Much below	.27	.13	.10	.06	.00	.125
Below	.23	.29	.26	.20	.08	.25
Near normal	.25	.30	.24	.30	.26	.25
Above	.13	.19	.25	.26	.33	.25
Much above	.12	.09	.15	.18	.33	.125
C. Summer						
Much below	.25	.15	.09	.07	.01	.125
Below	.37	.30	.22	.18	.10	.25
Near normal	.20	.28	.30	.25	.17	.25
Above	.14	.18	.25	.29	.29	.25
Much above	.04	.09	.14	.21	.43	.125
D. Fall						
Much below	.21	.15	.12	.08	.01	.125
Below	.33	.30	.28	.24	.23	.25
Near normal	.23	.28	.28	.26	.23	.25
Above	.17	.21	.23	.26	.30	.25
Much above	.06	.06	.09	.16	.23	.125

In studying these tables one may note, for instance, that in winter a temperature forecast of much above normal carries a probability of 0 percent of occurring as much below, 13 percent as below, 27 percent as near normal, 27 percent as above, and 33 percent as much above. Thus it nearly triples its own usual likelihood of occurrence (0.33 vs. 0.125), while it reduces the chances of much below normal to practically nil. A forecast of near normal, on the other hand, gives little information beyond climatology. Throughout the year, in fact, the temperature outlooks tend to be more skillful at predicting extreme than average conditions and, also, warmer rather than colder conditions. Similarly, it can be seen in table 5 that a precipitation forecast of light is generally more reliable than one of moderate or heavy.

Any subscriber who knows the influence of monthly mean temperature or total precipitation on his firm's sales volume and costs can use these probability tables as a guide in making choices between possible courses of action. The procedure goes as follows: suppose that there are two alternate courses of action, X and Y (to rent or not to rent additional oil storage space, perhaps). Suppose further that the subscriber knows that if he chooses course X, his *net* gain (or loss) for the month will be plus (or minus) A_1 dollars if much below temperatures occur in his locality, A_2 if below, A_3 if near normal, A_4 if above, and A_5 if much above. Similarly, he knows that if he chooses course Y, his net gain (or loss) will be B_1, B_2, B_3, B_4, or B_5, depending on which temperature category actually occurs. (The dollar values of the A's and B's might, for instance, be determined by comparing company accounts with the monthly temperature records for several past years, if courses X and Y have each been followed at various times during those years.) It then follows that, given the forecast probabilities (p_1, p_2, p_3, p_4, p_5) of the five temperature classes, the *expected* net gain to be achieved by choosing course X is E_x dollars, where

$$E_x = p_1A_1 + p_2A_2 + p_3A_3 + p_4A_4 + p_5A_5,$$

and the expected net gain to be achieved by choosing Y is

$$E_y = p_1B_1 + p_2B_2 + p_3B_3 + p_4B_4 + p_5B_5.$$

To obtain the probabilities p, the subscriber examines the current monthly outlook to see what

temperature class is being forecast for his locality and looks up the column of table 4 headed by that class. (A forecast of above in winter, for example, leads to $p_1=0.04$, $p_2=0.17$, $p_3=0.24$, $p_4=0.33$, and $p_5=0.22$.) By performing the sum of products indicated in the formulas for E_x and E_y, the subscriber learns which course of action will give him the larger expected net gain. This is the course he should choose.

The tables given here will be most useful to those subscribers for whom E_x and E_y are nearly the same when climatological (chance) probabilities are substituted for the p's. Their decisions will then benefit from any margin of skill beyond chance attained by the monthly outlooks.

5. USE OF THE 30-DAY OUTLOOKS

It is generally agreed that the science of meteorology is not yet sufficiently developed to predict reliably the day-by-day details of the weather for more than a week in advance.[5] For this reason, the 30-day outlooks issued by the Weather Bureau are not specific weather forecasts in the usual sense. In the case of surface temperature and 700-mb. circulation, the outlooks apply only to average or mean conditions for the entire 30-day period. In the case of precipitation, they refer to the total amount which falls during a given month, regardless of how it is distributed in time. Thus, during a particular month, temperatures may average near normal and precipitation be moderate despite large fluctuations of weather from day to day or from week to week. Likewise, a forecast of much below normal temperature and heavy precipitation does not preclude the possibility of a hot day or a dry week some time during the month in question.

The outlooks also differ from conventional weather forecasts in that they are not primarily intended for specific points, especially those which have local peculiarities of climate. Being based upon the broadscale features of the atmospheric circulation over the entire Northern Hemisphere, they should instead be best suited to large geographical areas. For this reason, the user of the outlook should feel less secure about the prediction when the region with which he is concerned lies near the borders of the forecast classes of temperature and precipitation than when it is well within

[5] "Statement on Weather Forecasting" issued by the Council of the American Meteorological Society on July 1, 1957 and published in the *Bulletin of the American Meteorological Society*, vol. 38, No. 7, Sept. 1957, p. 406.

TABLE 5.—*Probability of occurrence of 30-day precipitation forecasts. Data from the 6 years ending December 1959.*

Probability of occurrence of—	Forecast			Chance
	Light	Moderate	Heavy	
A. Winter				
Light	.39	.37	.36	.33
Moderate	.36	.36	.33	.33
Heavy	.25	.27	.31	.33
B. Spring				
Light	.37	.33	.29	.33
Moderate	.34	.37	.37	.33
Heavy	.29	.30	.34	.33
C. Summer				
Light	.44	.33	.30	.33
Moderate	.29	.38	.38	.33
Heavy	.27	.29	.32	.33
D. Fall				
Light	.40	.34	.29	.33
Moderate	.33	.35	.35	.33
Heavy	.27	.31	.36	.33

the boundaries. This would be particularly true in areas of transition where several anomaly classes are close together. Even when the general pattern over the United States is predicted correctly, a small displacement can produce major errors in these areas. It is therefore believed that the outlooks are best adapted to the uses of a business concern with wide sectional or national interests.

The outlooks are also designed primarily for users with a consistent month-to-month need for weather information. Since a poor verification can be expected from time to time, too much weight should not be given to any one forecast. In the long run, however, benefit should be obtained by judicious use of the outlooks (perhaps along the lines indicated in section 4), since on the average they have demonstrated positive skill beyond chance.

Because of the large scale of the patterns which are forecast and the uncertainties involved in present forecast methods, the outlooks should not be taken too literally. If the prediction calls for one temperature or precipitation class in a certain locality, the user should be prepared for one of the adjacent classes to be observed, with probabilities given in tables 4 and 5. However, extremely

large errors, such as predicting much below when much above is observed or vice versa, are rare. In fact, table 4 shows that such errors of four classes have, on the average, a chance of only 3.5 percent of occurring when the extreme classes have been forecast. If all forecasts are considered, the frequency of occurrence of four-class errors averages 0.5 percent.

It should be noted that the 30-day outlooks are issued every 15 days, about the 1st and 16th of each month. One reason for this procedure is the fact that the outlooks, like all weather forecasts, appear to be more successful during the first part of the period to which they apply. In one sense, then, the outlooks may be used as 15-day forecasts. On the other hand, they are intended for the full 30 days and should not necessarily be abandoned after only 15 days have passed. Two successive 30-day outlooks need not agree with each other as regards the weather pattern predicted, in spite of their 15-day overlap. Even when they differ, in fact, each outlook may be correct for its own period.

6. SAMPLE 30-DAY OUTLOOKS

Each 30-day prediction consists of three maps showing the mean 700-mb. contours over the Northern Hemisphere and the temperature anomaly and precipitation classes over the contiguous United States. In addition, the outlooks contain maps showing the pattern of each of these three elements observed during the *previous* month. In this paper the maps observed during the *following* month have been reproduced alongside the predicted maps for the same period, so that each outlook may be readily verified by inspection. Beneath each prediction has been entered its verification score, using the same units discussed in section 3; i.e., the percent of 100 stations within one class for temperature, the percent correct for precipitation, and the correlation coefficients for the 700-mb. anomaly pattern. Forty-eight consecutive outlooks for the two years of 1958 and 1959 have been reproduced, starting with the prediction for the period mid-December 1957 to mid-January 1958 and ending with the one for December 1959.

The mean 700-mb. maps show the prevailing air flow at about 10,000 ft. They give the height of contours of the 700-mb. surface and are labeled in tens of feet; i.e., the contour labeled 1020 locates the area where atmospheric pressure is exactly 700 mb. at a height of 10,200 ft. Thin solid contours are drawn for every 200 ft., and certain intermediate contours at 100-ft. intervals are dashed. The wide arrows showing principal cyclone and anticyclone tracks on the prognostic 700-mb. charts are difficult to verify and therefore should be disregarded for purposes of this paper.

Of the 48 30-day outlooks reproduced on the following pages, the most successful on an overall basis was the one for October 1959 (p. 54). This outlook had a higher verification score than any other made during 1958 or 1959 in both United States precipitation (67 percent in correct class) and North American 700-mb. anomaly pattern (correlation of 0.93), and it scored well above the 2-year average on the three other verification statistics presented here; namely, United States temperature (93 percent correct within one class), Atlantic circulation (correlation of 0.74), and Pacific circulation (correlation of 0.54). It will therefore serve as a good example of what the user can expect with an excellent 30-day outlook. Note that, despite the overall excellence of the forecast, there were still areas in the Far Southwest where below normal temperatures were predicted, but above normal were observed, while the reverse situation existed in southern Texas. Heavy precipitation was observed in parts of Oregon and Florida where light had been forecast, while an area of light precipitation in the Black Hills region of South Dakota was observed where heavy had been predicted. The latter is an example of the rather localized, small-scale phenomena which make precipitation extremely difficult to explain or predict in all its detail.

It is interesting to note that the excellent 30-day outlook for October 1959 was followed by one almost as good, for mid-October to mid-November 1959 (p. 55), which had an even higher temperature score (95) but was lower in scores for precipitation (51) and 700-mb. anomaly pattern (correlations of 0.46, −0.24, and 0.35 in North America, Atlantic, and Pacific, respectively). The next 30-day outlook, for November 1959 (p. 56), was also very good, scoring above average in all verification statistics except precipitation.

On the other hand, the excellent October outlook was preceded by a very bad forecast, the one for mid-September to mid-October 1959 (p. 53), which had the second lowest temperature score in two years (37) and negative skill in 700-mb. anomaly pattern over North America (correlation of −0.23). The outlook for Septem-

ber 1959 (p. 52), was also quite poor, with the second lowest precipitation score in two years (23) and negative skill in 700-mb. anomaly pattern over the Atlantic (correlation of −0.03). Such a sequence of outlooks (poor followed by good) is not uncommon and usually indicates that an unsettled, variable regime of weather and circulation which is difficult to predict has finally crystallized into a well-marked and clear-cut regime which is apt to exhibit considerable stability for several months.

A somewhat similar sequence may occur when one well-defined pattern undergoes dramatic readjustment into an equally well-defined pattern of opposite type. For example, a very good outlook for mid-October to mid-November 1958 (p. 31) was followed by two very poor ones for November (p. 32) and mid-November to mid-December (p. 33) as most of the United States underwent a transition from a warm to a cold regime. This was followed by a series of good outlooks from December 1958 (p. 34) to February 1959 (p. 38), as the cold pattern became dominant.

There are times when drastic reversals of weather and circulation are well predicted. For example, the outlook for March 1959 (p. 40) was distinctly above average in all verification statistics, despite the fact that a large change from the February regime (p. 38) occurred in temperature, precipitation, and 700-mb. contour pattern. Another example of a good overall forecast during a transition period is the outlook for mid-June to mid-July 1958 (p. 23). In a similar fashion, the outlooks for both April and May (pp. 42, 44) of 1959 were excellent in temperature, despite the occurrence of marked month-to-month reversals in circulation and weather patterns.

Some typical forecast errors are well illustrated by the outlook for January 1958 (p. 12), which may be considered as an average forecast in terms of nearly all its verification scores. The temperature prediction correctly called for colder than normal weather in the eastern half of the United States (except New England) and warmer conditions in the West. However, the boundary between the areas of above and below normal temperatures was predicted to extend from northwest to southeast, but on the observed map it ran from northeast to southwest. Another typical error occurred over the Great Basin, where a large area of near normal temperature was predicted, surrounded by above normal, due in part to the effect of radiational cooling under a center of high pressure. In actuality, the outlook was one class too cool, as all the area forecast as near normal verified as above, and a good deal of that predicted above verified as much above. Note also that an isolated pocket of near normal temperatures (due to radiational cooling under a "Basin High") was observed, but it was displaced northeastward from the forecast position and much smaller in size.

Turning now to precipitation for January 1958, a typical error occurred in the Far West, where heavy was predicted in the south but was observed in the north. A displacement of this type can easily occur with a slight northward or southward shift of the principal storm track and "jet stream." The worst forecast was for the Southern Plains, where light precipitation was forecast, but heavy was observed, An error of the opposite type was found in parts of the Southeast, where heavy was forecast, but light was observed. It is fairly common for a large, continuous area of predicted heavy precipitation, such as drawn in the East, to verify in a broken, discontinuous fashion with areas of moderate, and even light, interspersed with the heavy, such as actually occurred this month. It is difficult to predict accurately a precipitation distribution of this type, even with a perfect 700-mb. contour prognosis.

The errors in temperature and precipitation for January 1958, discussed above, were associated with corresponding errors in prognostic 700-mb. anomaly patterns. The ridge of high contour values observed over western North America was not forecast with sufficient intensity in the outlook, whereas the high center over the Caribbean was predicted too strong. At the same time, the trough of low contour values observed over eastern North America was predicted too deep in Canada, but too weak and too far west in the United States. As a result the weather was colder and drier than forecast in the Southeast. The low center observed in the western Gulf of Alaska was well positioned in the outlook but not forecast of sufficient intensity. This factor combined with the strength of the ridge over the Great Basin to produce unexpected heavy precipitation in the Pacific Northwest, mild weather in the Northern Plains, and light precipitation in parts of the West. Thus, temperature and precipitation are very sensitive to the 700-mb. contour pattern, and relatively minor errors in prognosis of the latter can lead to important errors in predicting the weather.

With the above considerations in mind, the reader is now invited to examine carefully the file of outlooks and verifying maps reproduced in the next 48 pages. After studying this file in conjunction with the rest of the paper, readers may judge for themselves the usefulness of the 30-day outlooks for their own particular needs.

It is also hoped that these maps will stimulate the interest of meteorologists and other scientists in the behavior of long-period mean circulation patterns—an important class of meteorological phenomena which has sometimes been neglected in the past. For it is only through continuation and expansion of our current limited research program in this field that substantial progress toward increasing the accuracy of the 30-day outlooks can be attained.

7. CONCLUSIONS

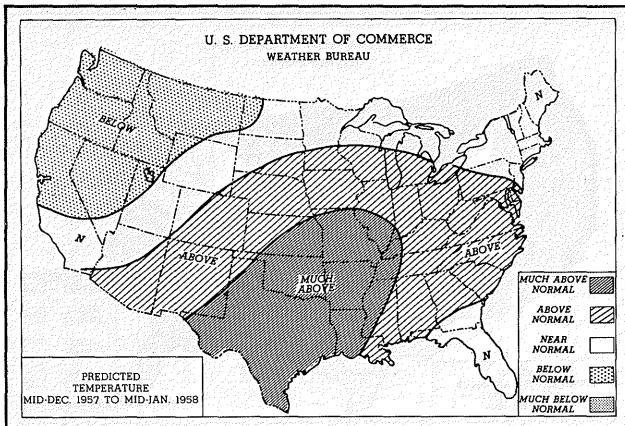
The principal findings of this report may be summarized as follows:

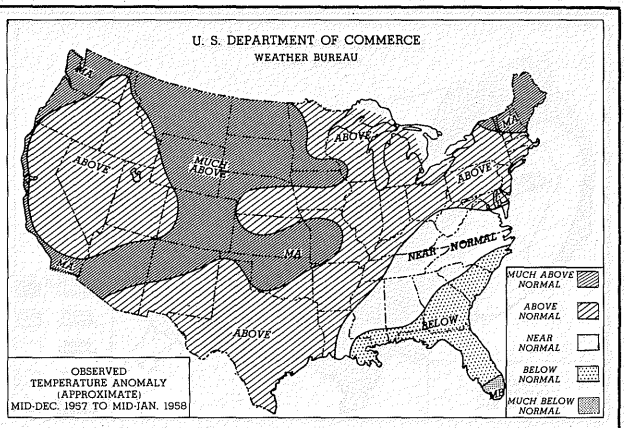
1. Although there are large fluctuations in the accuracy of the 30-day outlooks from one month to the next, on the average they show positive skill when compared to climatological probability or to persistence. In addition, they have been somewhat more accurate during 1958–59 than previously.

2. The skill of the temperature forecasts lies more in the prediction of extremes than of average conditions, and of warmer weather rather than colder; the skill of the precipitation forecasts lies more in the ability to predict dry rather than wet conditions. For both temperature and precipitation the skill is greatest in summer.

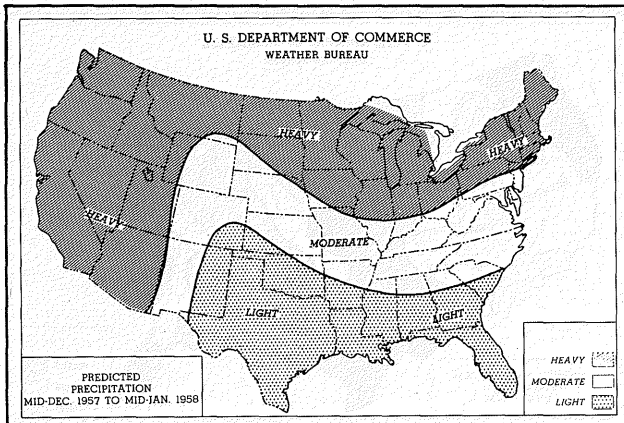
3. The reliability of the temperature predictions is greater than that of precipitation predictions and is related to the degree of accuracy of the prediction of prevailing upper-air winds.

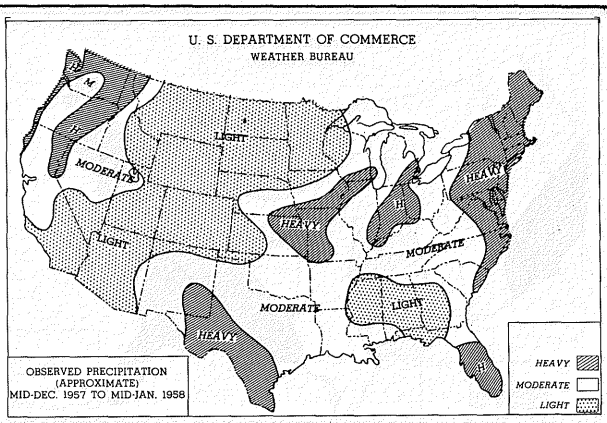
4. Those subscribers to the outlooks who know how their business is affected by average monthly weather conditions can, by interpreting the forecasts in probability terms, estimate the expected gain accruing from various choices of action.



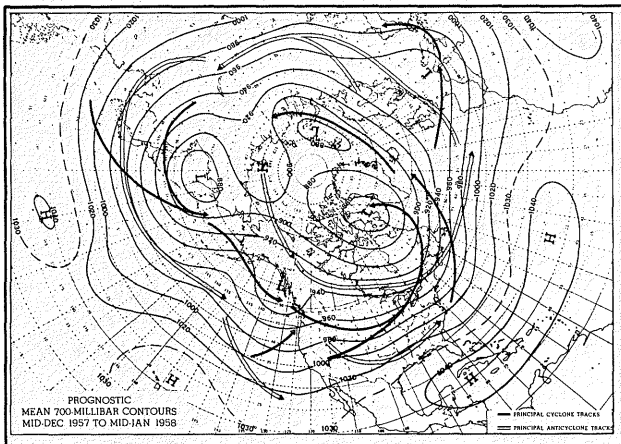


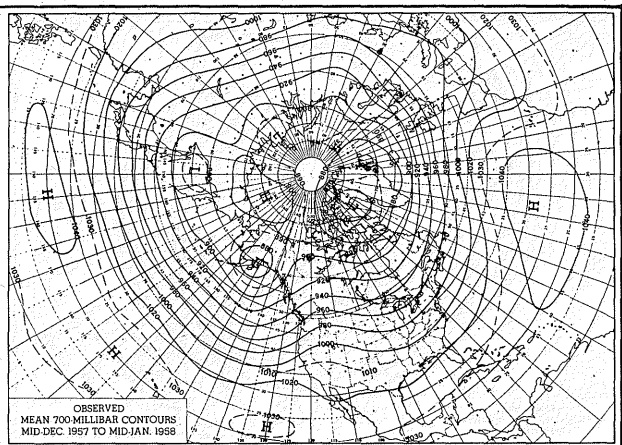
Temperature Score: 63 % within 1 class (of five)





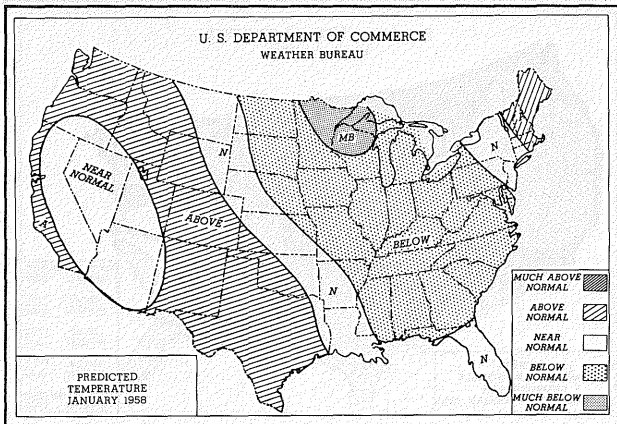
Precipitation Score: 34 % in the correct class (of three)

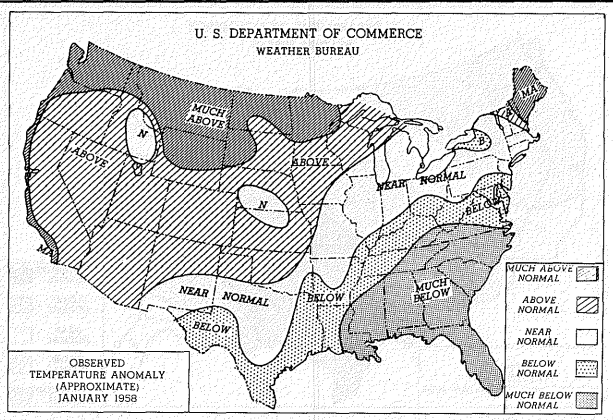




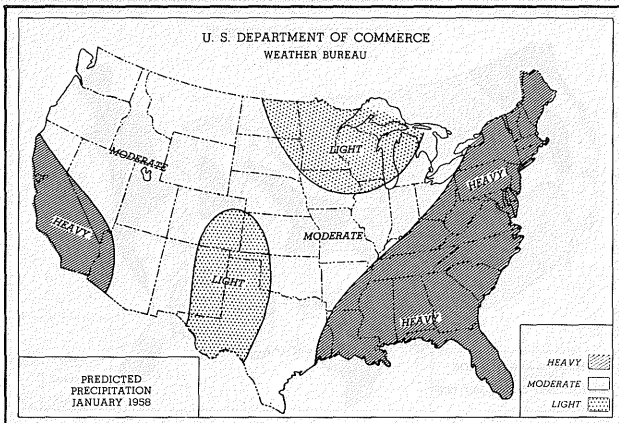
700 mb Anomaly Pattern Correlation Coefficients:

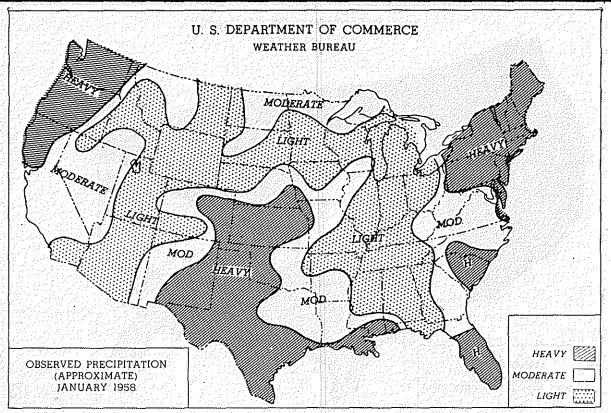
Atlantic	+0.69
North America	+0.43
Pacific	+0.04



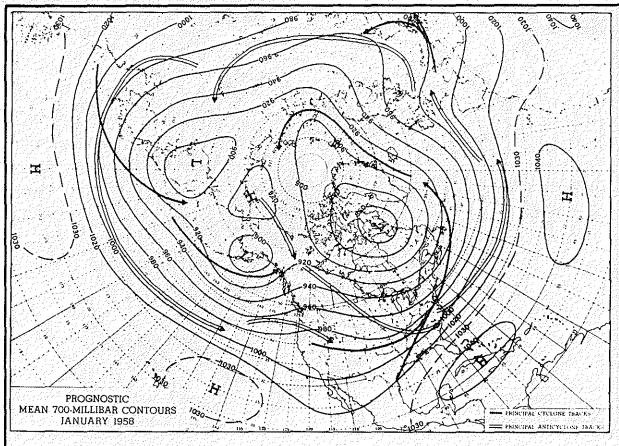


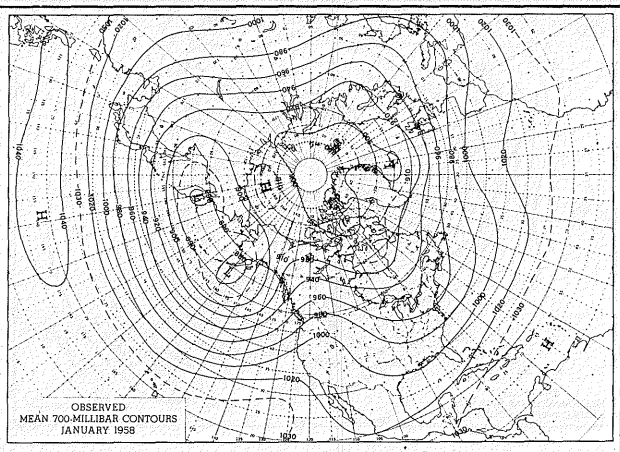
Temperature Score: 77 % within 1 class (of five)





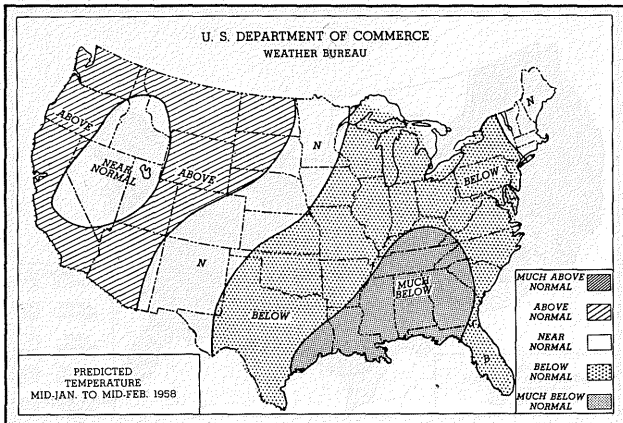
Precipitation Score: 37 % in the correct class (of three)

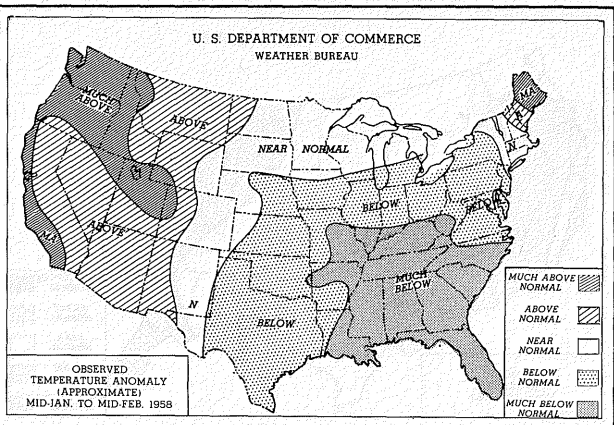




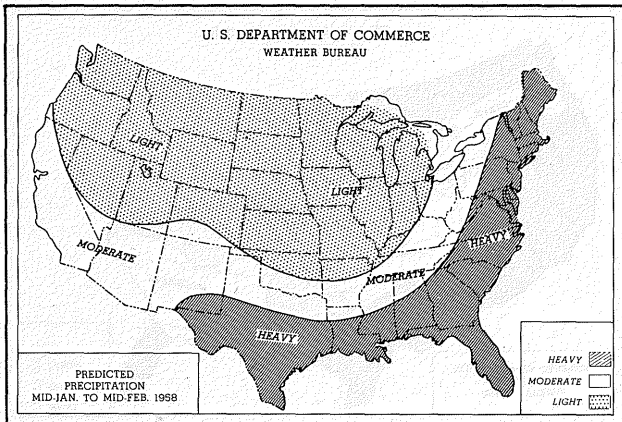
700 mb Anomaly Pattern Correlation Coefficients:

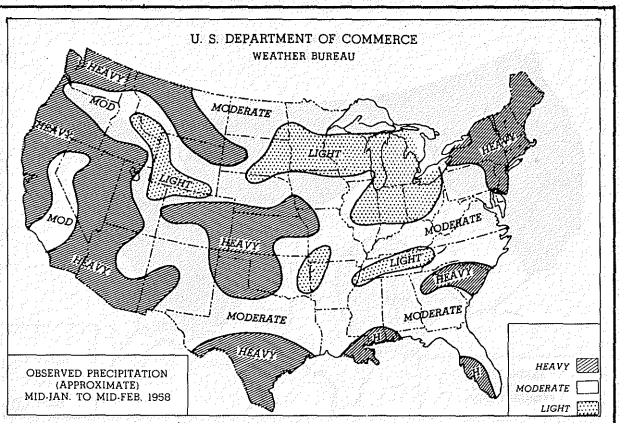
Atlantic	-0.05
North America	+0.34
Pacific	+0.37



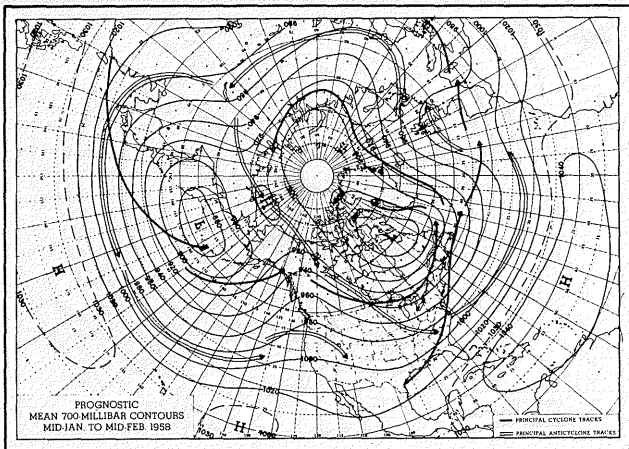


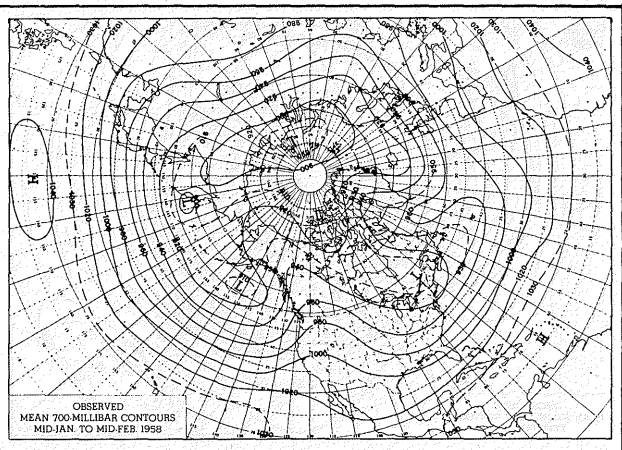
Temperature Score: 96 % within 1 class (of five)





Precipitation Score: 35 % in the correct class (of three)





700 mb Anomaly Pattern Correlation Coefficients:

Atlantic	+0.29
North America	+0.16
Pacific	+0.46

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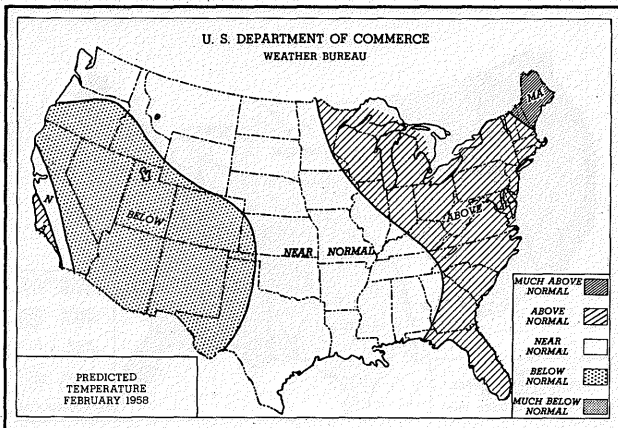
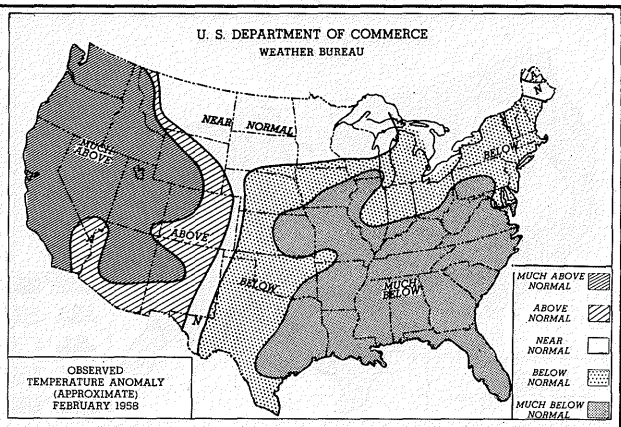
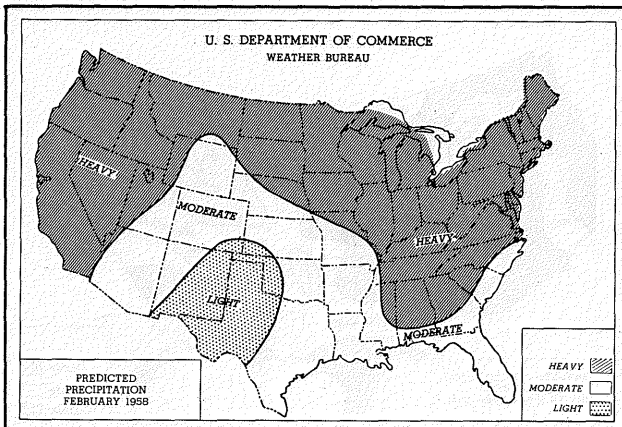
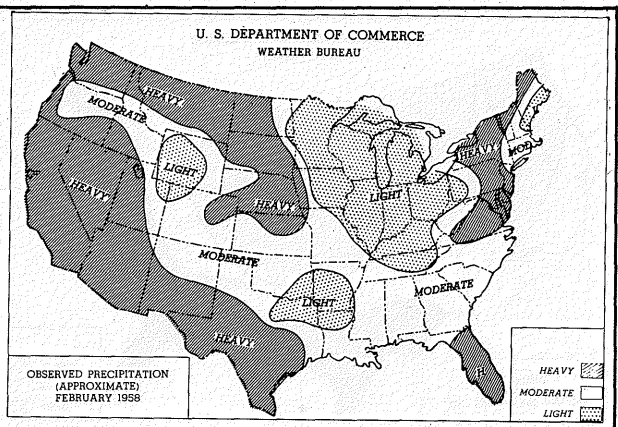


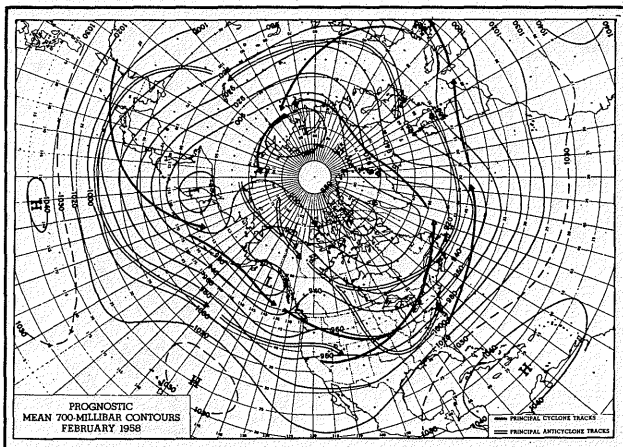


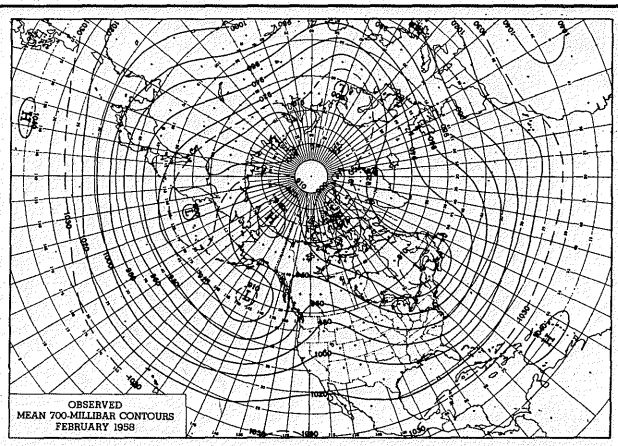
Temperature Score: 23 % within 1 class (of five)





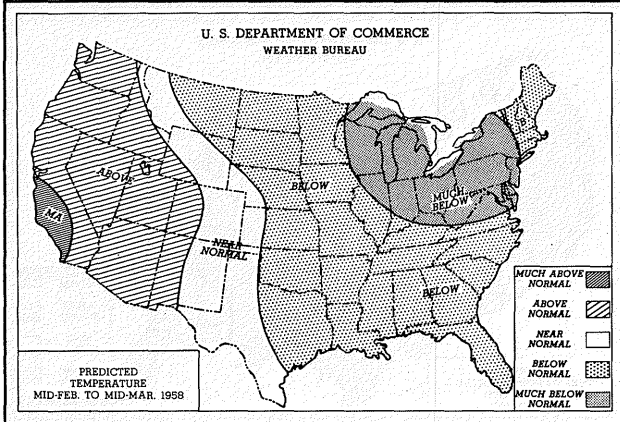
Precipitation Score: 41 % in the correct class (of three)

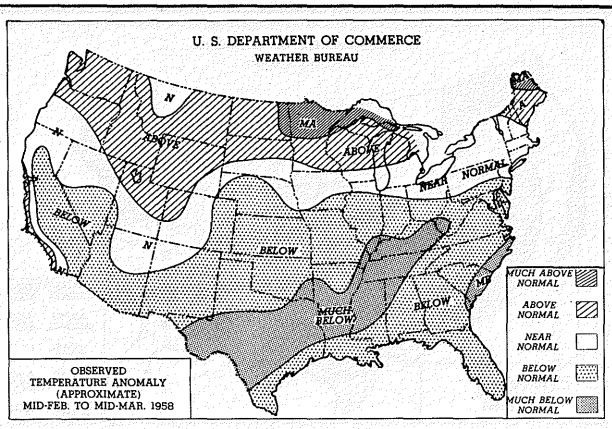




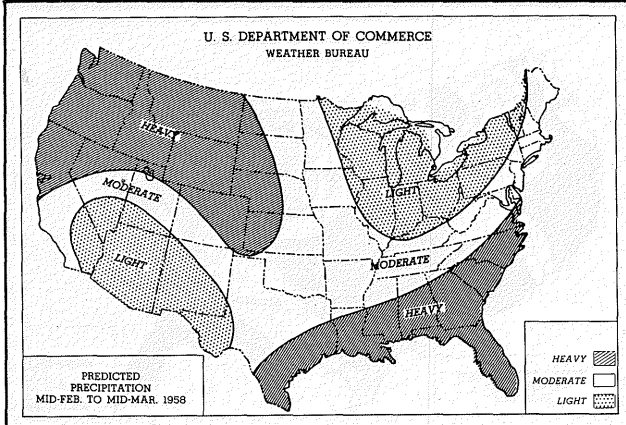
700 mb Anomaly Pattern Correlation Coefficients:

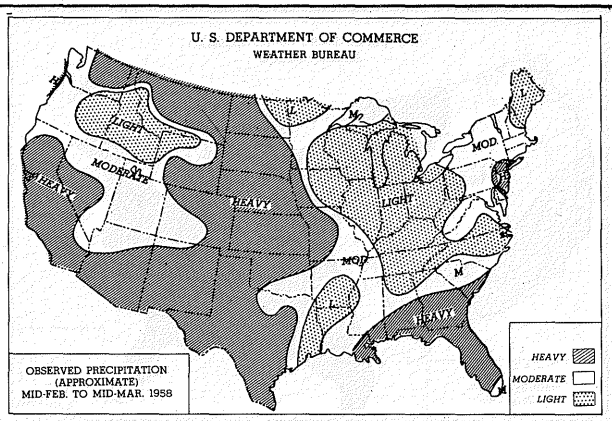
Atlantic	+0.58
North America	+0.27
Pacific	-0.21



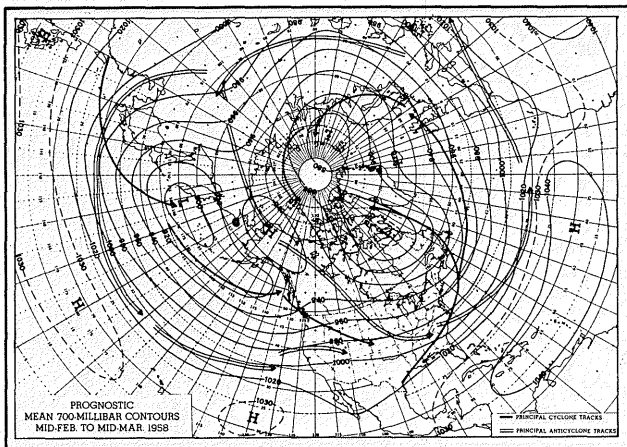


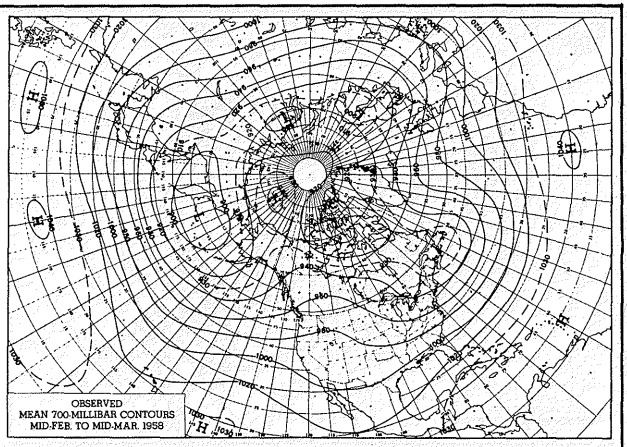
Temperature Score: 68 % within 1 class (of five)





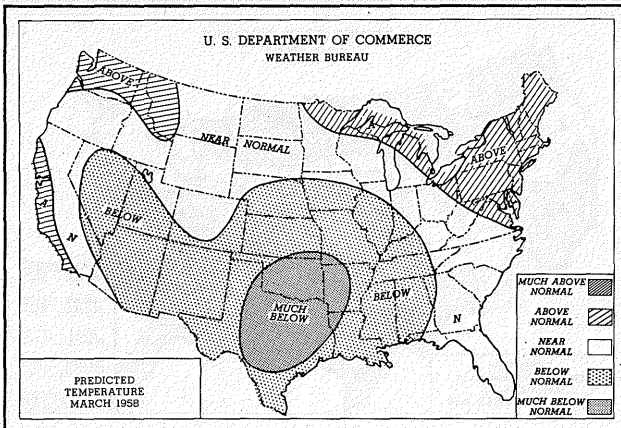
Precipitation Score: 41 % in the correct class (of three)

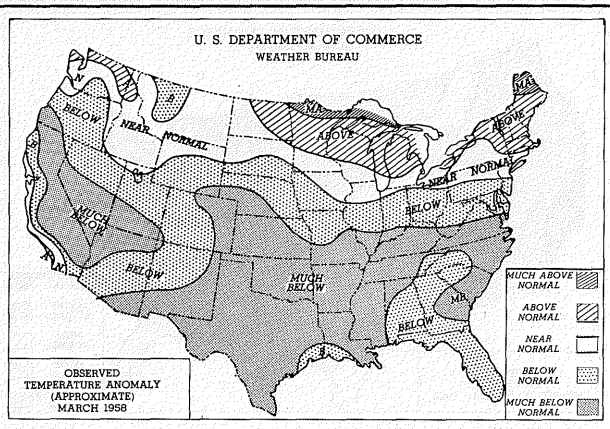




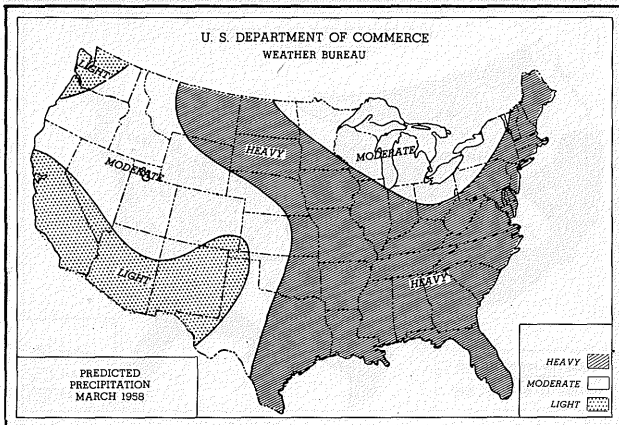
700 mb Anomaly Pattern Correlation Coefficients:

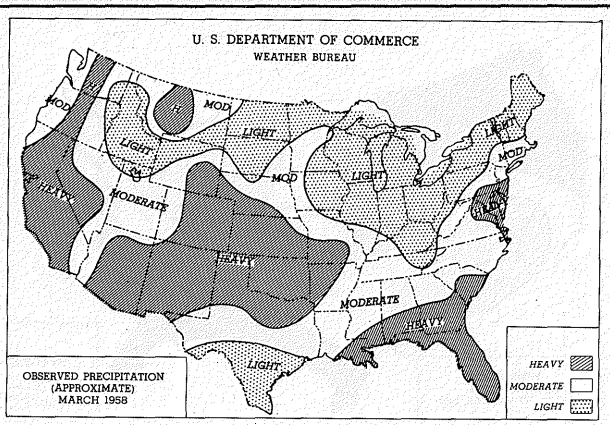
Atlantic	-0.05
North America	-0.12
Pacific	+0.67



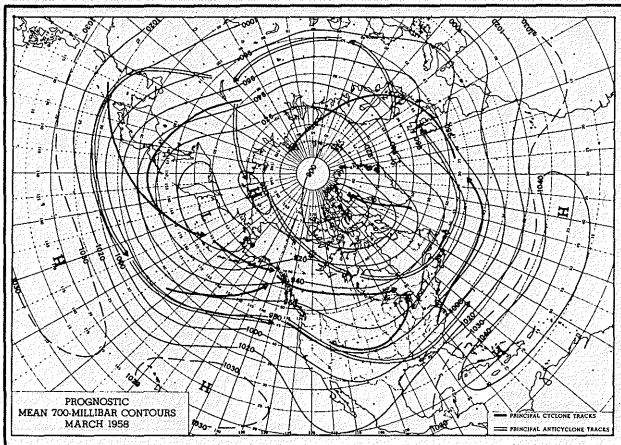


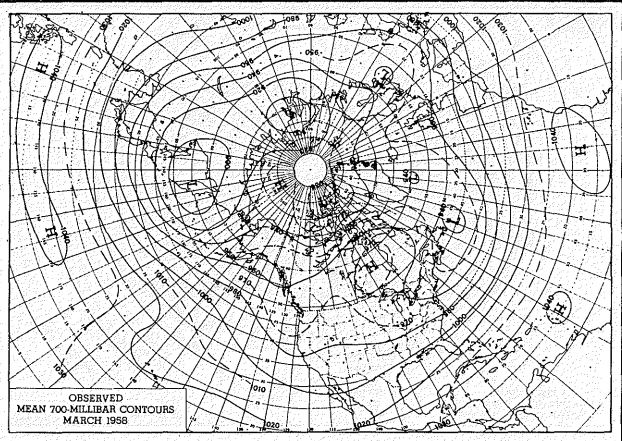
Temperature Score: 87 % within 1 class (of five)





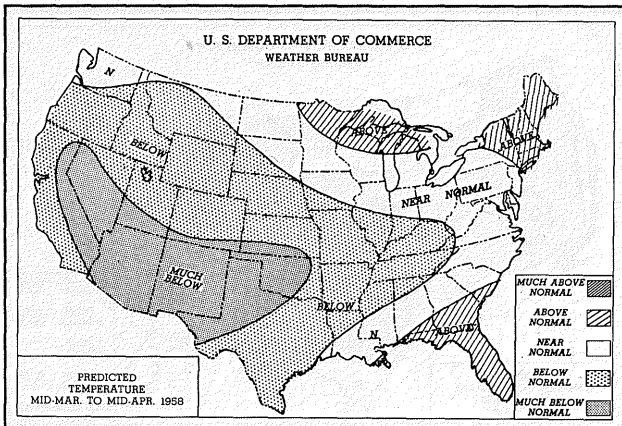
Precipitation Score: 28 % in the correct class (of three)

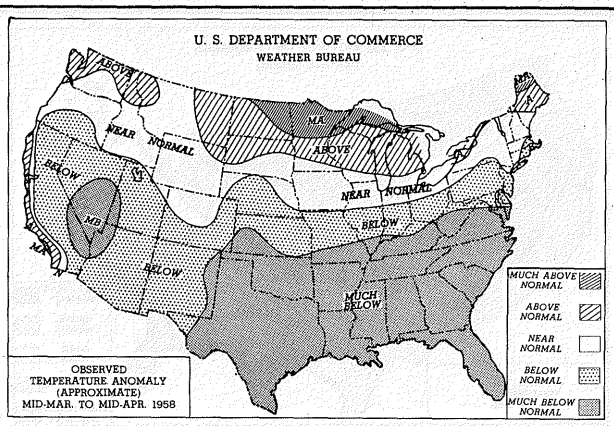




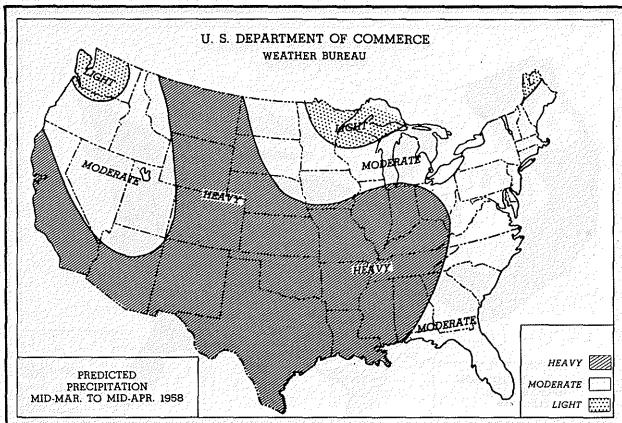
700 mb Anomaly Pattern Correlation Coefficients:

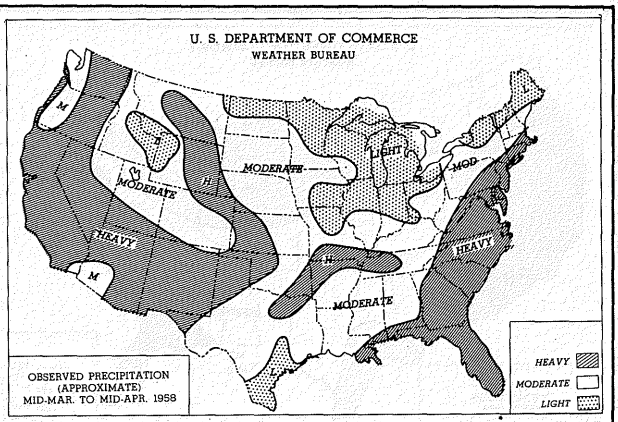
Atlantic	+0.40
North America	+0.06
Pacific	-0.33



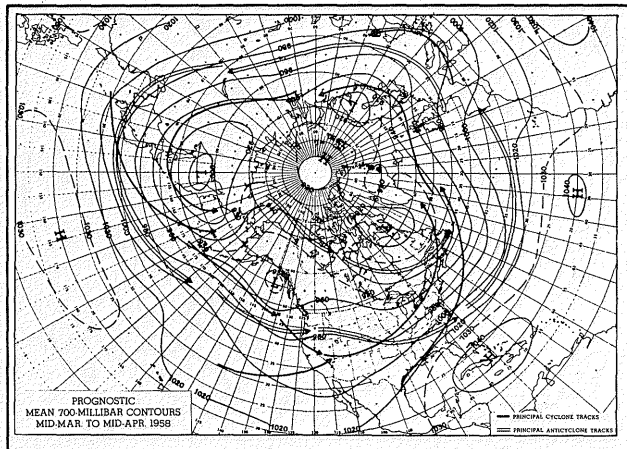


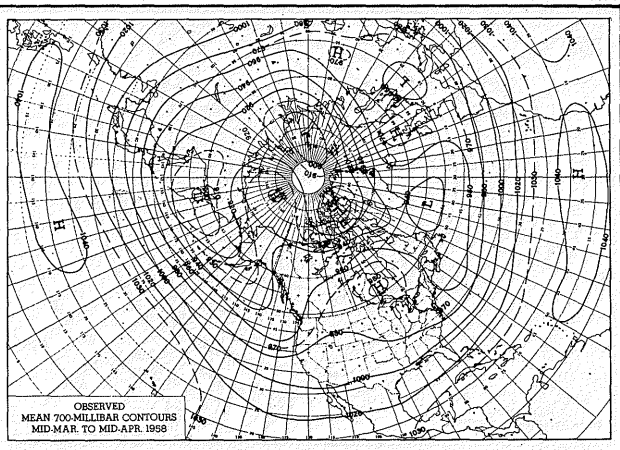
Temperature Score: 78 % within 1 class (of five)





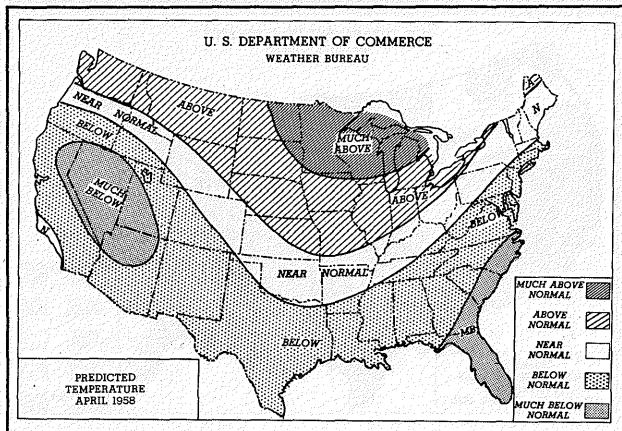
Precipitation Score: 34 % in the correct class (of three)

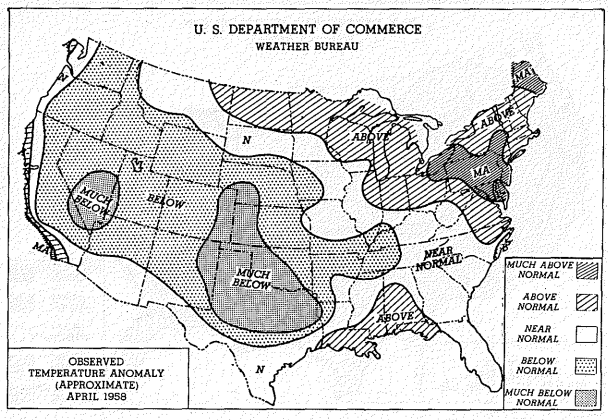




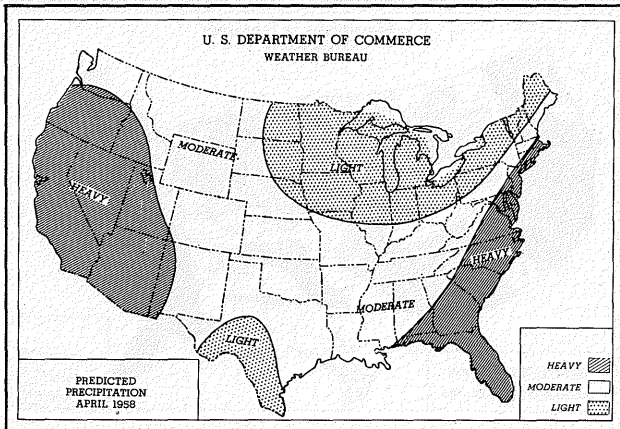
700 mb Anomaly Pattern Correlation Coefficients:

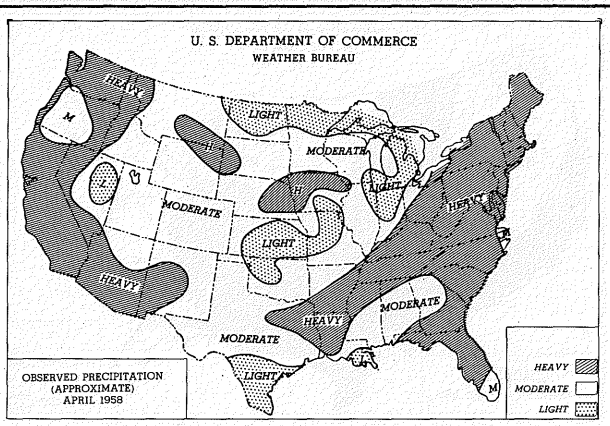
Atlantic	+0.41
North America	+0.46
Pacific	+0.42



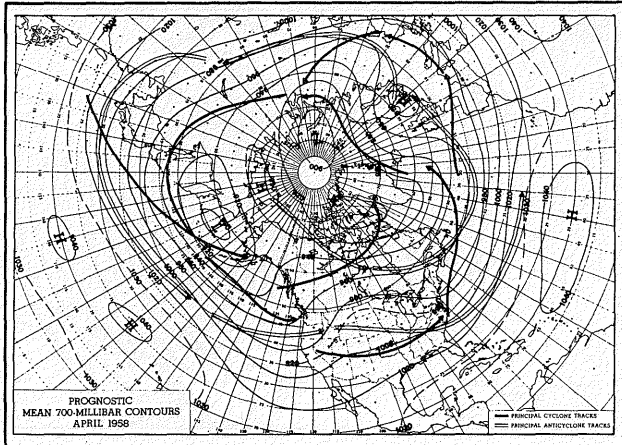


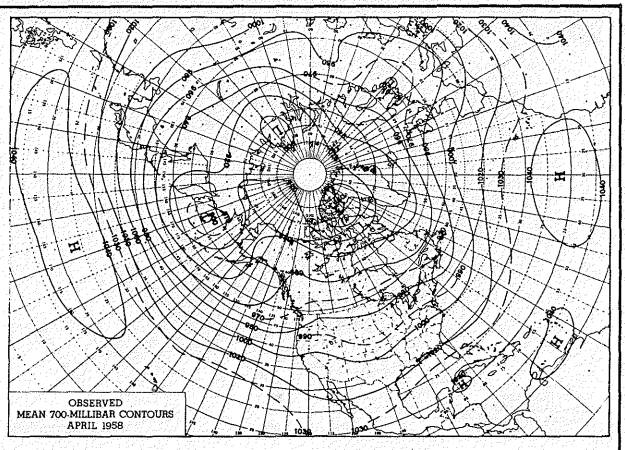
Temperature Score: 76 % within 1 class (of five)





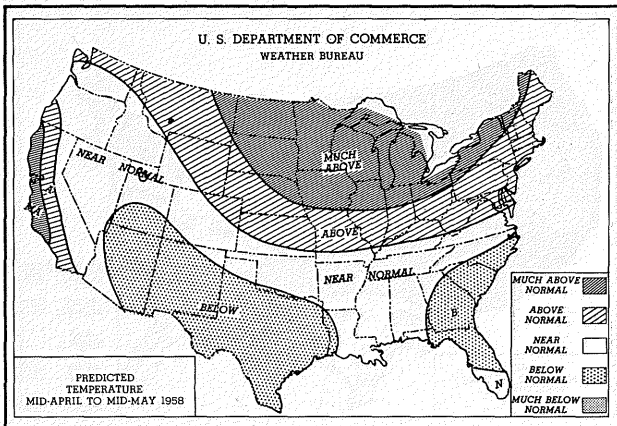
Precipitation Score: 48 % in the correct class (of three)

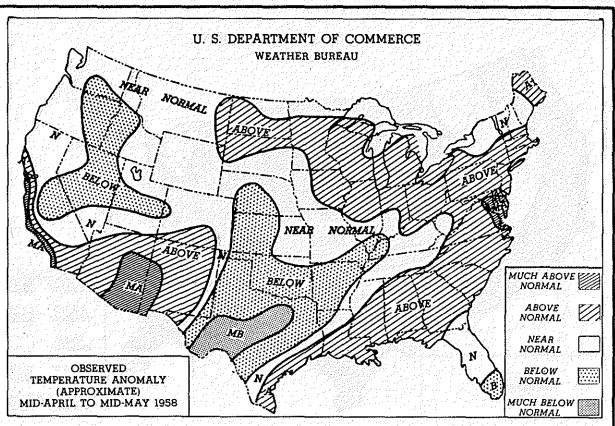




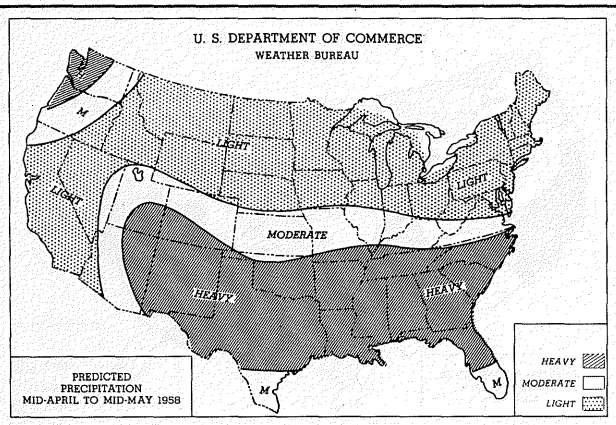
700 mb Anomaly Pattern Correlation Coefficients:

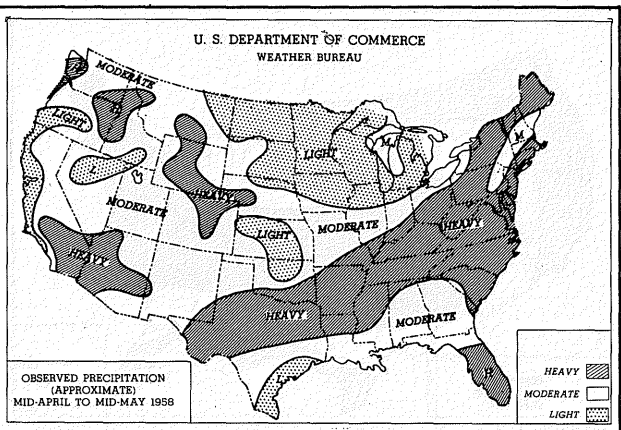
Atlantic	-0.11
North America	+0.54
Pacific	+0.53



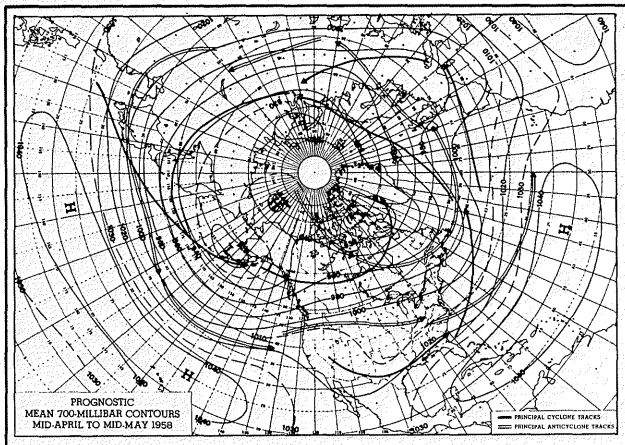


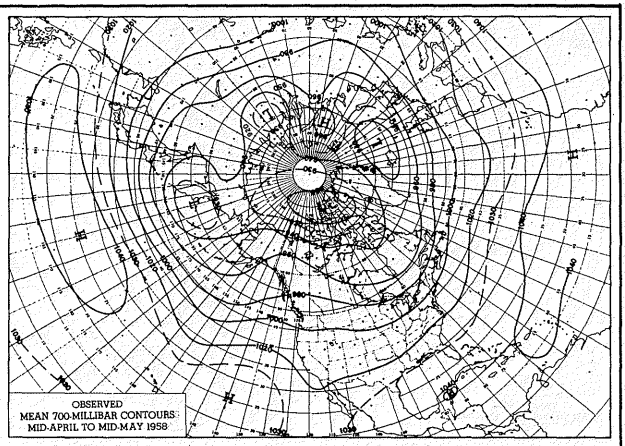
Temperature Score: 77 % within 1 class (of five)





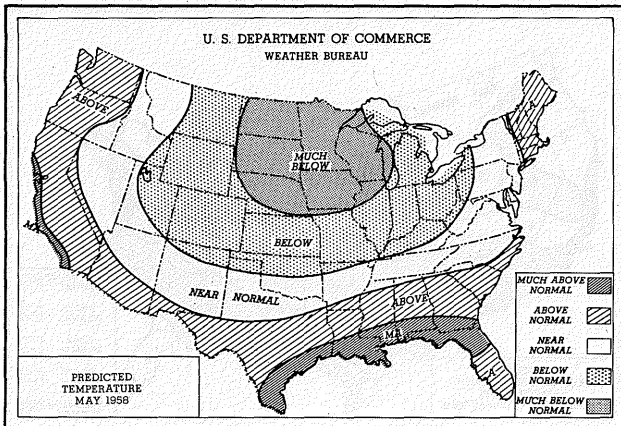
Precipitation Score: 38 % in the correct class (of three)

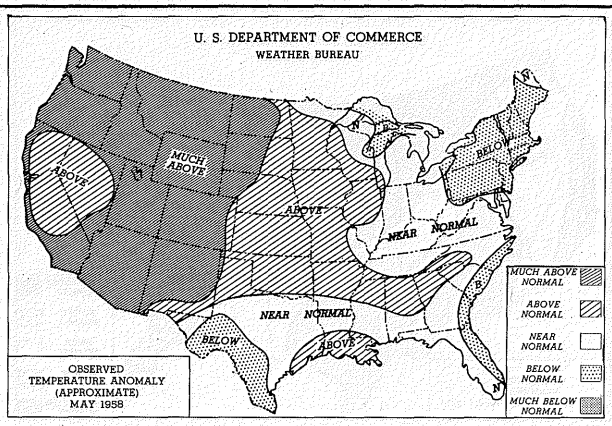




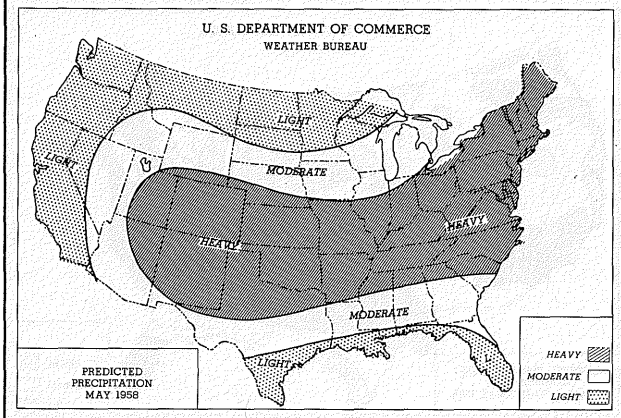
700 mb Anomaly Pattern Correlation Coefficients:

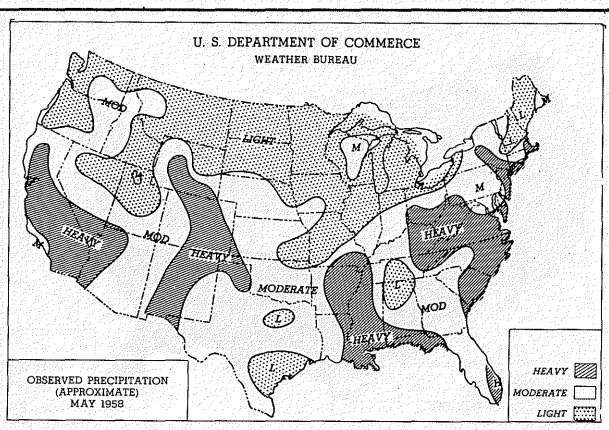
Atlantic	+0.23
North America	+0.28
Pacific	+0.26



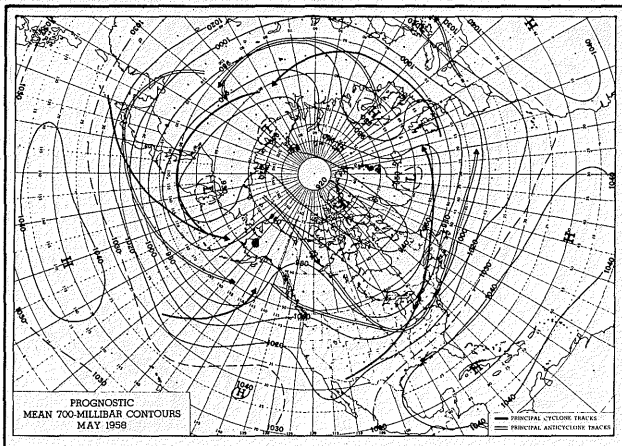


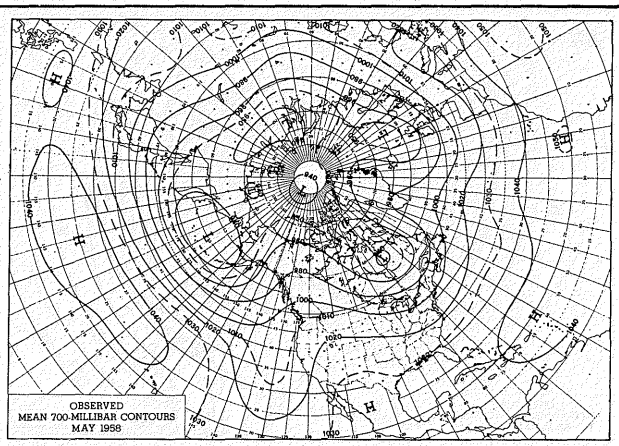
Temperature Score: 60 % within 1 class (of five)





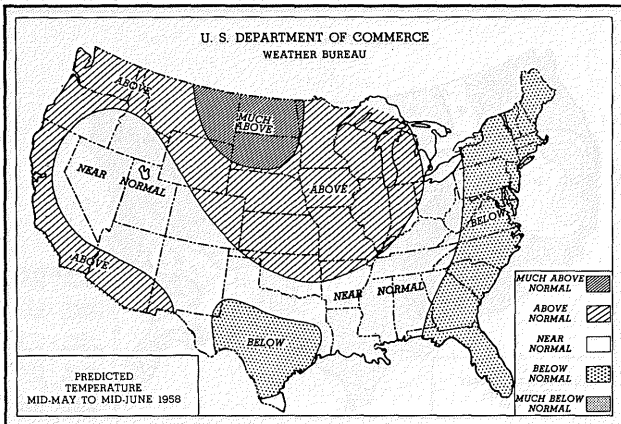
Precipitation Score: 38 % in the correct class (of three)

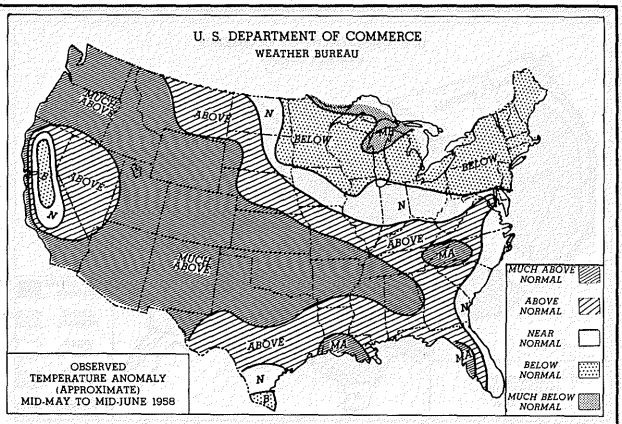




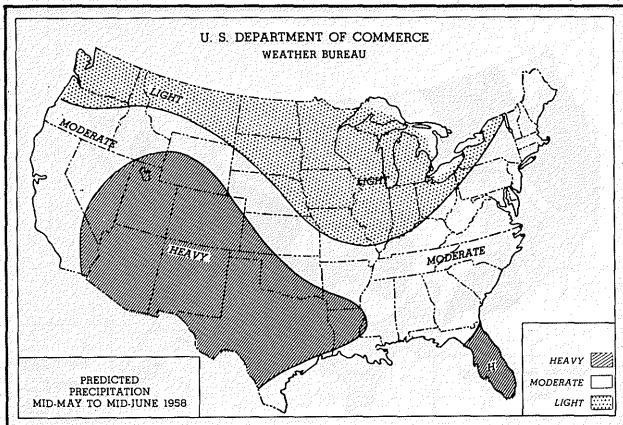
700 mb Anomaly Pattern Correlation Coefficients:

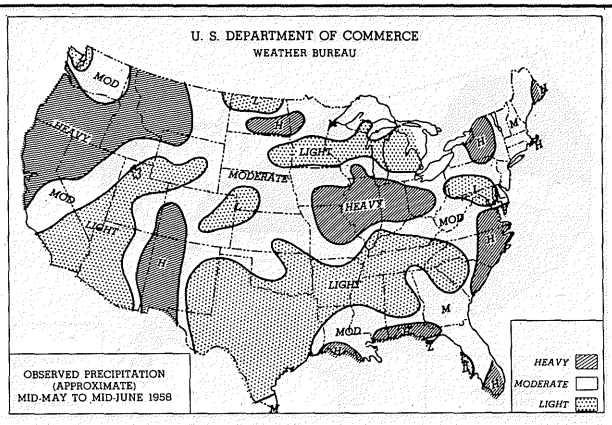
Atlantic	+0.33
North America	+0.17
Pacific	+0.31



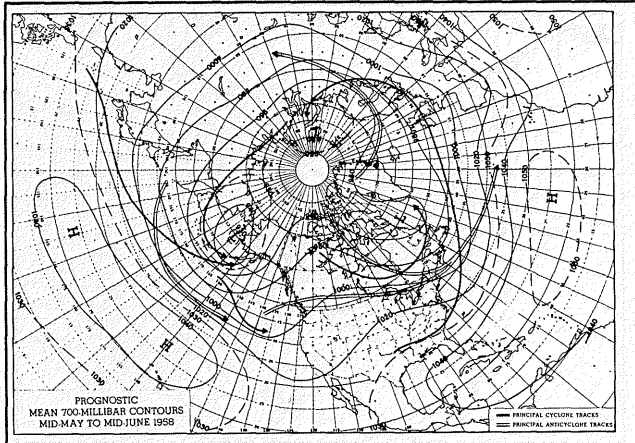


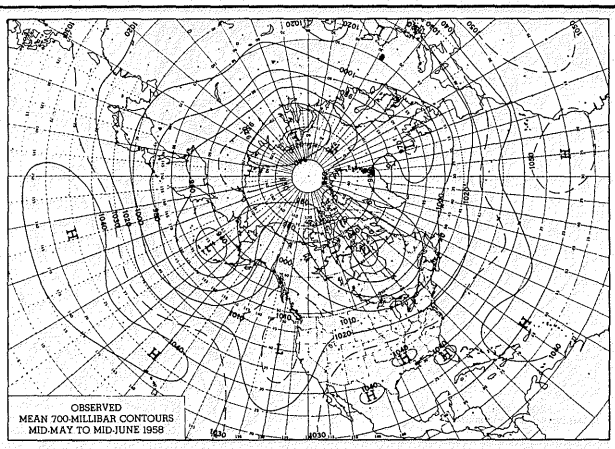
Temperature Score: 66 % within 1 class (of five)





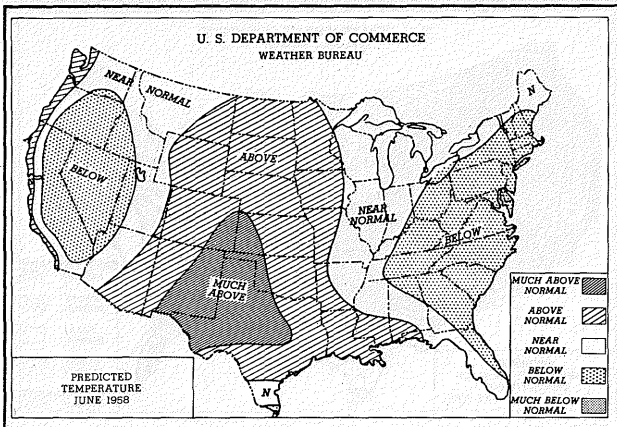
Precipitation Score: 32 % in the correct class (of three)

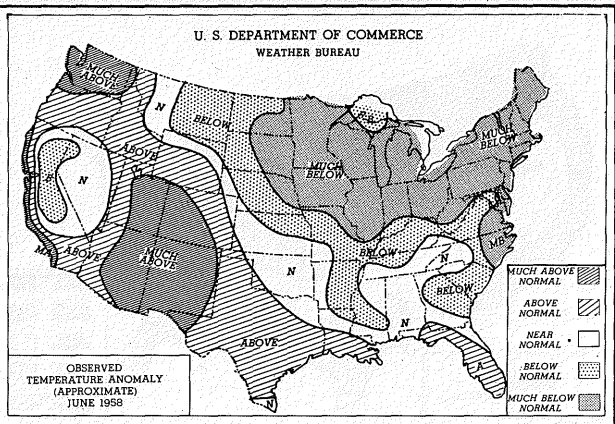




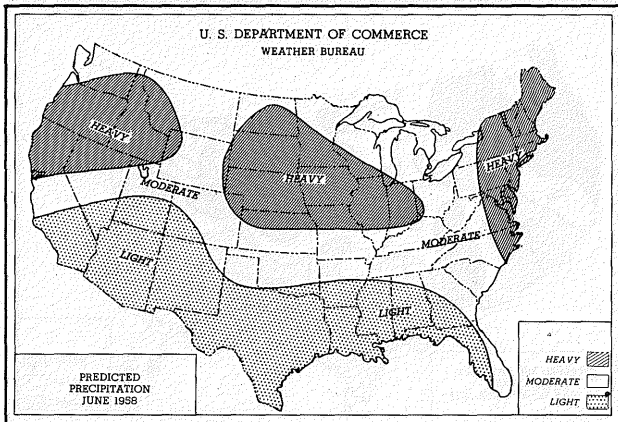
700 mb Anomaly Pattern Correlation Coefficients:

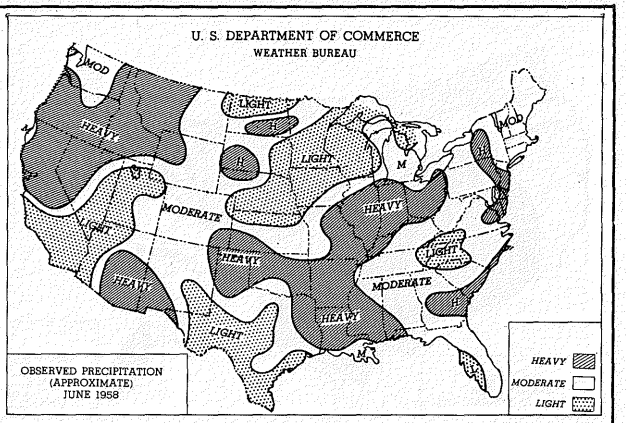
Atlantic	+0.43
North America	-0.23
Pacific	+0.17



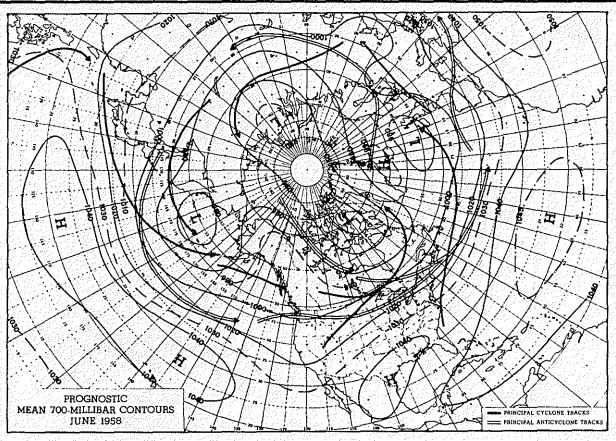


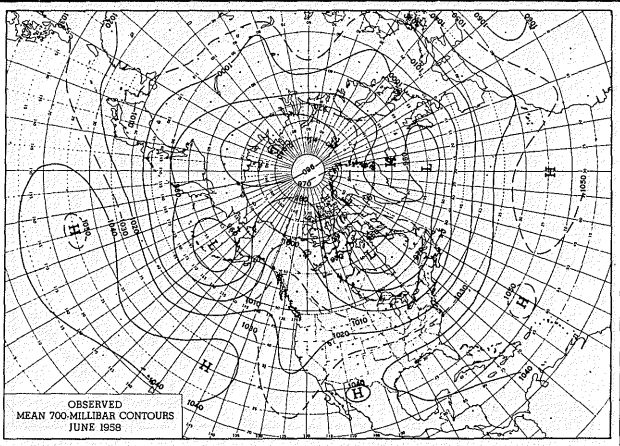
Temperature Score: 66 % within 1 class (of five)





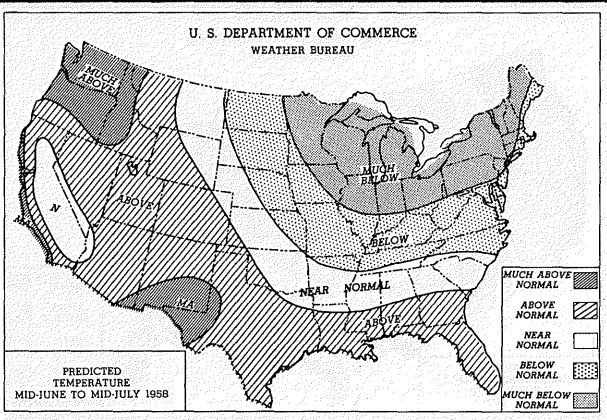
Precipitation Score: 46 % in the correct class (of three)

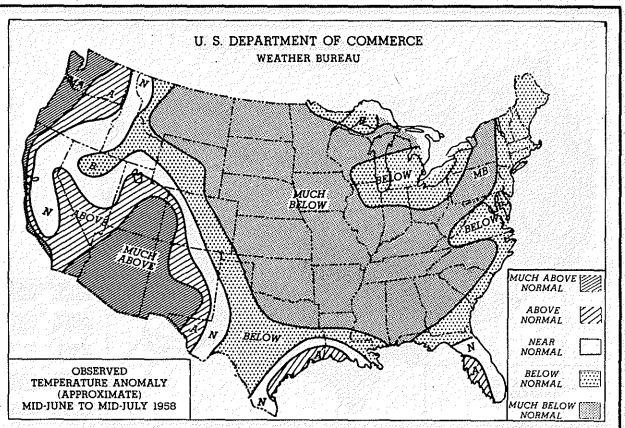




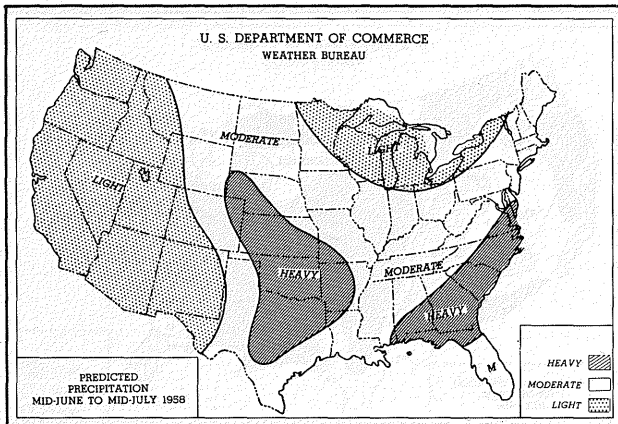
700 mb Anomaly Pattern Correlation Coefficients:

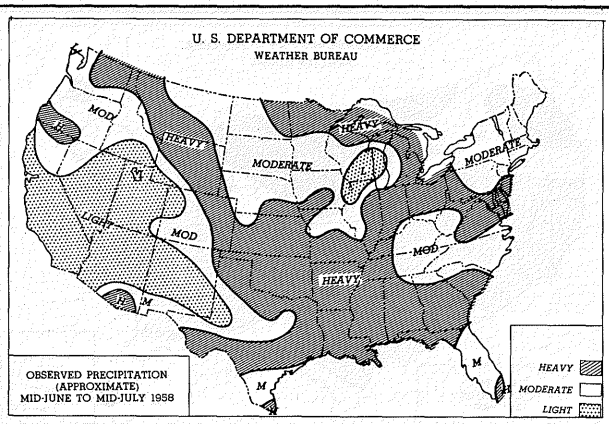
Atlantic	+0.69
North America	-0.21
Pacific	+0.39



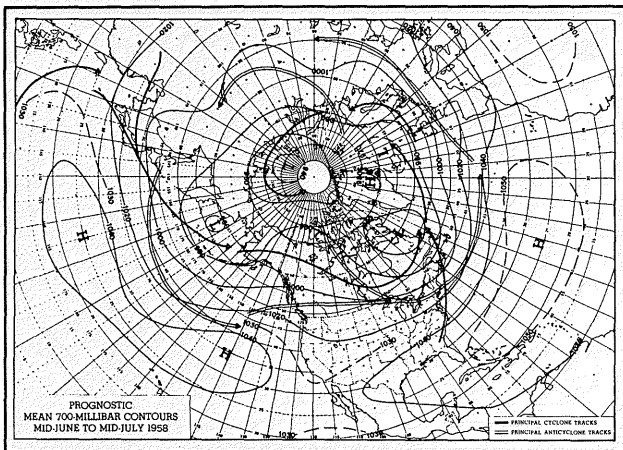


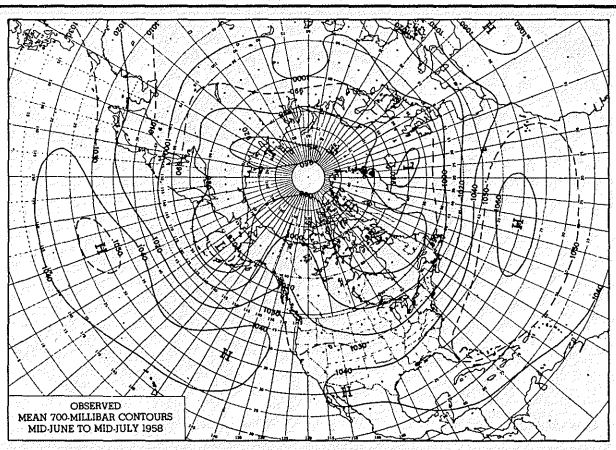
Temperature Score: 72 % within 1 class (of five)





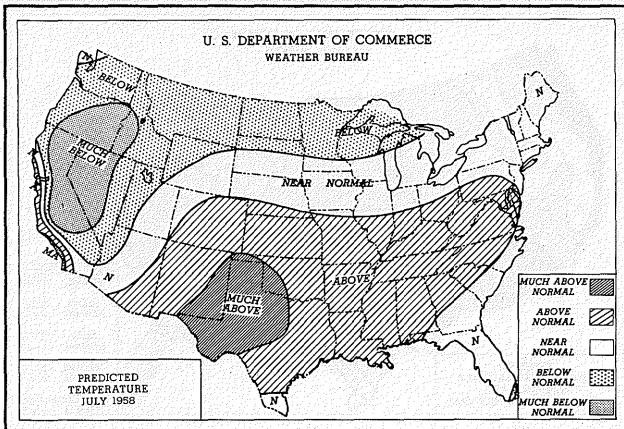
Precipitation Score: 47 % in the correct class (of three)

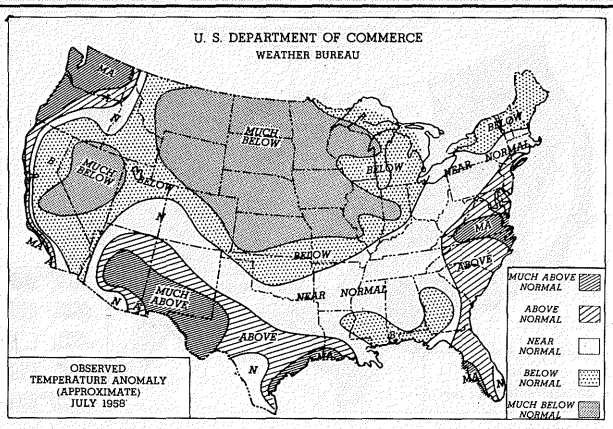




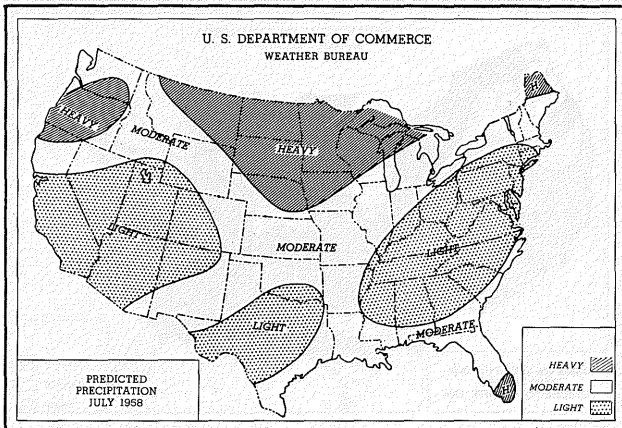
700 mb Anomaly Pattern Correlation Coefficients:

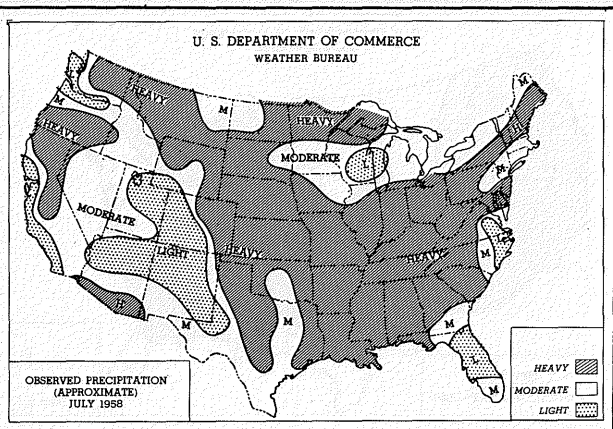
Atlantic	+0.18
North America	+0.78
Pacific	+0.60



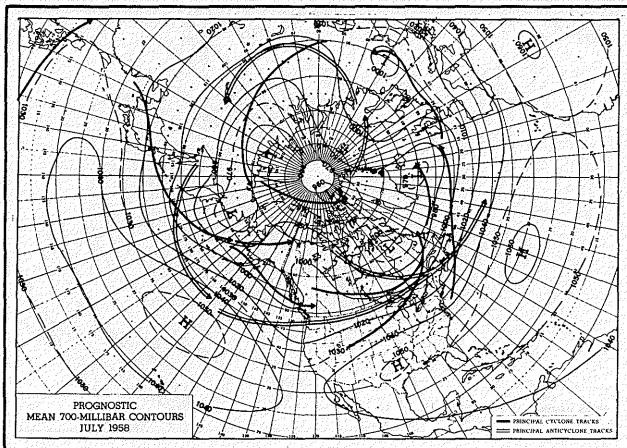


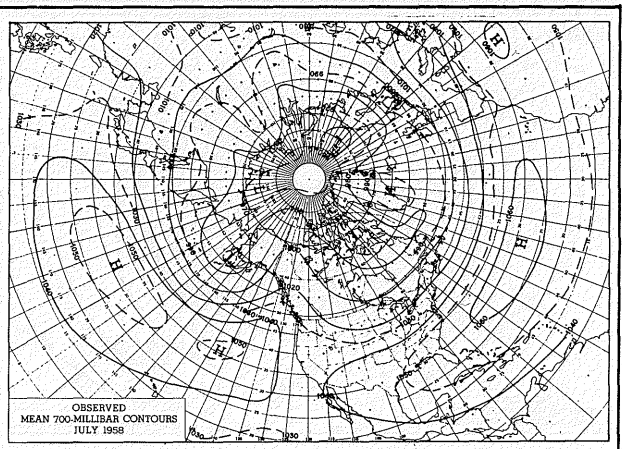
Temperature Score: 65 % within 1 class (of five)





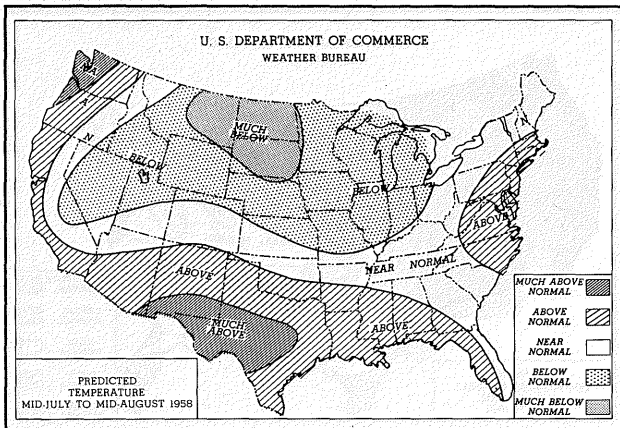
Precipitation Score: 30 % in the correct class (of three)

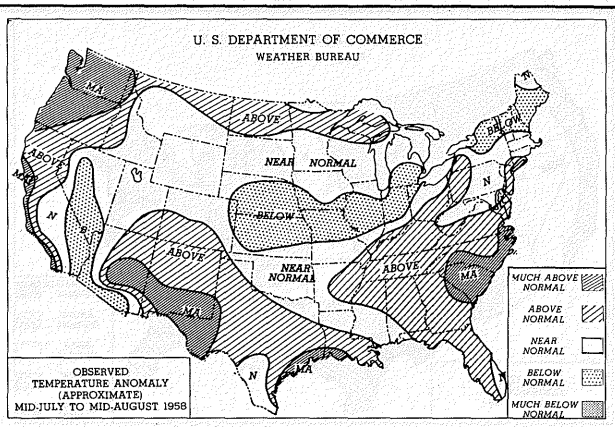




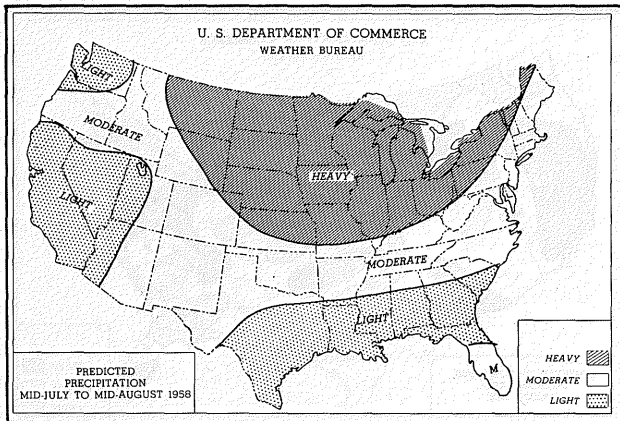
700 mb Anomaly Pattern Correlation Coefficients:

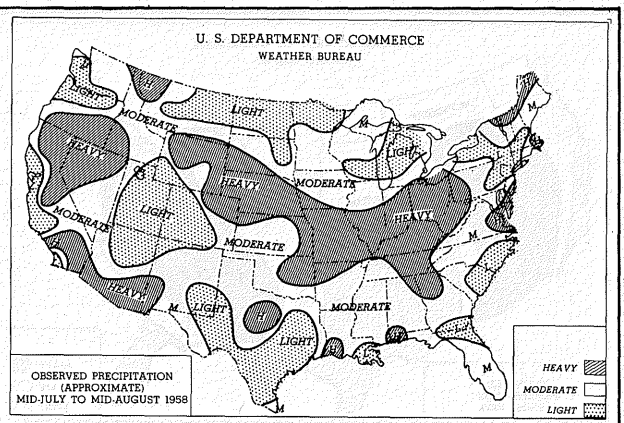
Atlantic	+0.64
North America	+0.37
Pacific	-0.47



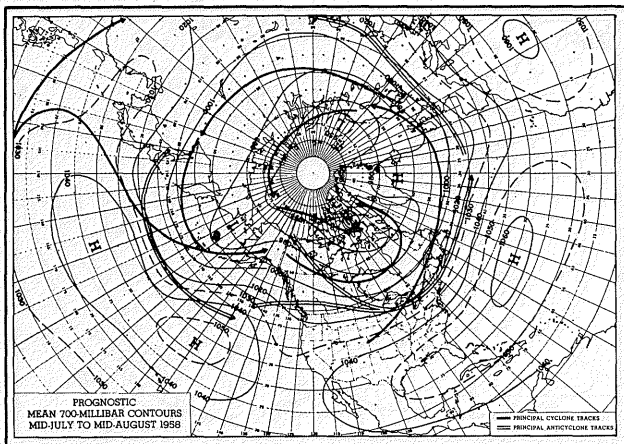


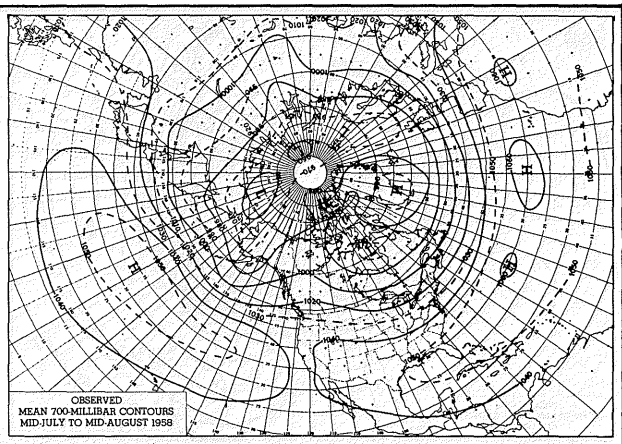
Temperature Score: 89 % within 1 class (of five)





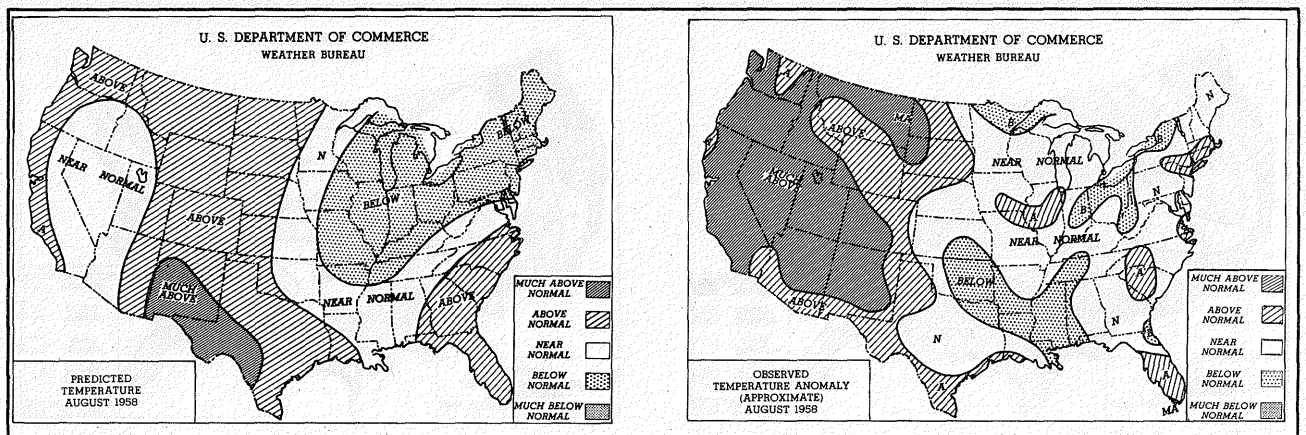
Precipitation Score: 40 % in the correct class (of three)



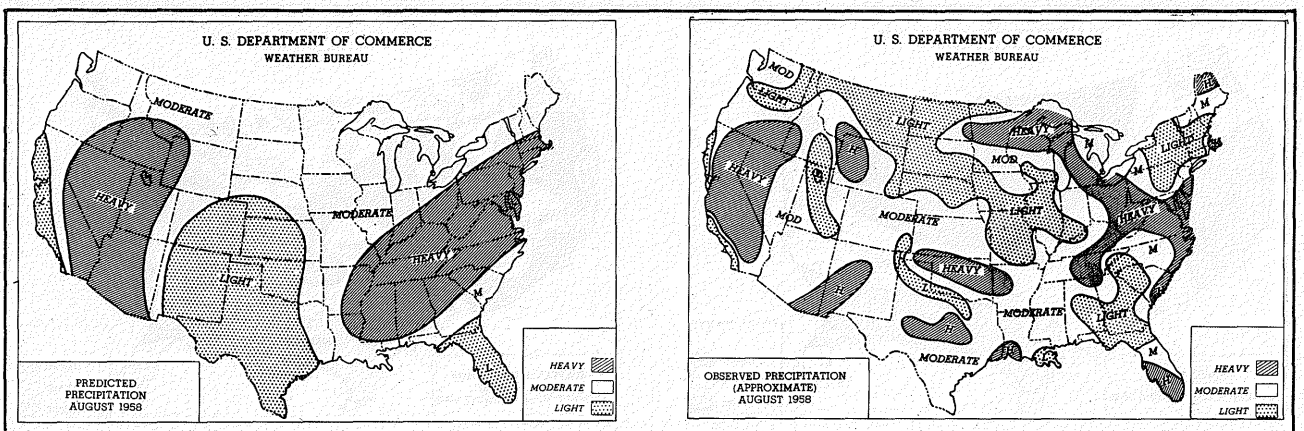


700 mb Anomaly Pattern Correlation Coefficients:

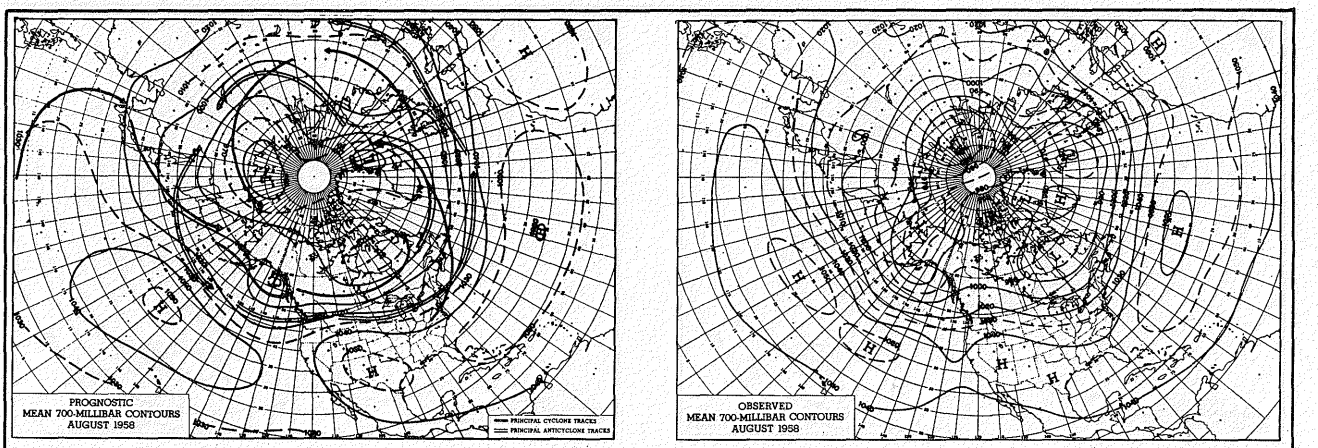
Atlantic	+0.42
North America	-0.07
Pacific	-0.24



Temperature Score: 82 % within 1 class (of five)

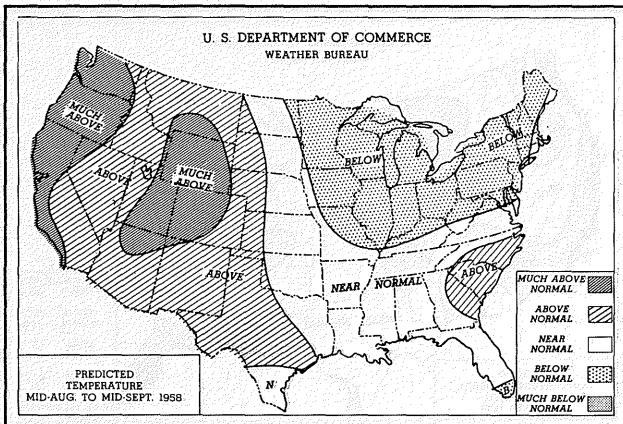


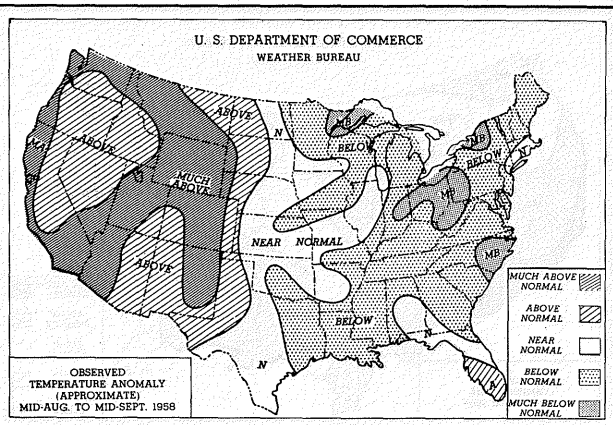
Precipitation Score: 34 % in the correct class (of three)



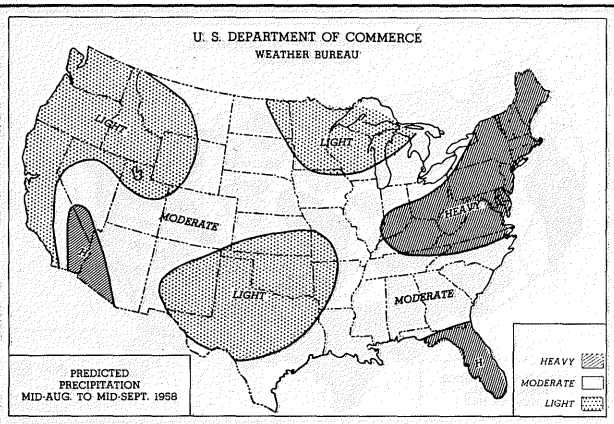
700 mb Anomaly Pattern Correlation Coefficients:

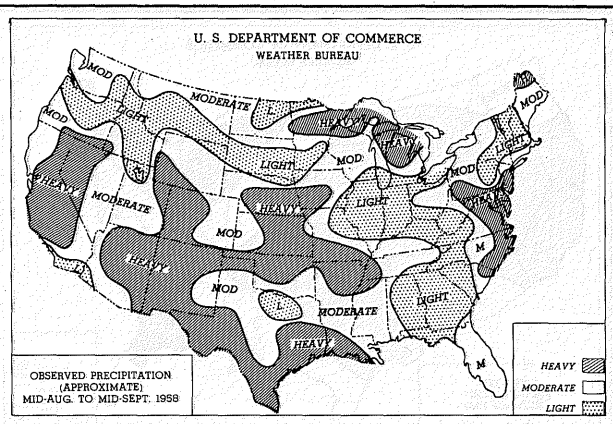
Atlantic	+0.52
North America	+0.75
Pacific	+0.17



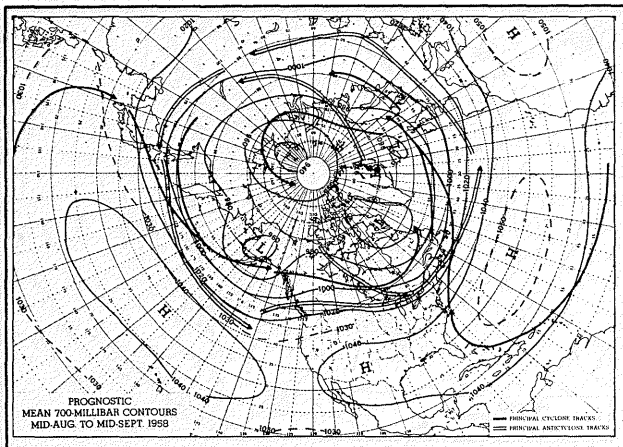


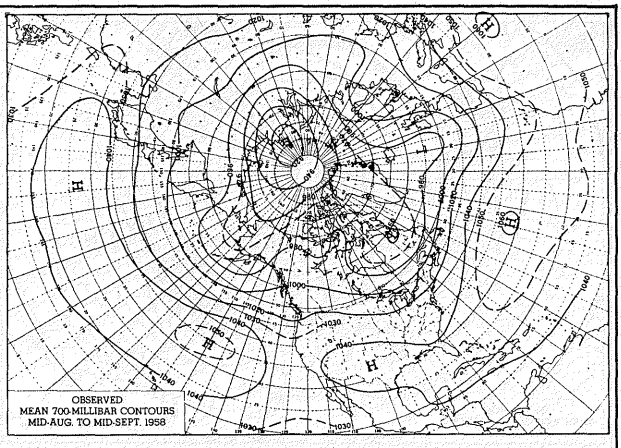
Temperature Score: 94 % within 1 class (of five)





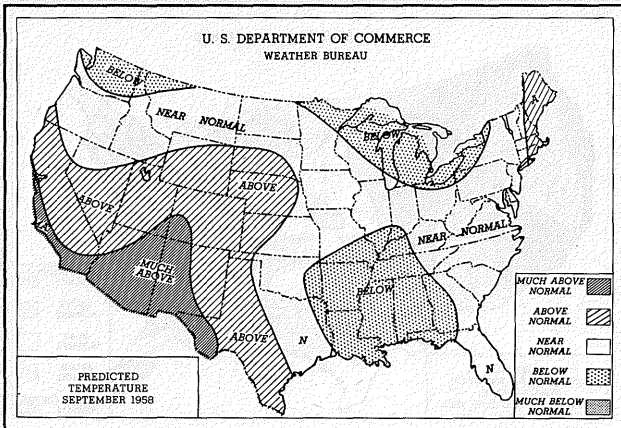
Precipitation Score: 35 % in the correct class (of three)

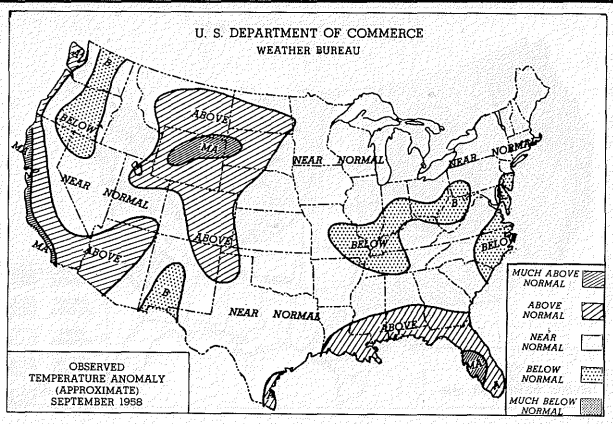




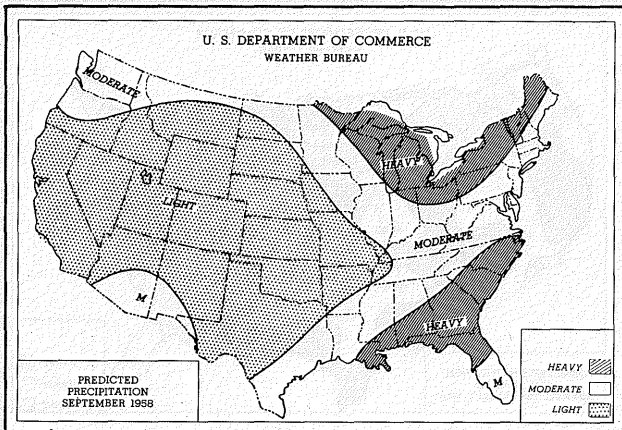
700 mb Anomaly Pattern Correlation Coefficients:

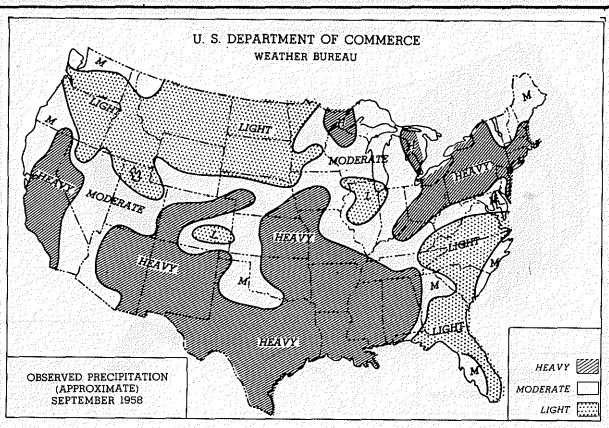
Atlantic	+0.76
North America	+0.91
Pacific	+0.25



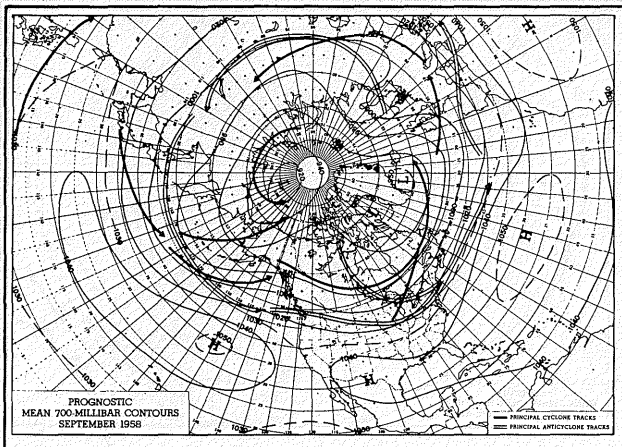


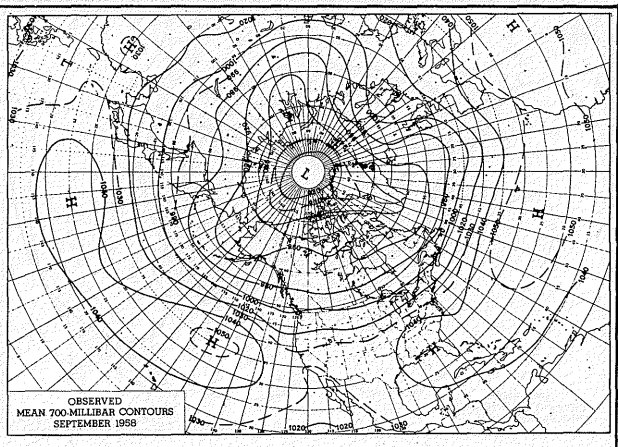
Temperature Score: 90 % within 1 class (of five)





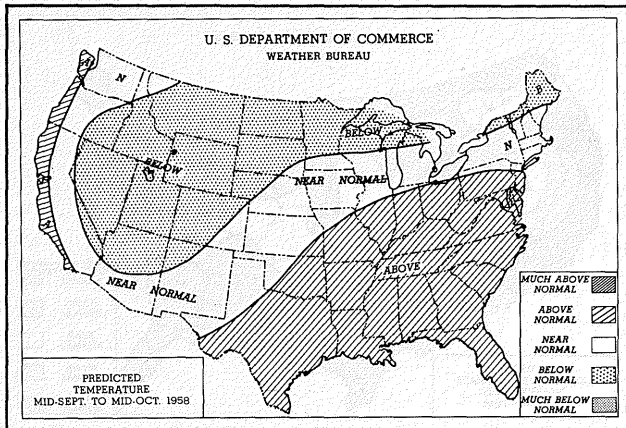
Precipitation Score: 36 % in the correct class (of three)

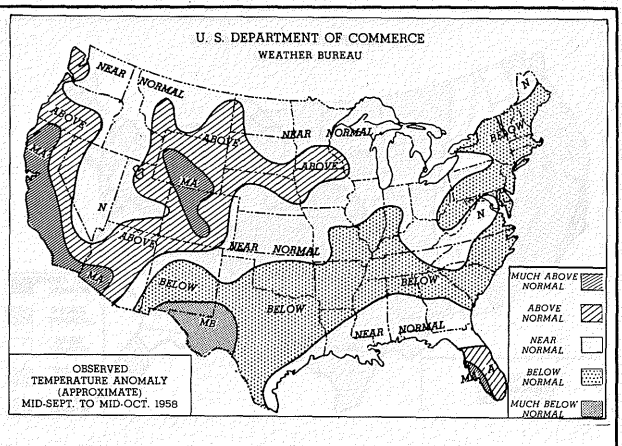




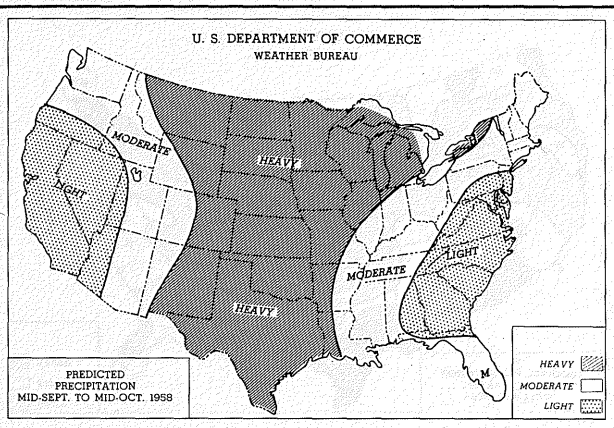
700 mb Anomaly Pattern Correlation Coefficients:

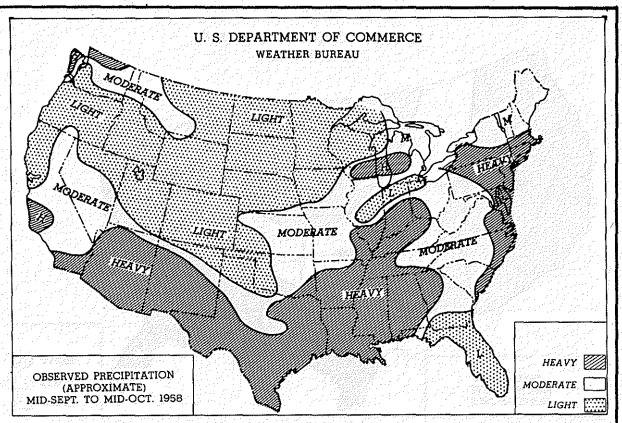
Atlantic	+0.72
North America	+0.62
Pacific	+0.36



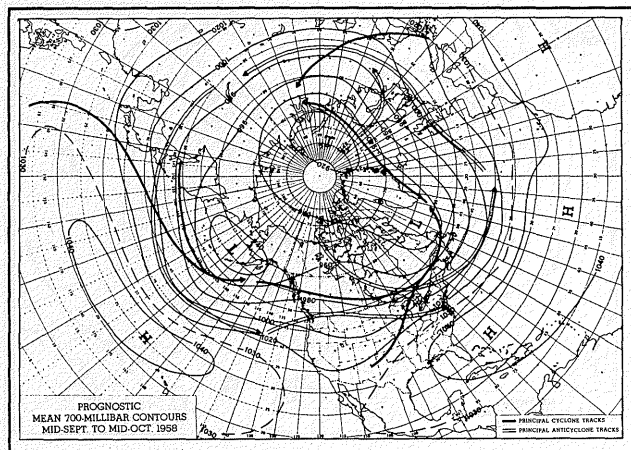


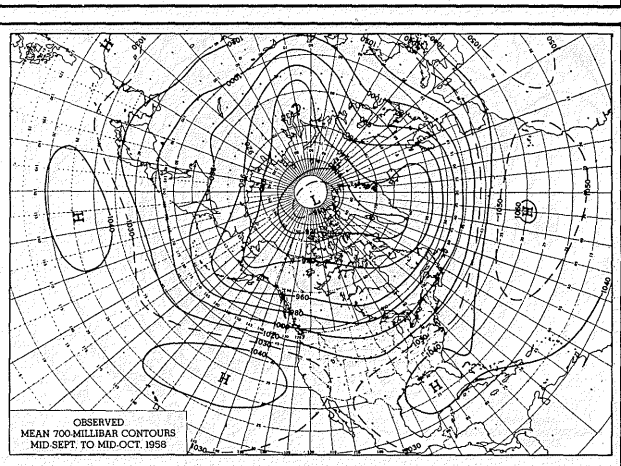
Temperature Score: 65 % within 1 class (of five)





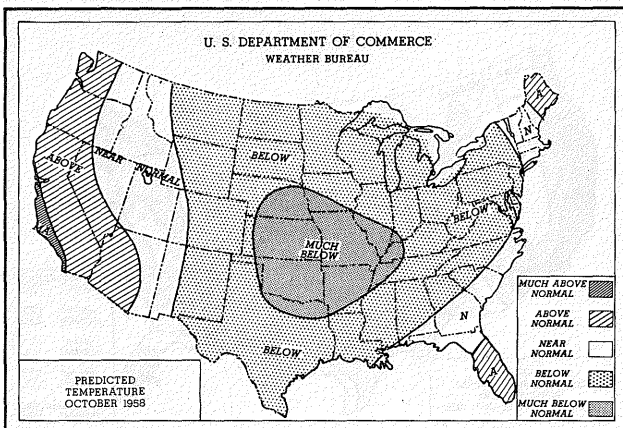
Precipitation Score: 31 % in the correct class (of three)

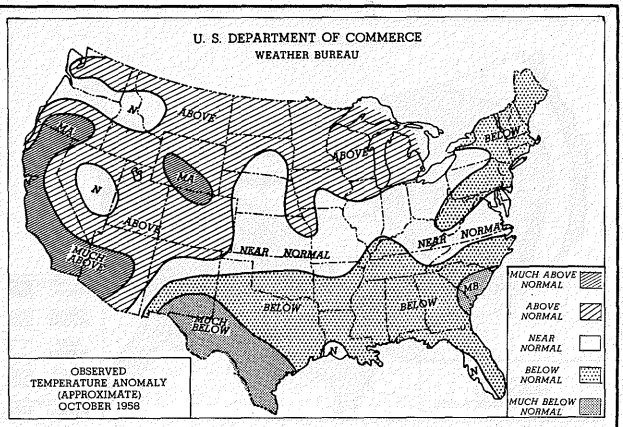




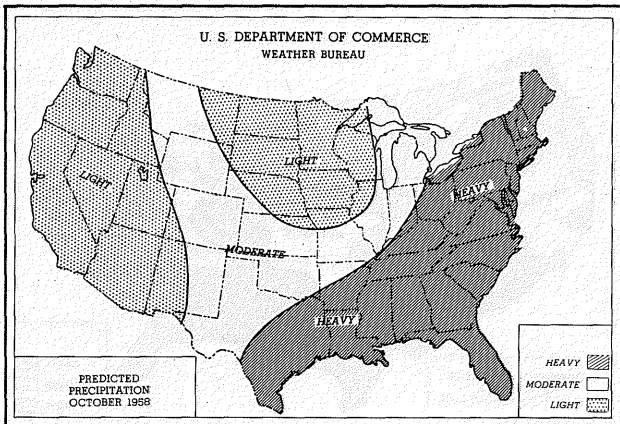
700 mb Anomaly Pattern Correlation Coefficients:

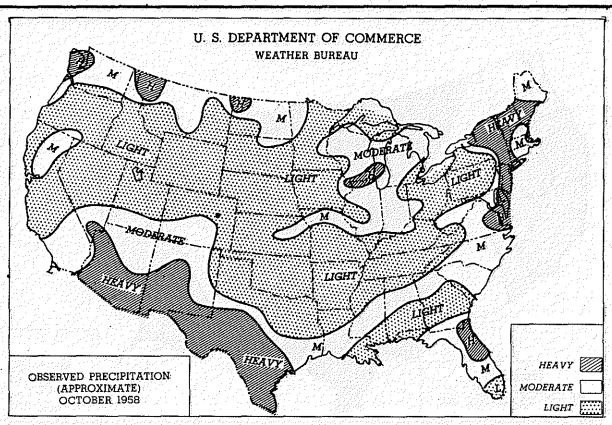
Atlantic	+0.21
North America	+0.14
Pacific	-0.11



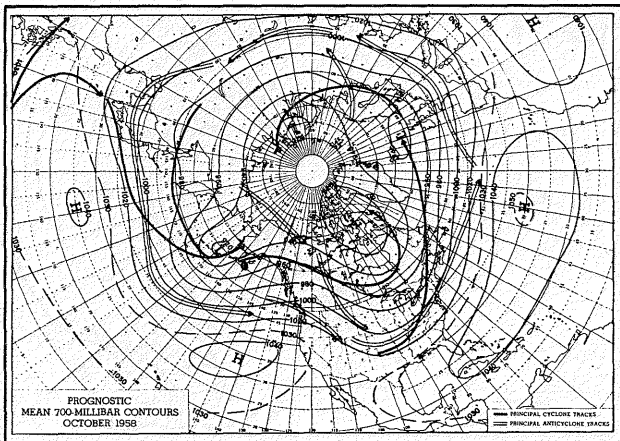


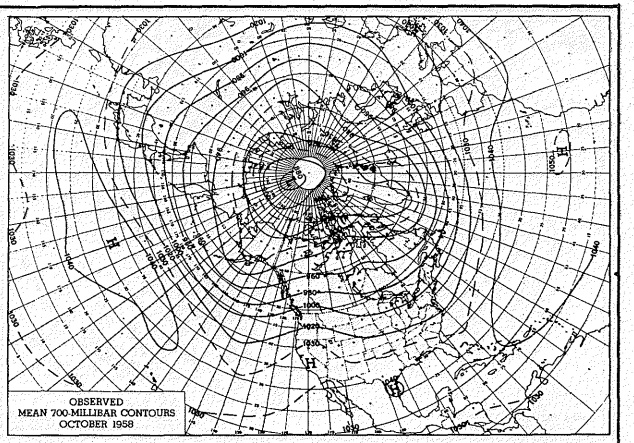
Temperature Score: 70 % within 1 class (of five)





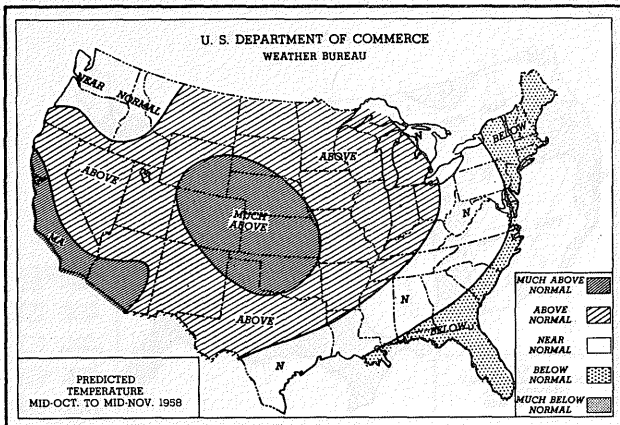
Precipitation Score: 42 % in the correct class (of three)

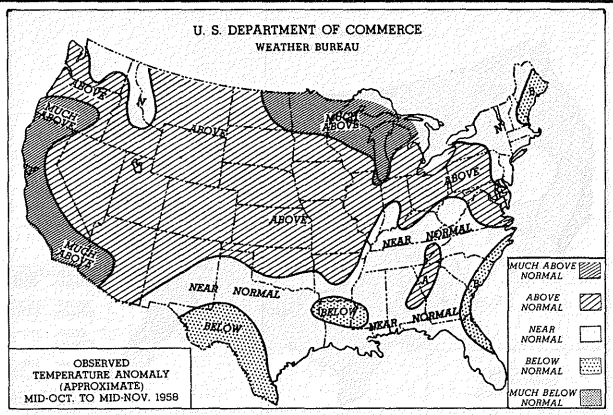




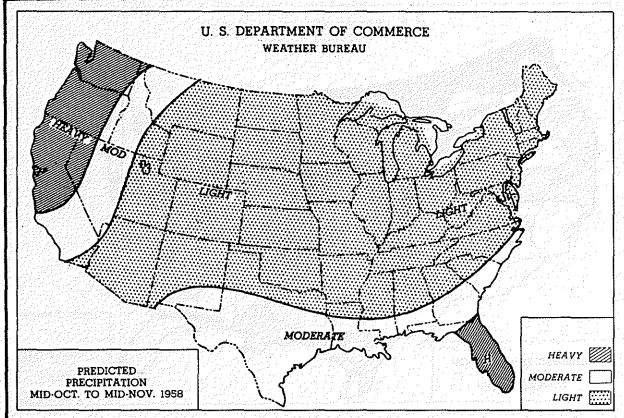
700 mb Anomaly Pattern Correlation Coefficients:

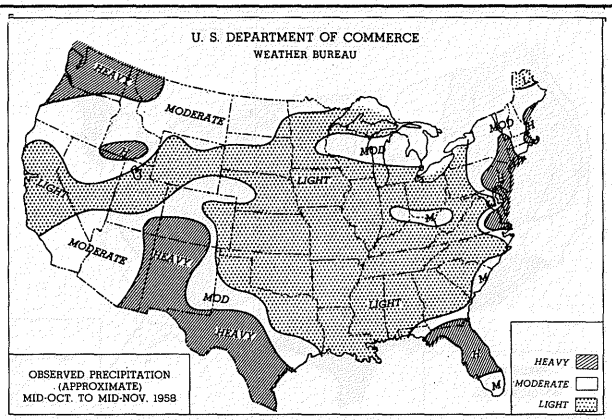
Atlantic	-0.07
North America	+0.04
Pacific	-0.41



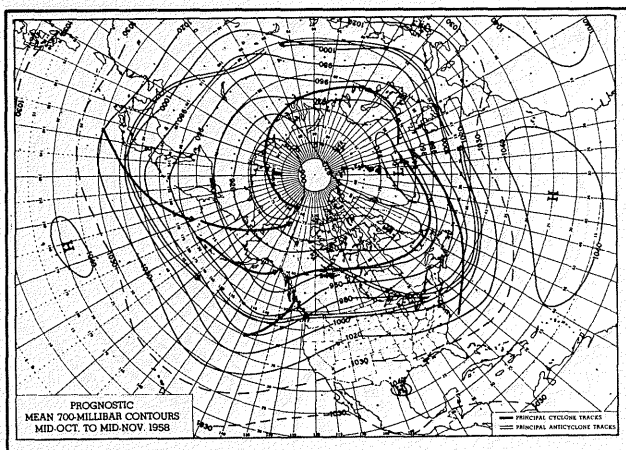


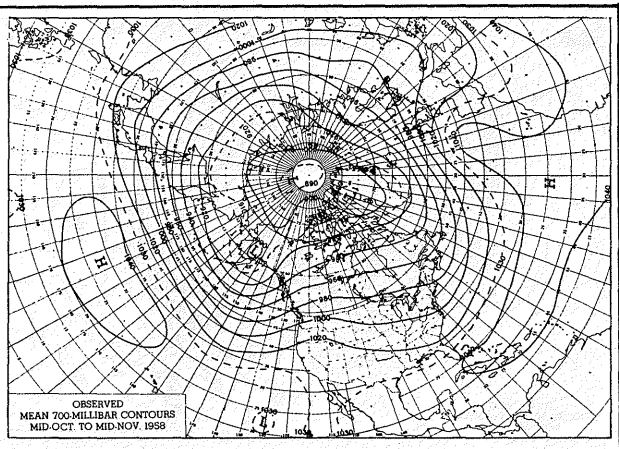
Temperature Score: 94 % within 1 class (of five)





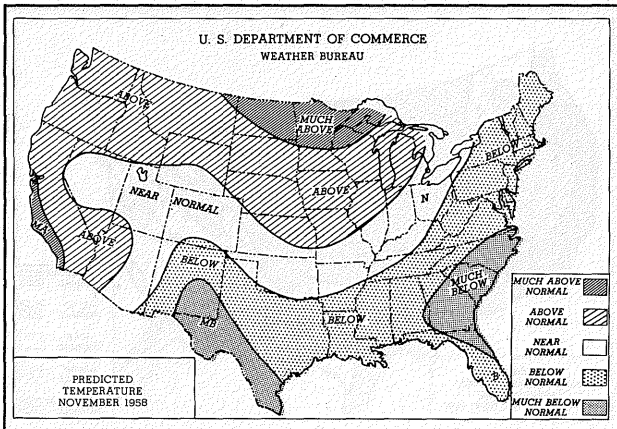
Precipitation Score: 40 % in the correct class (of three)

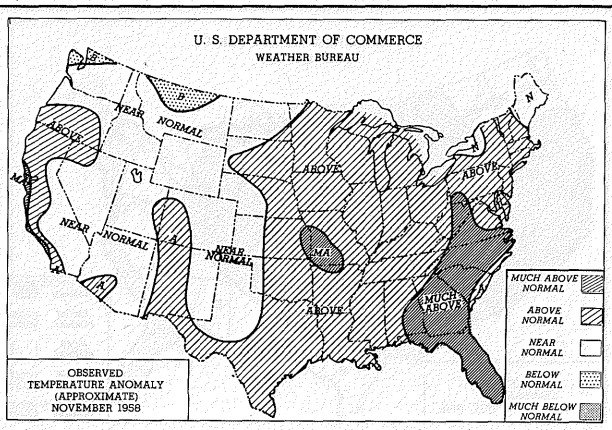




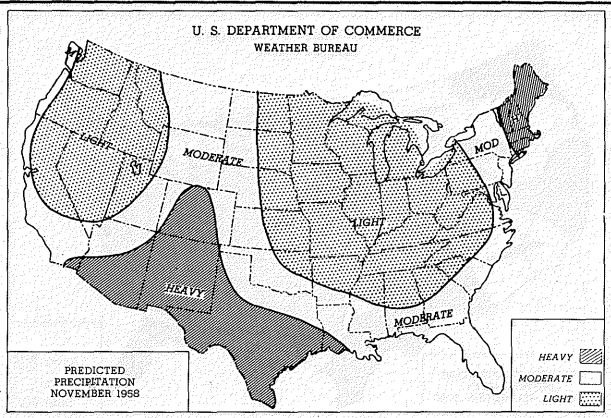
700 mb Anomaly Pattern Correlation Coefficients:

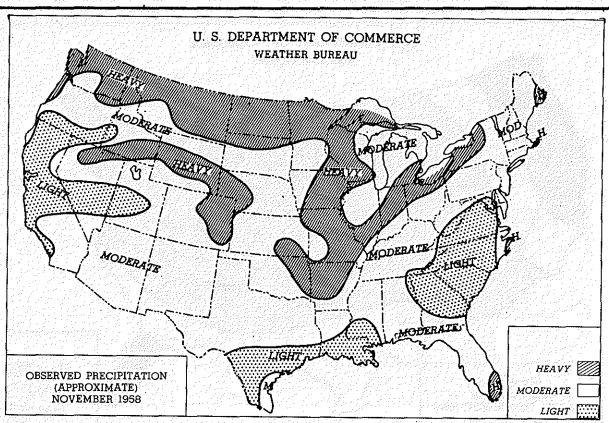
Atlantic	+0. 76
North America	+0. 73
Pacific	+0. 28



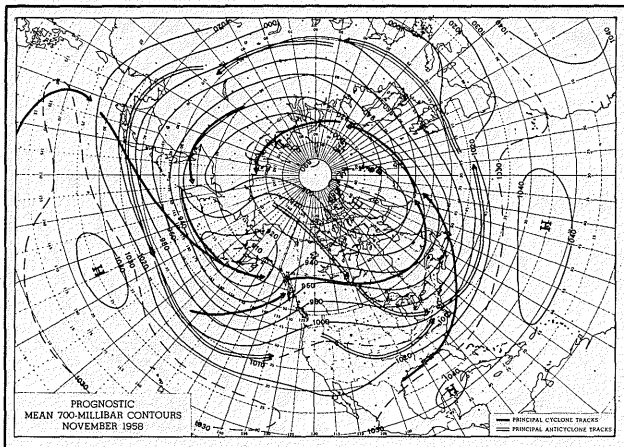


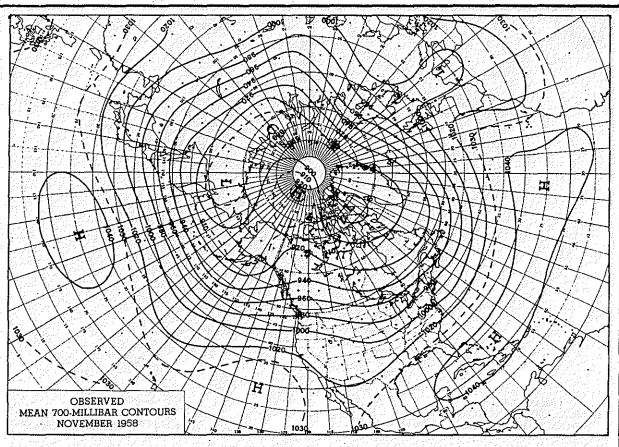
Temperature Score: 63 % within 1 class (of five)





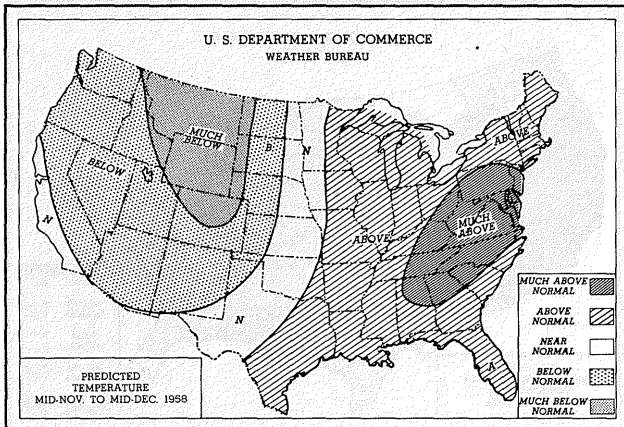
Precipitation Score: 19 % in the correct class (of three)

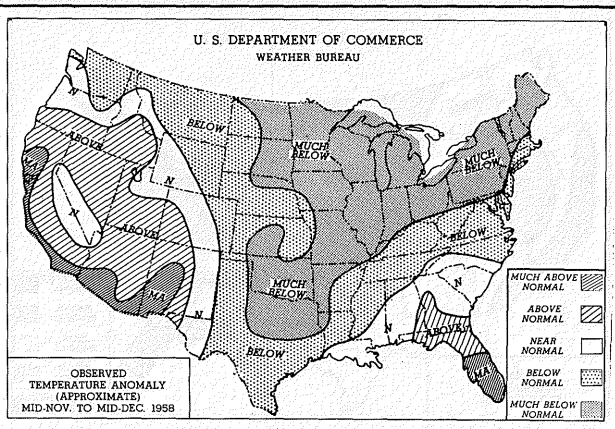




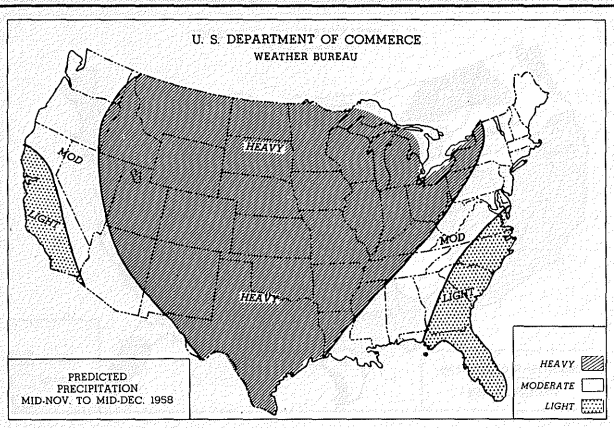
700 mb Anomaly Pattern Correlation Coefficients:

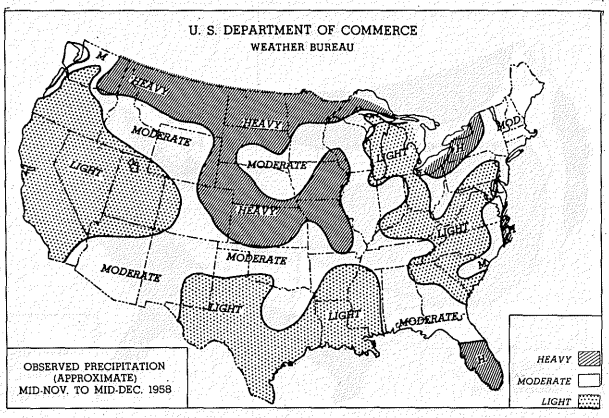
Atlantic	+0.87
North America	+0.40
Pacific	+0.21



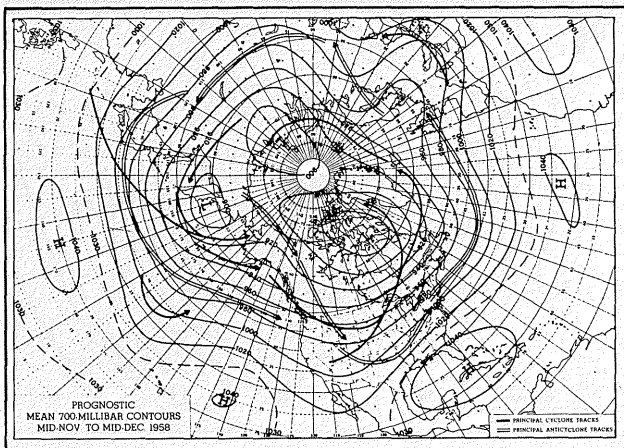


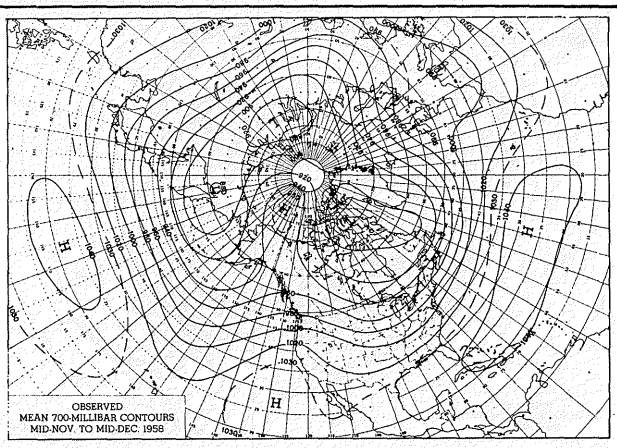
Temperature Score: 39 % within 1 class (of five)





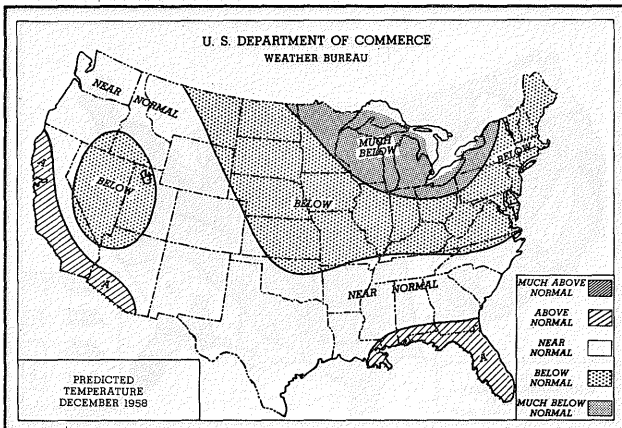
Precipitation Score: 33 % in the correct class (of three)

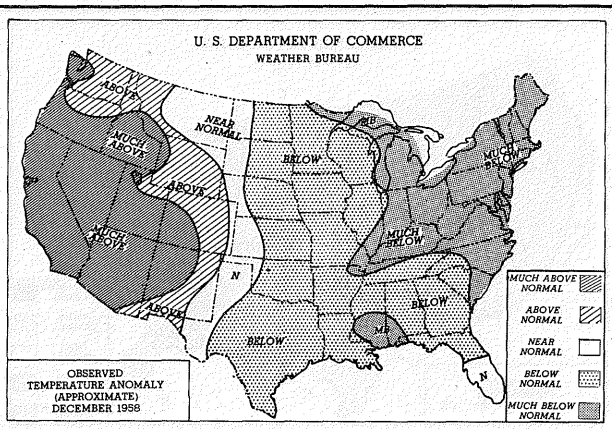




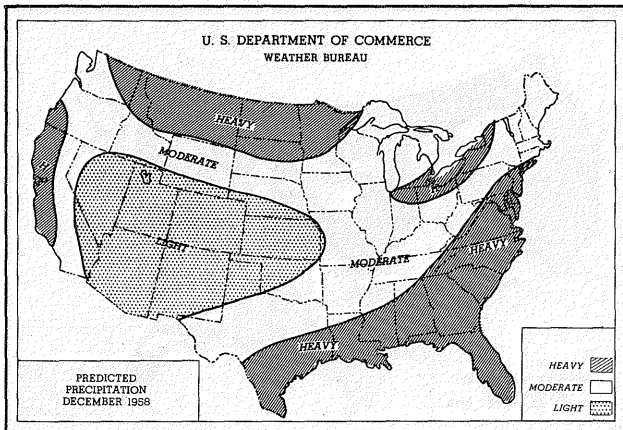
700 mb Anomaly Pattern Correlation Coefficients:

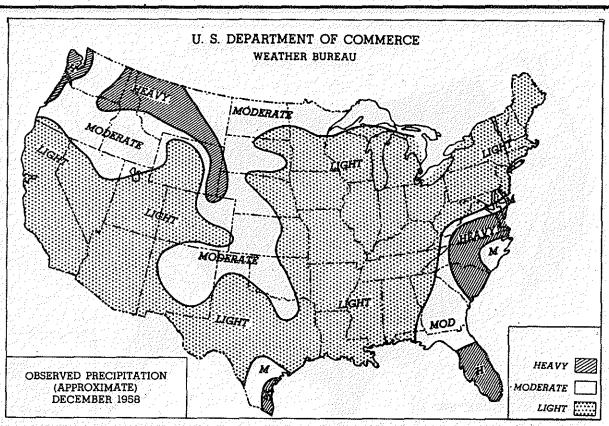
Atlantic	+0.02
North America	-0.16
Pacific	0.00



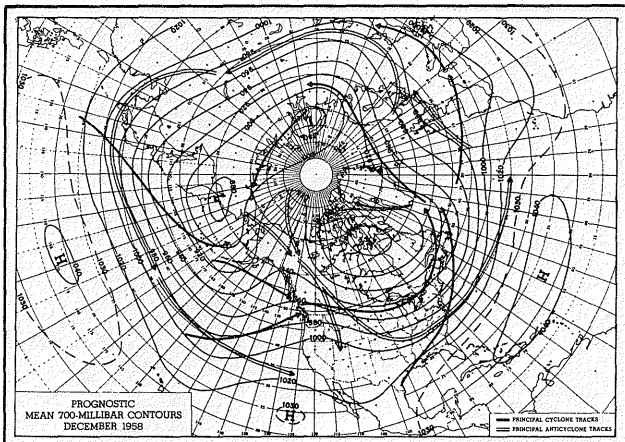


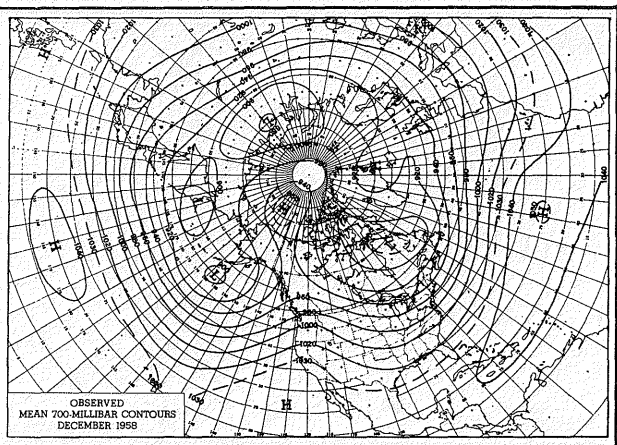
Temperature Score: 76 % within 1 class (of five)





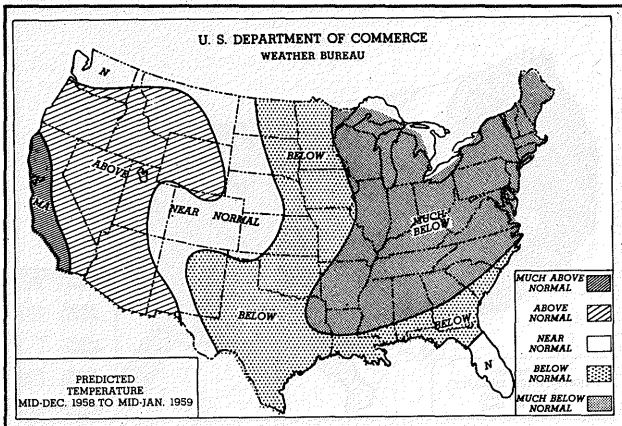
Precipitation Score: 32 % in the correct class (of three)

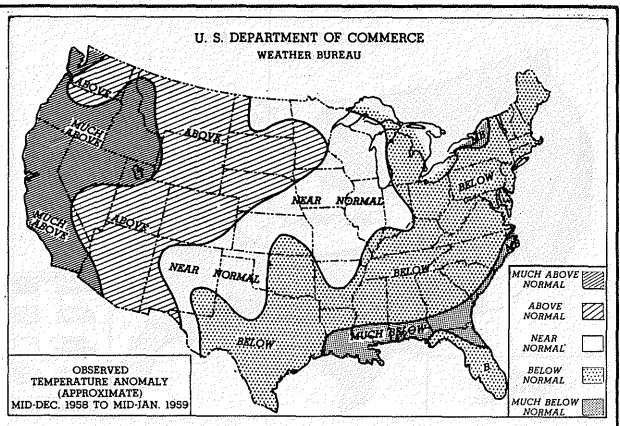




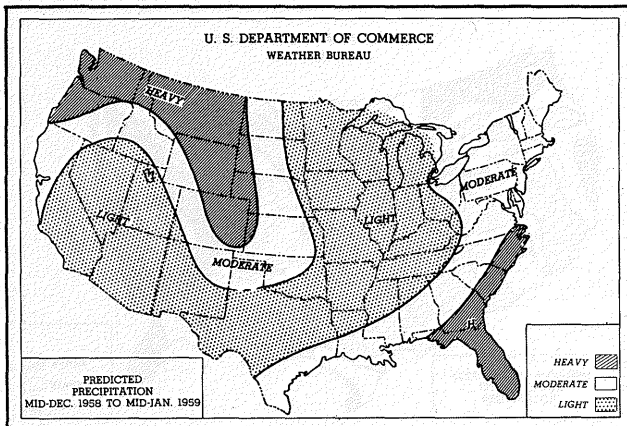
700 mb Anomaly Pattern Correlation Coefficients:

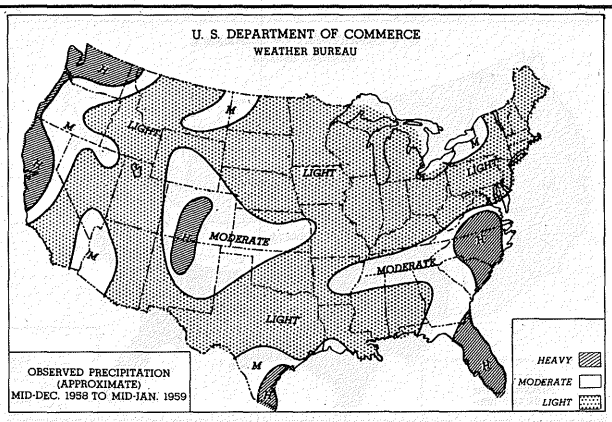
Atlantic	+0.60
North America	+0.75
Pacific	+0.49



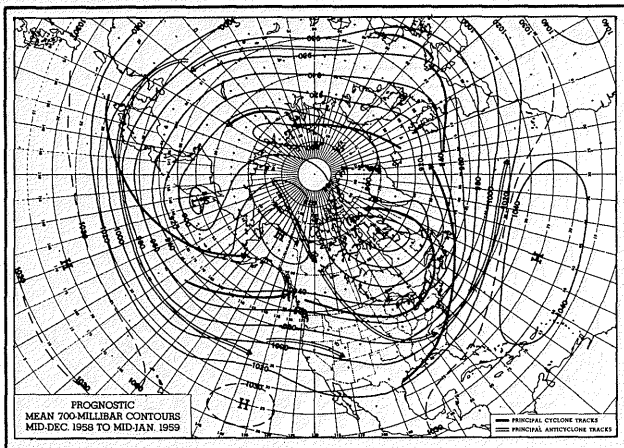


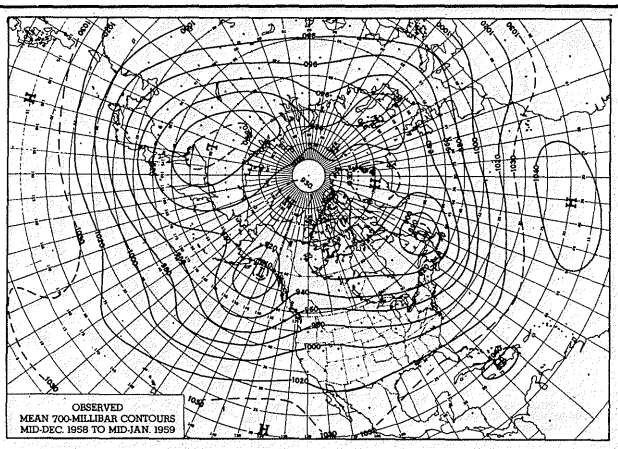
Temperature Score: 91 % within 1 class (of five)





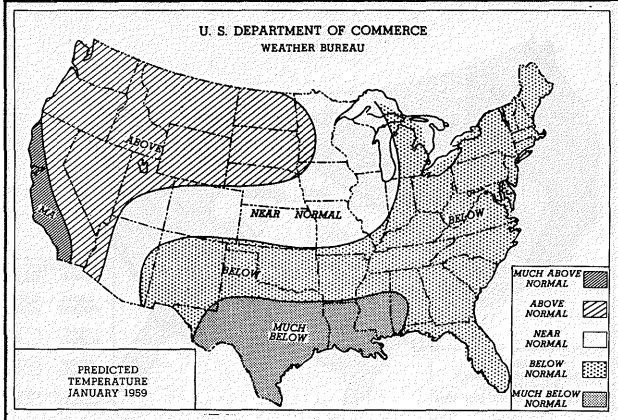
Precipitation Score: 50 % in the correct class (of three)

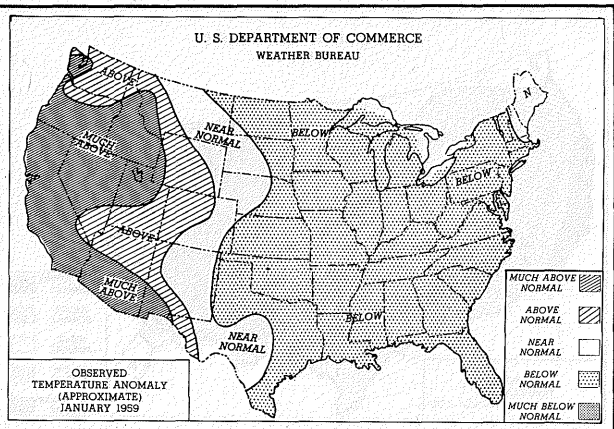




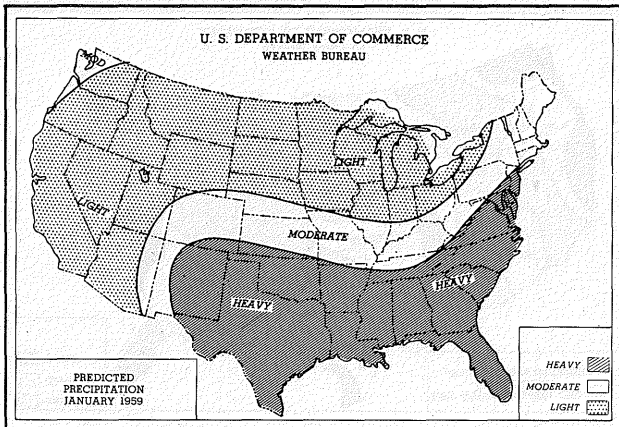
700 mb Anomaly Pattern Correlation Coefficients:

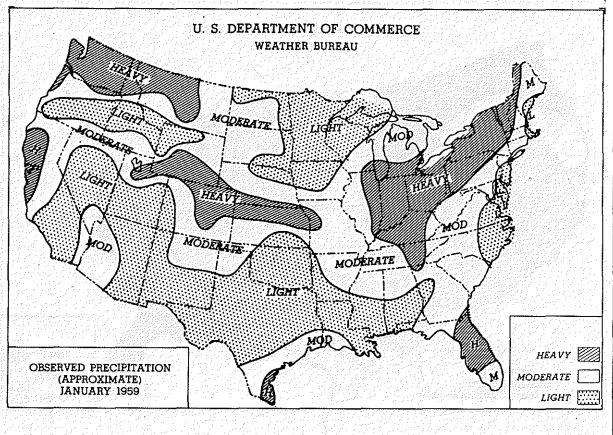
Atlantic	+0.53
North America	+0.41
Pacific	+0.25



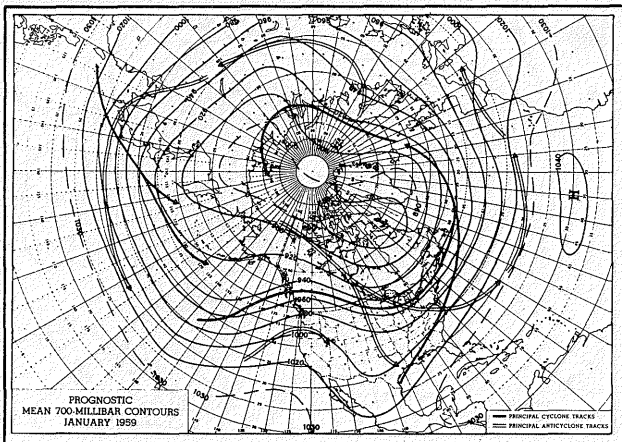


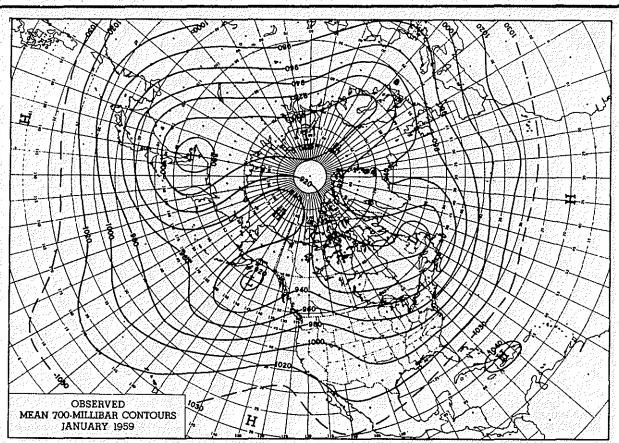
Temperature Score: 88 % within 1 class (of five)





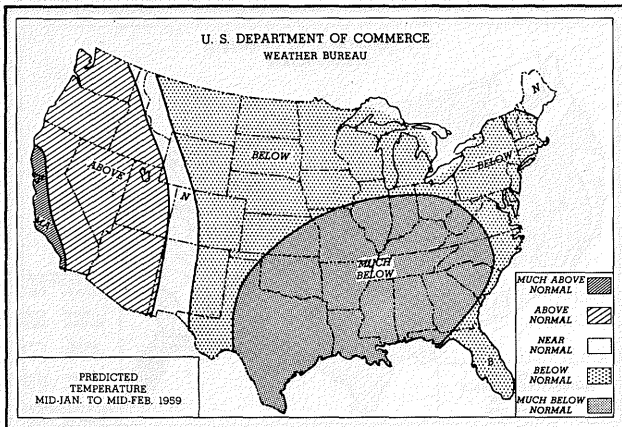
Precipitation Score: 24 % in the correct class (of three)

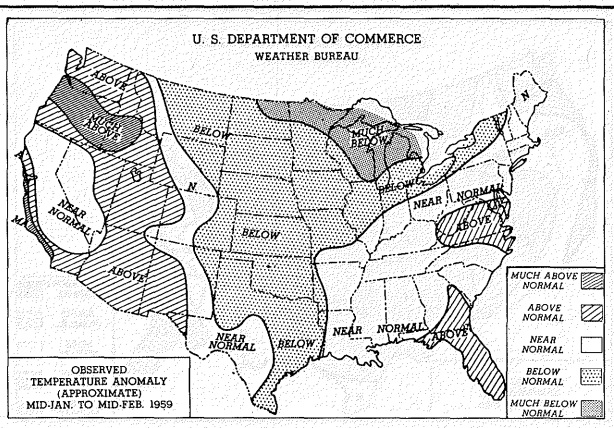




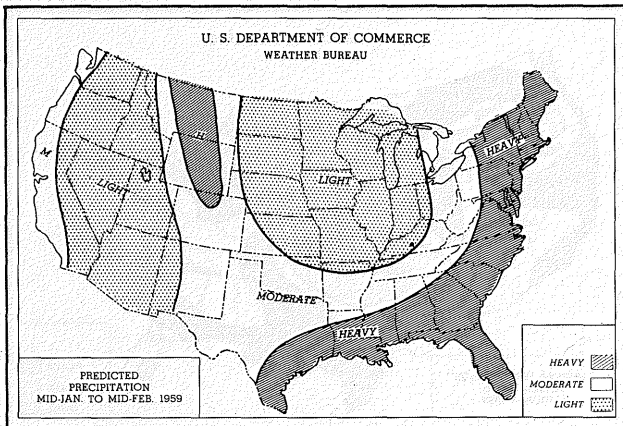
700 mb Anomaly Pattern Correlation Coefficients:

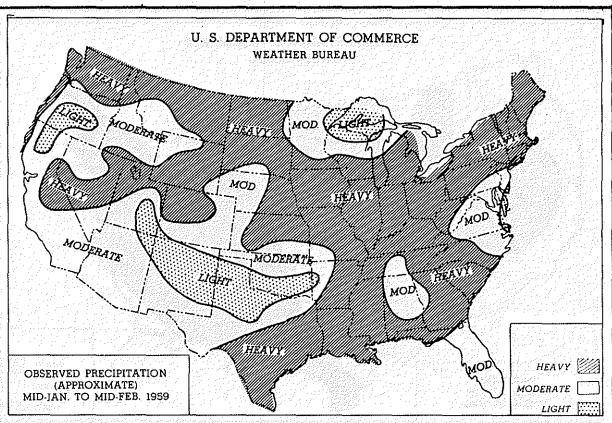
Atlantic	+0.53
North America	+0.32
Pacific	+0.10



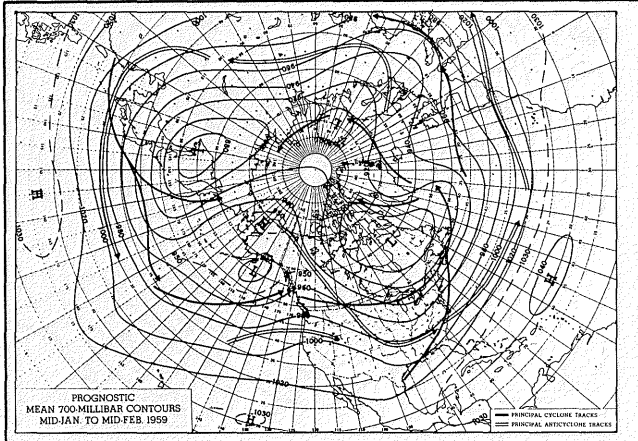


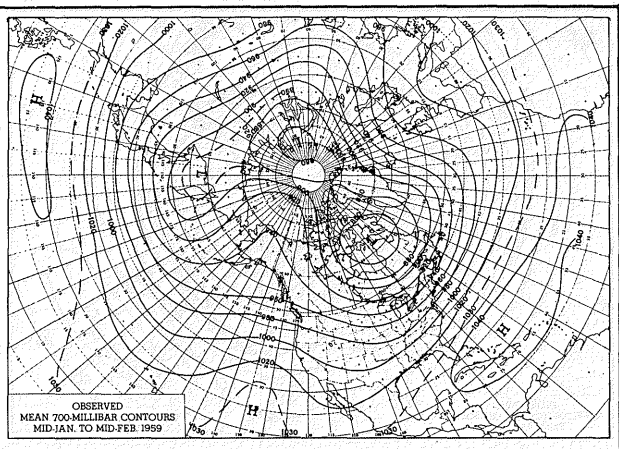
Temperature Score: 76 % within 1 class (of five)





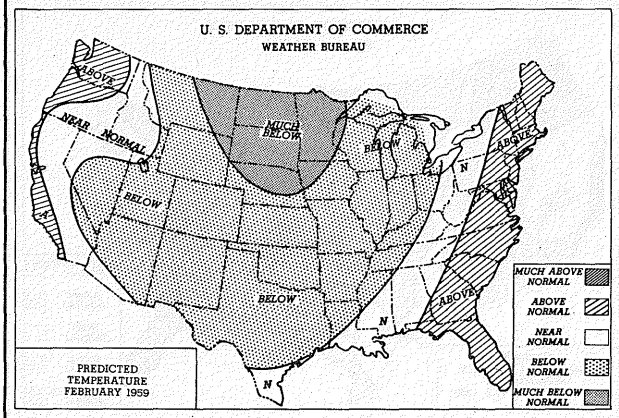
Precipitation Score: 30 % in the correct class (of three)

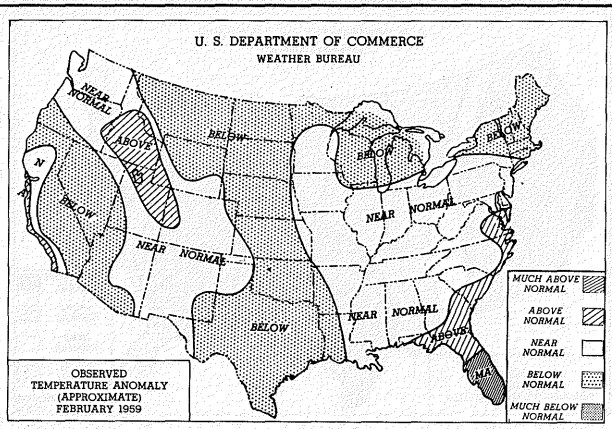




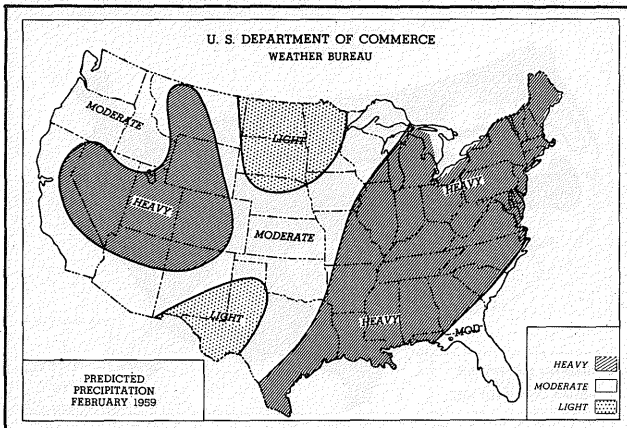
700 mb Anomaly Pattern Correlation Coefficients:

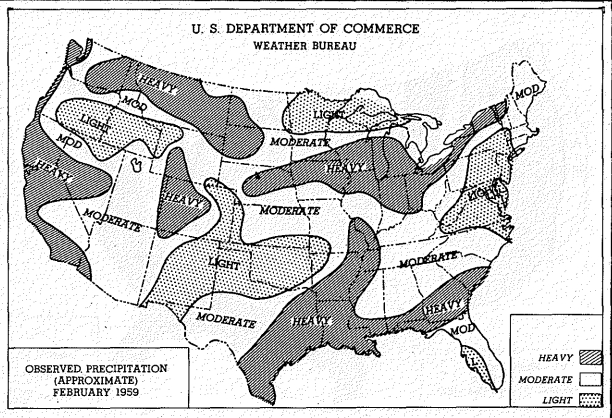
Atlantic	+0.34
North America	+0.08
Pacific	+0.65



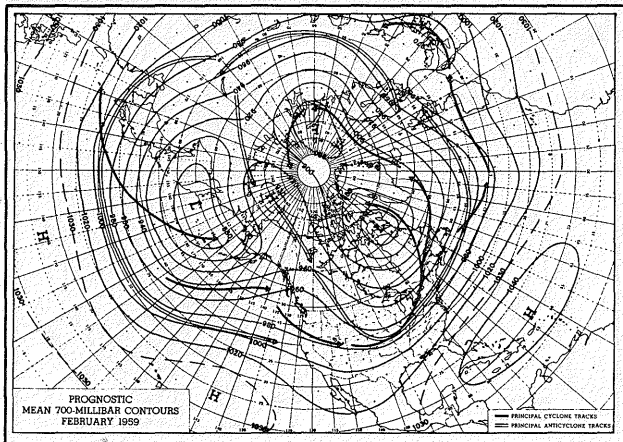


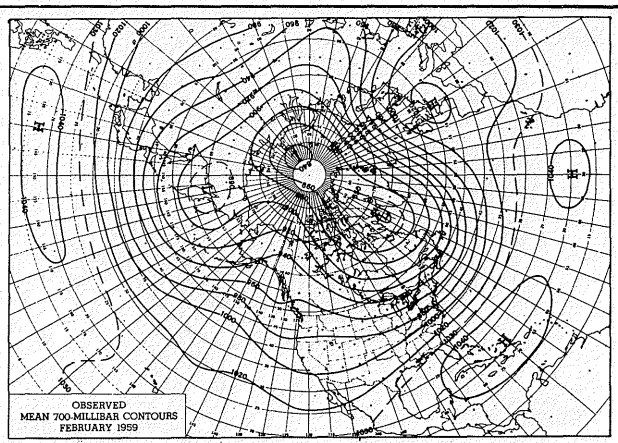
Temperature Score: 88 % within 1 class (of five)





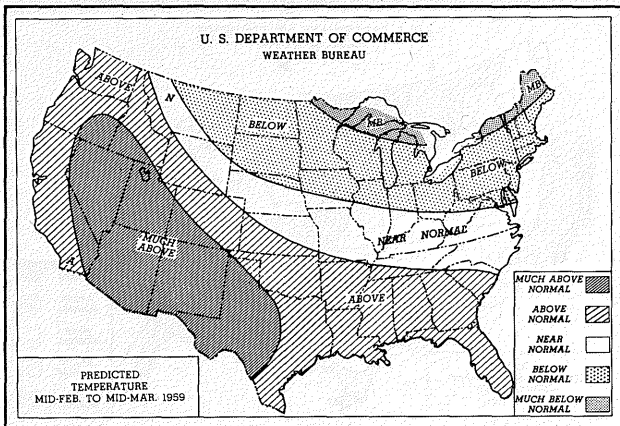
Precipitation Score: 47 % in the correct class (of three)

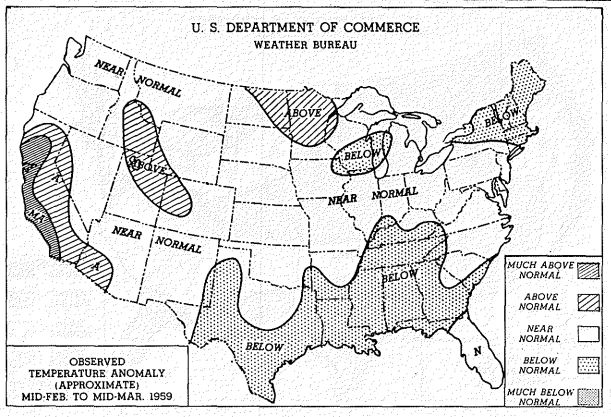




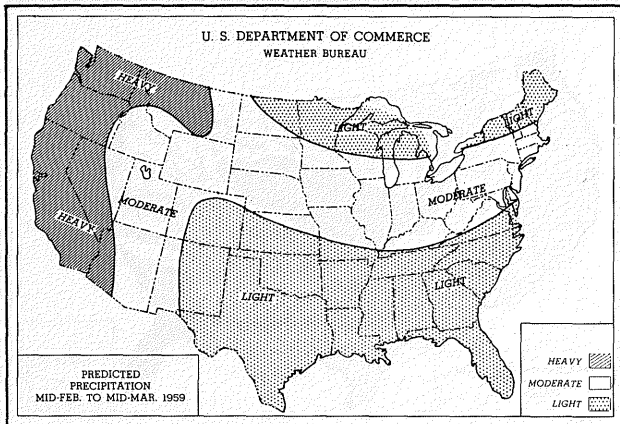
700 mb Anomaly Pattern Correlation Coefficients:

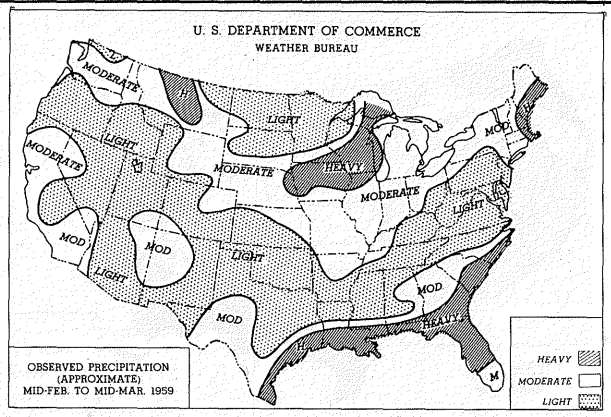
Atlantic	-0.04
North America	+0.42
Pacific	-0.21



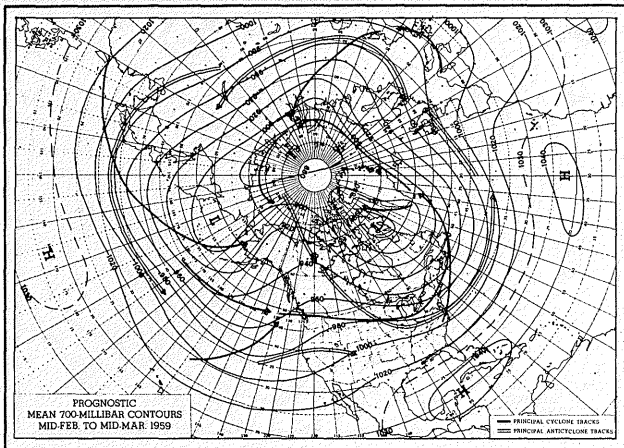


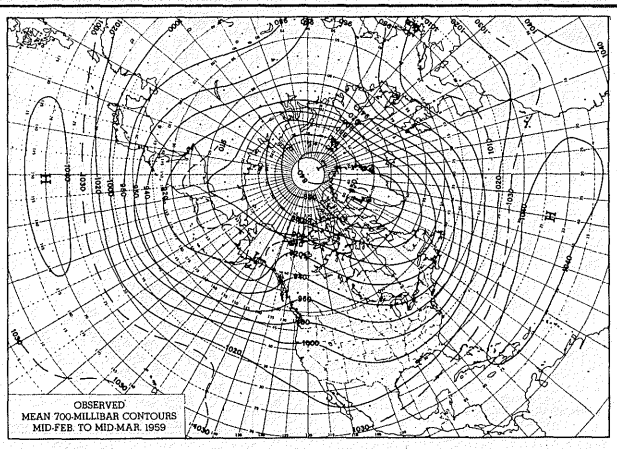
Temperature Score: 68 % within 1 class (of five)





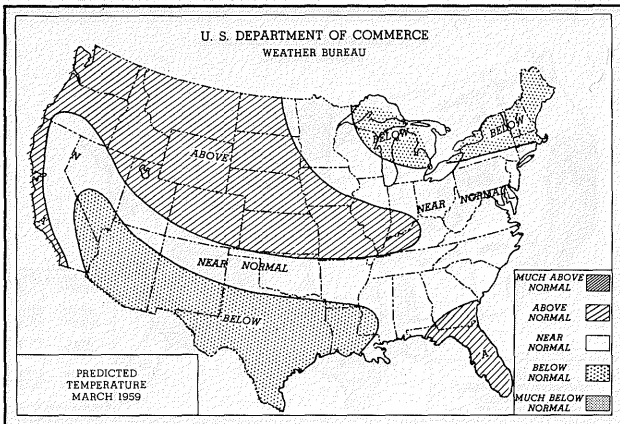
Precipitation Score: 37 % in the correct class (of three)

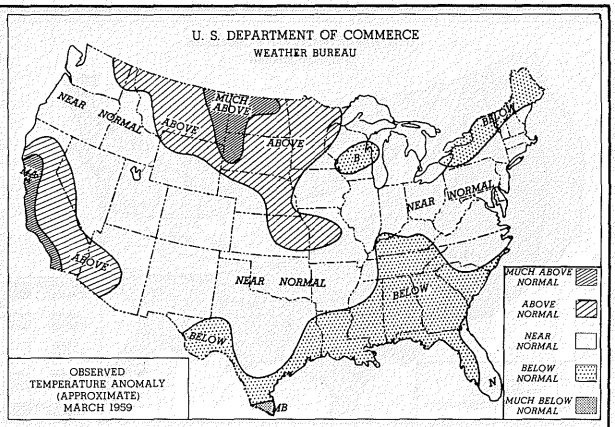




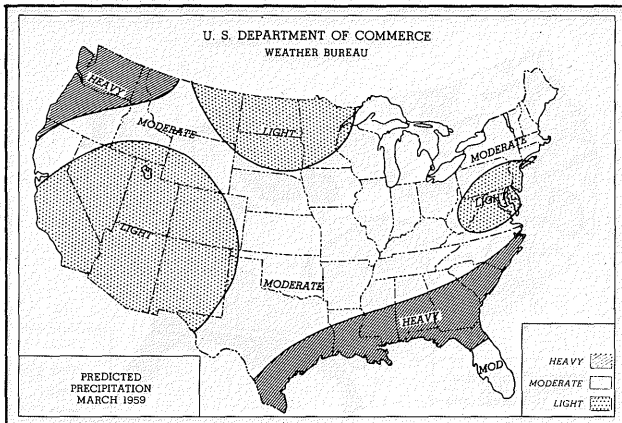
700 mb Anomaly Pattern Correlation Coefficients:

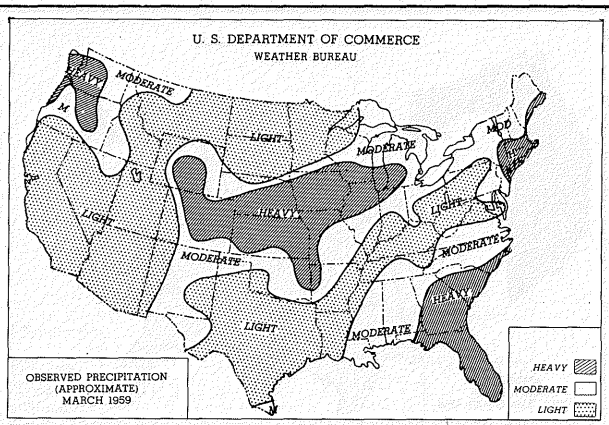
Atlantic	+0.73
North America	+0.10
Pacific	+0.22



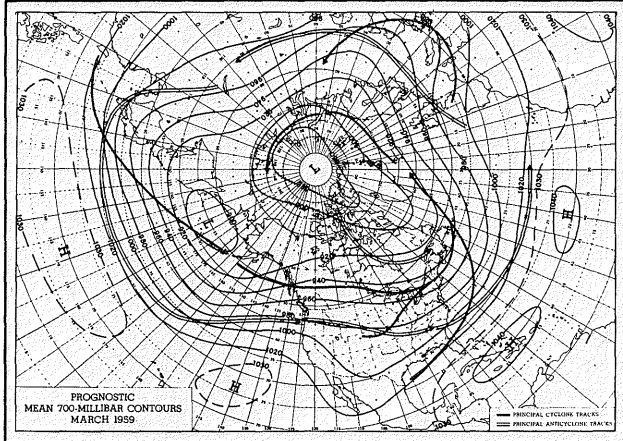


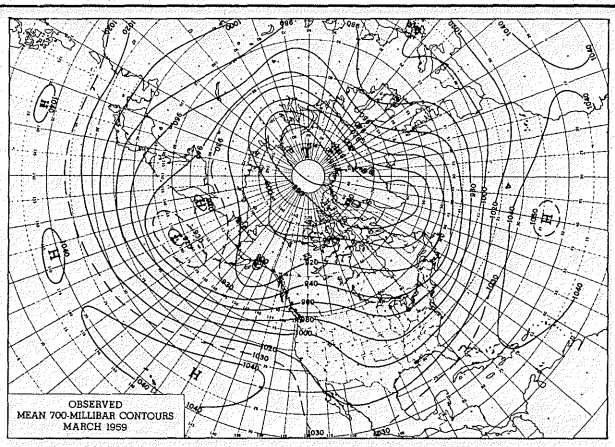
Temperature Score: 94 % within 1 class (of five)





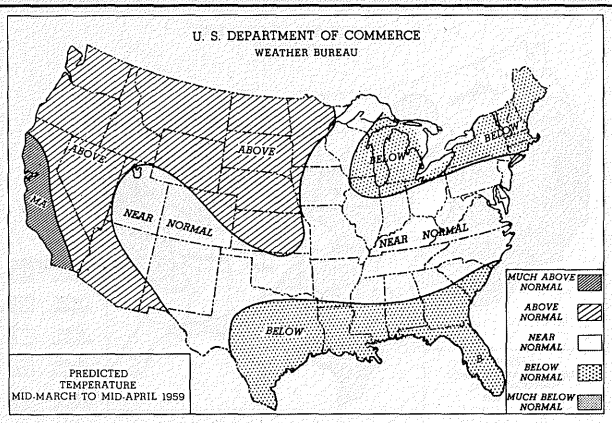
Precipitation Score: 51 % in the correct class (of three)

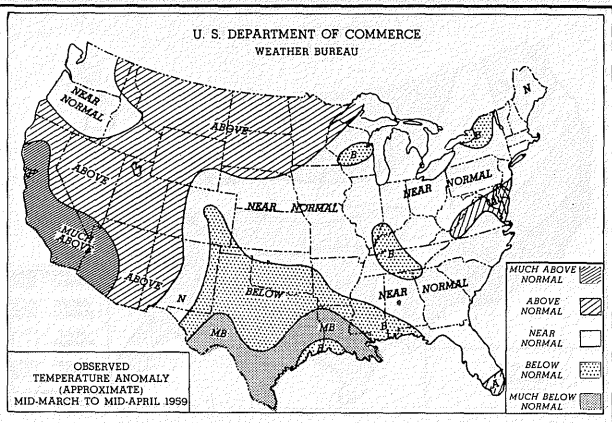




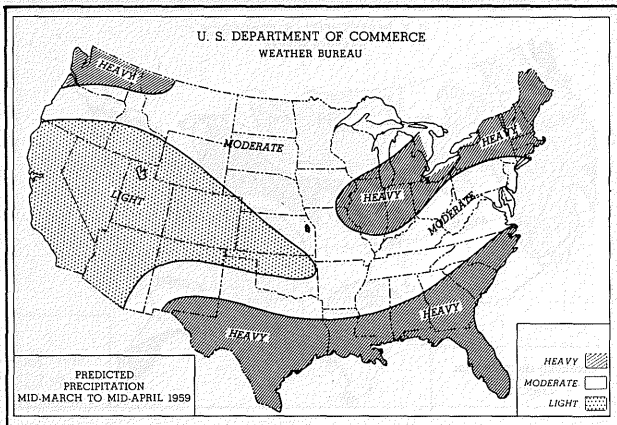
700 mb Anomaly Pattern Correlation Coefficients:

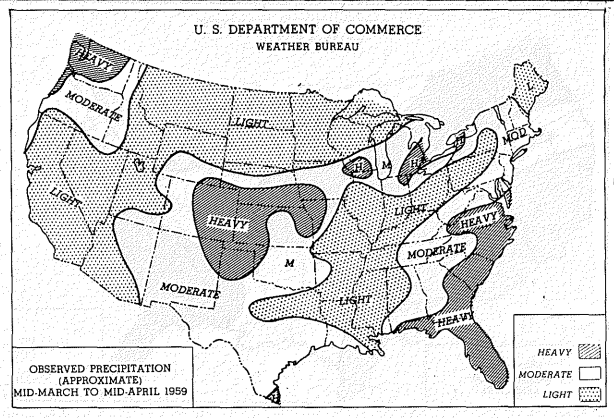
Atlantic	+0.27
North America	+0.72
Pacific	+0.47



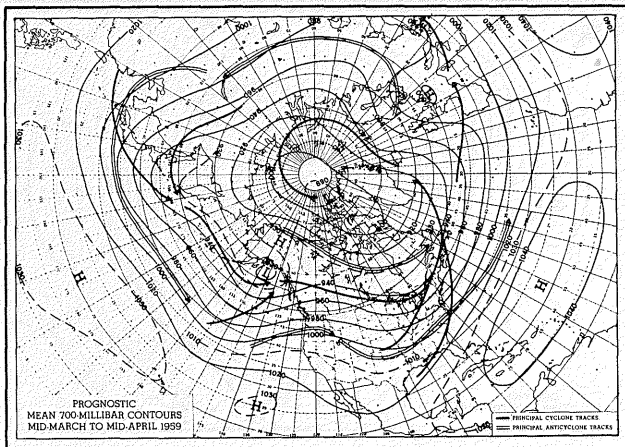


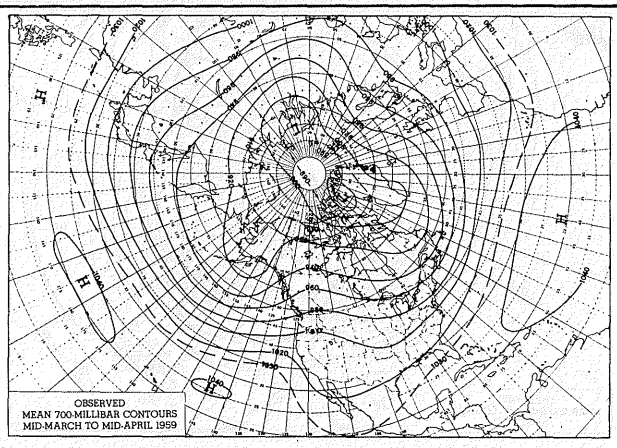
Temperature Score: 97 % within 1 class (of five)





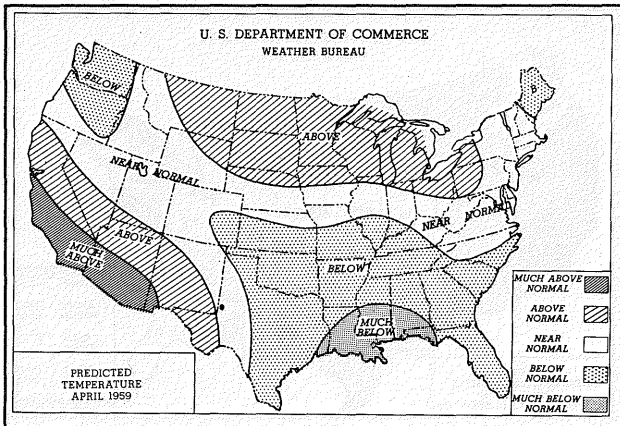
Precipitation Score: 40 % in the correct class (of three)

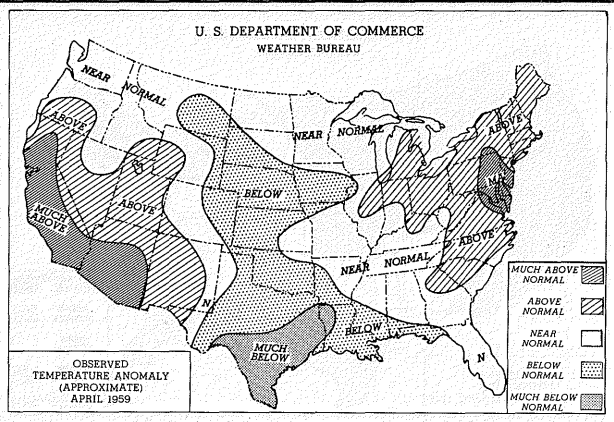




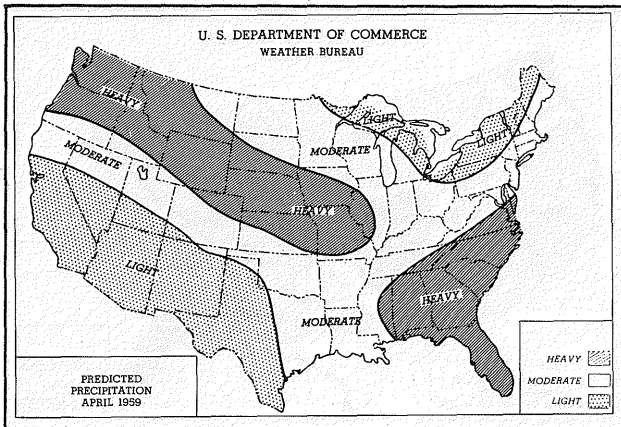
700 mb Anomaly Pattern Correlation Coefficients:

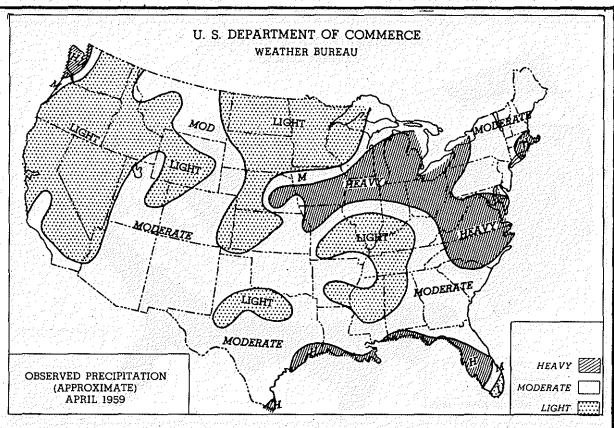
Atlantic	+0.40
North America	+0.59
Pacific	+0.50



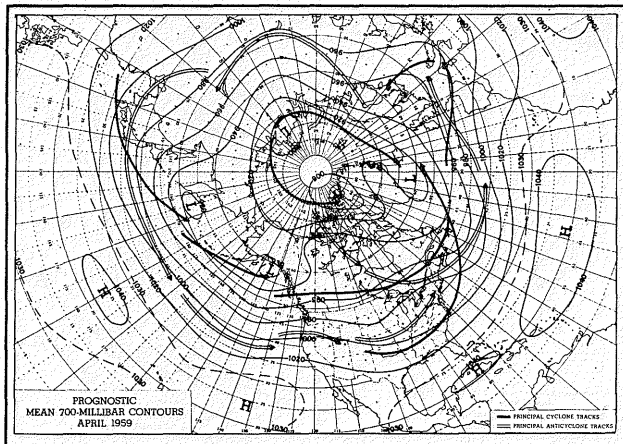


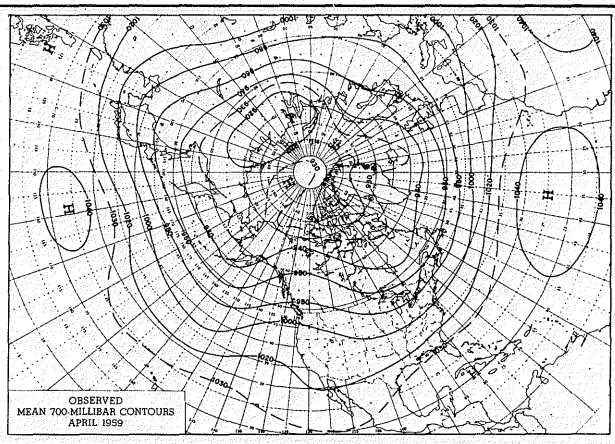
Temperature Score: 85 % within 1 class (of five)





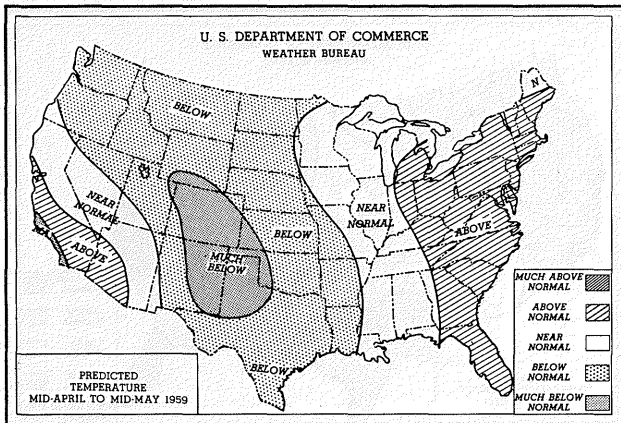
Precipitation Score: 28 % in the correct class (of three)

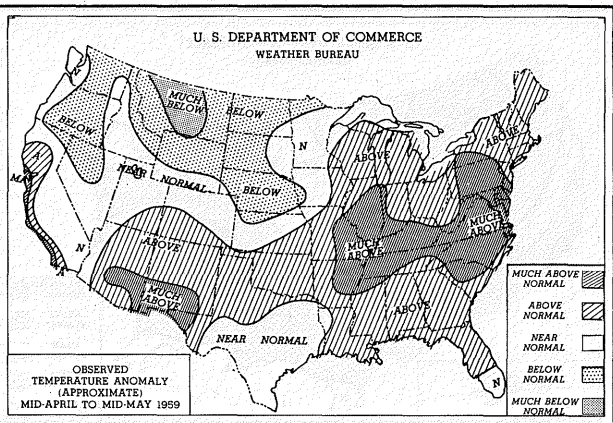




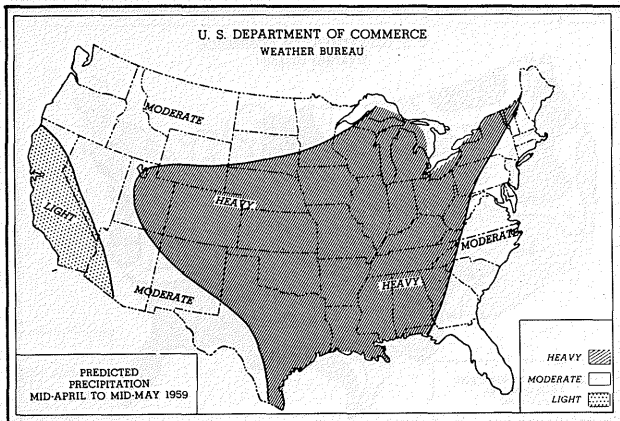
700 mb Anomaly Pattern Correlation Coefficients:

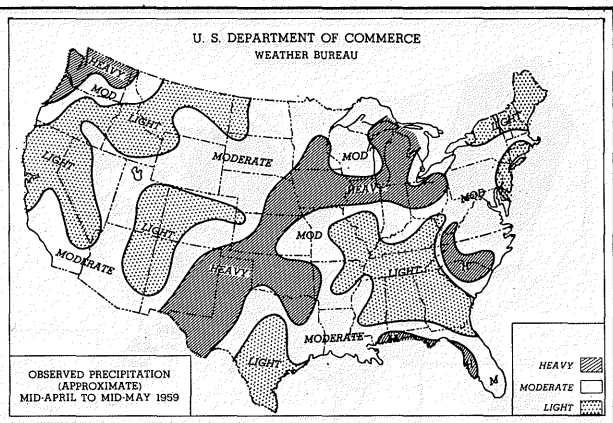
Atlantic	+0.70
North America	+0.19
Pacific	-0.04



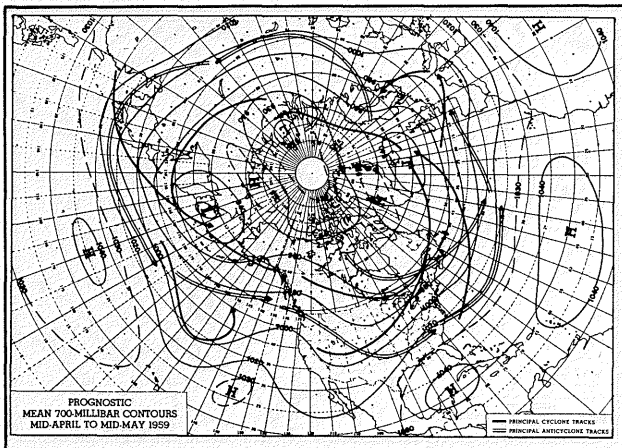


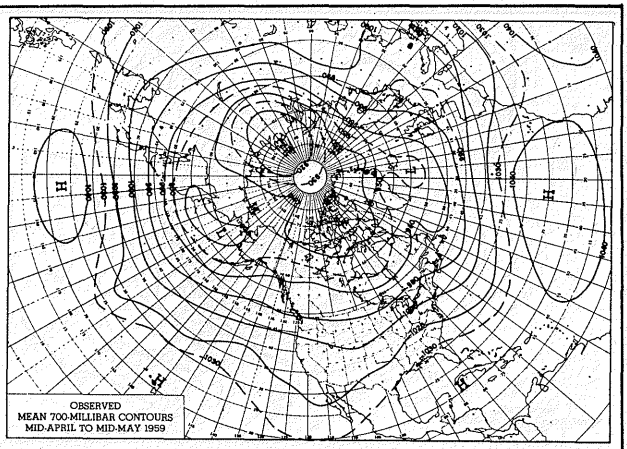
Temperature Score: 81 % within 1 class (of five)





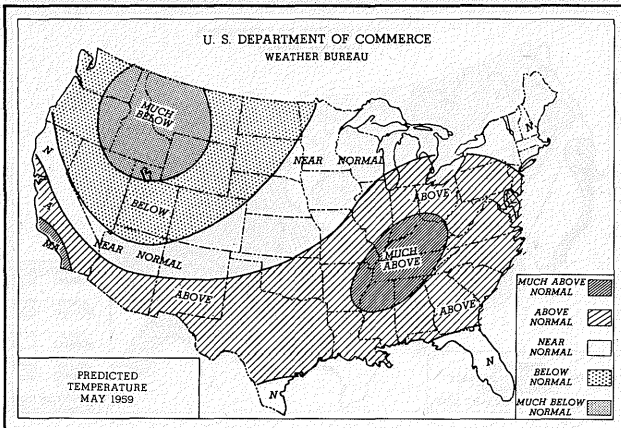
Precipitation Score: 47 % in the correct class (of three)

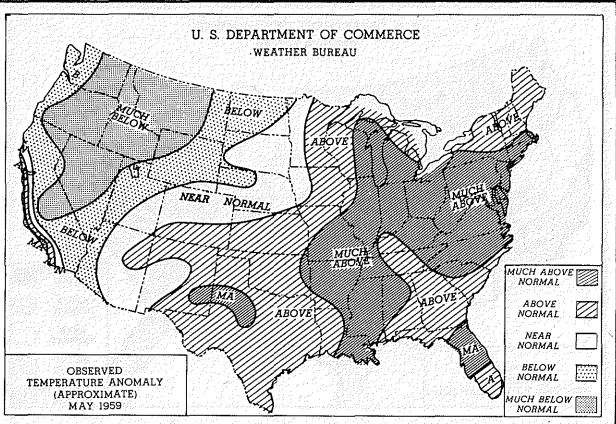




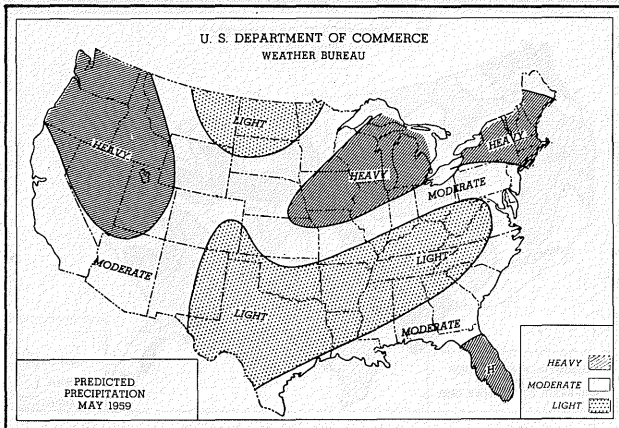
700 mb Anomaly Pattern Correlation Coefficients:

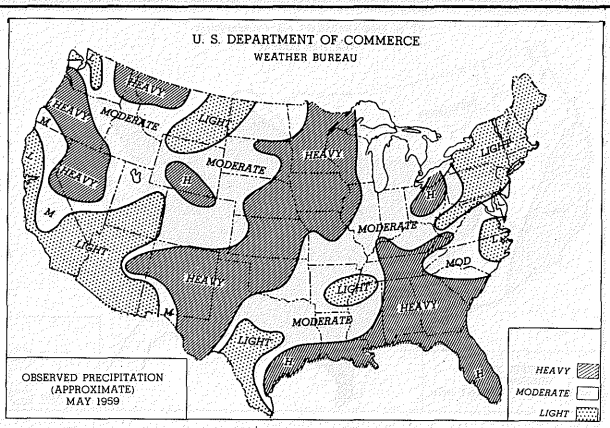
Atlantic	+0.77
North America	+0.42
Pacific	+0.46



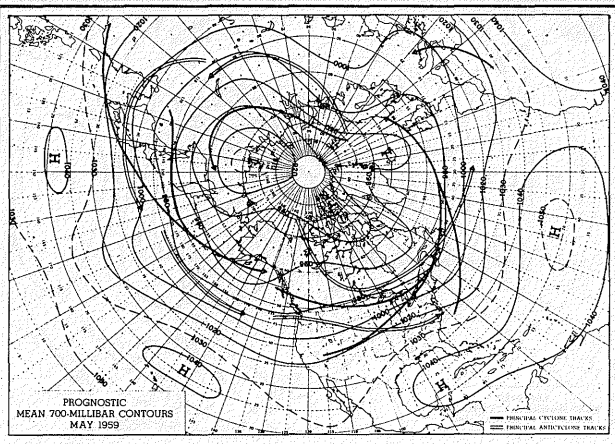


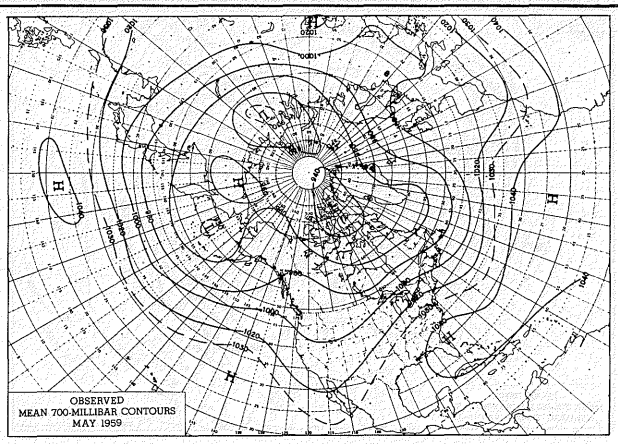
Temperature Score: 92 % within 1 class (of five)





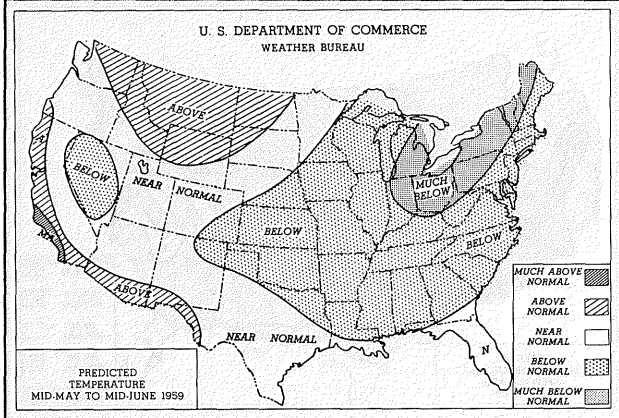
Precipitation Score: 27 % in the correct class (of three)

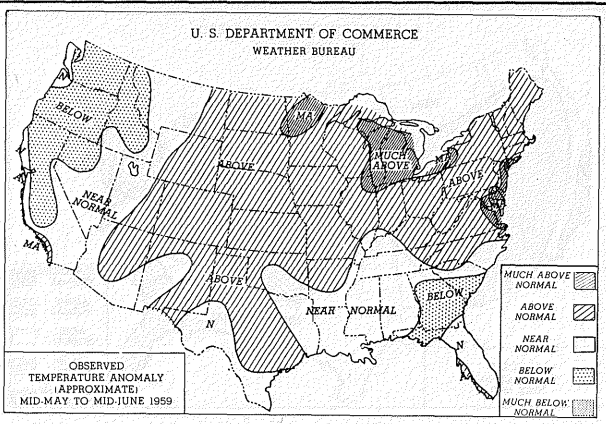




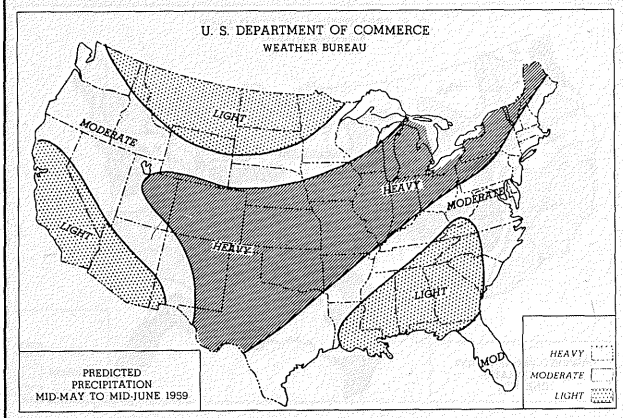
700 mb Anomaly Pattern Correlation Coefficients:

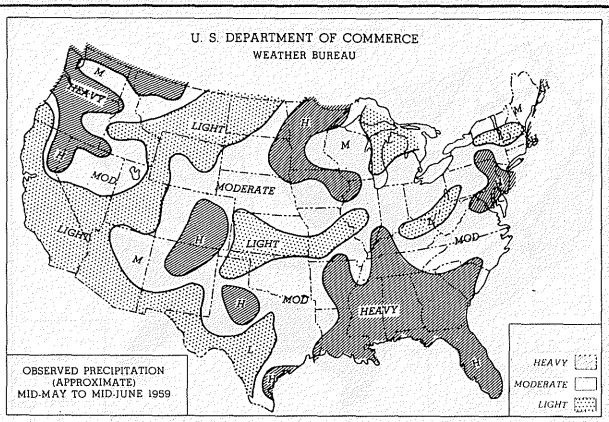
Atlantic	-0.03
North America	+0.55
Pacific	-0.19



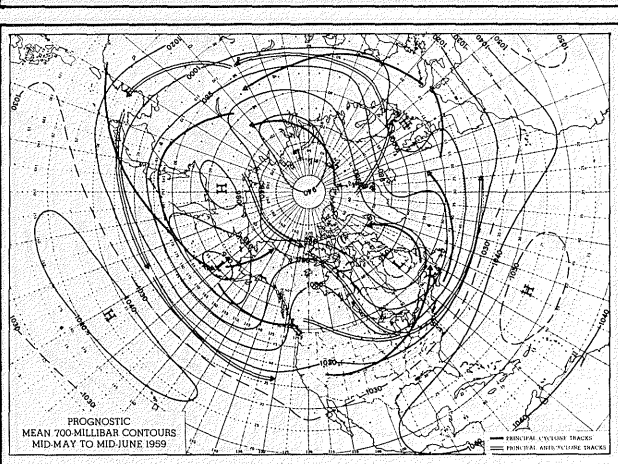


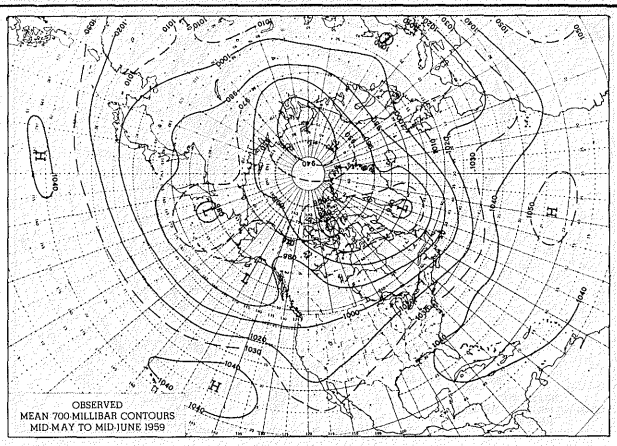
Temperature Score: 58 % within 1 class (of five)





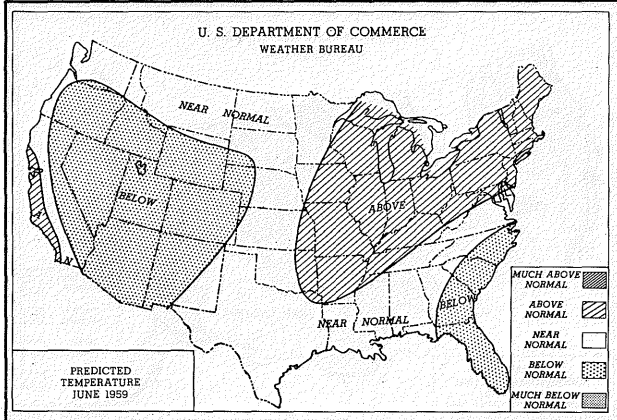
Precipitation Score: 38 % in the correct class (of three)

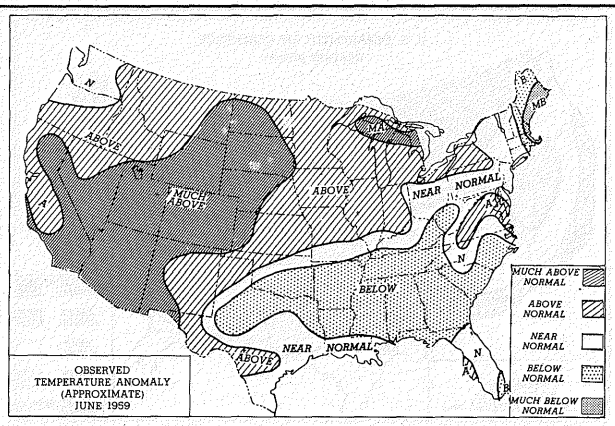




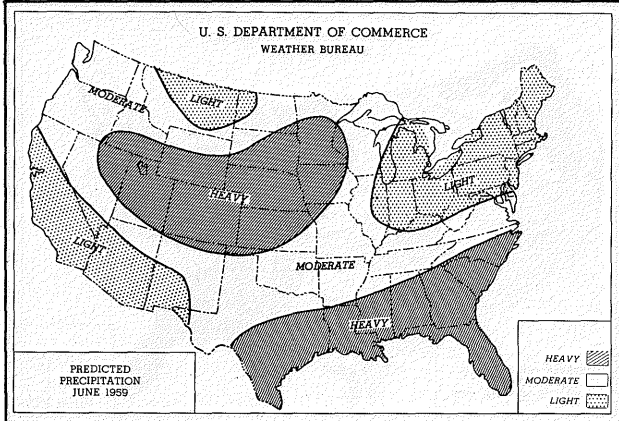
700 mb Anomaly Pattern Correlation Coefficients:

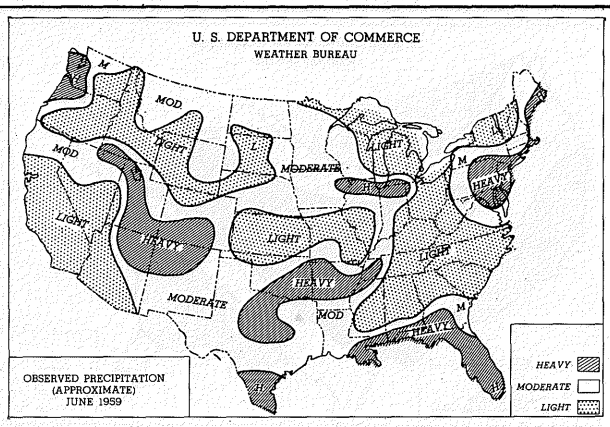
Atlantic	-0.34
North America	-0.58
Pacific	+0.13



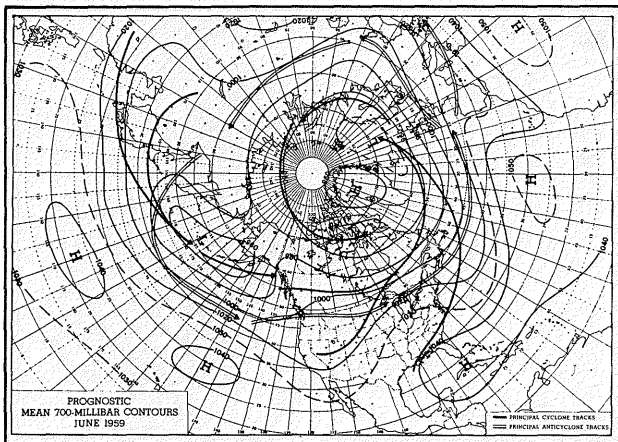


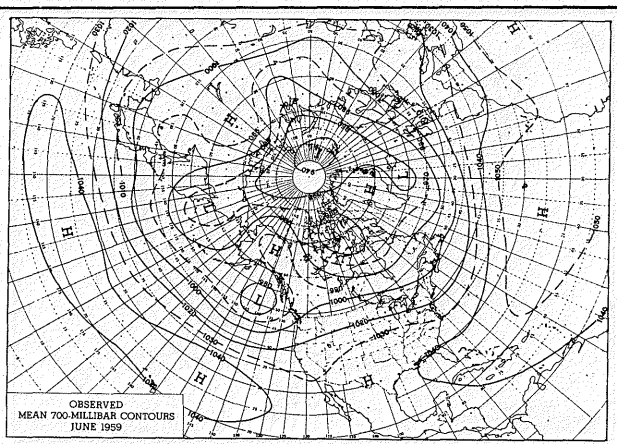
Temperature Score: 68 % within 1 class (of five)





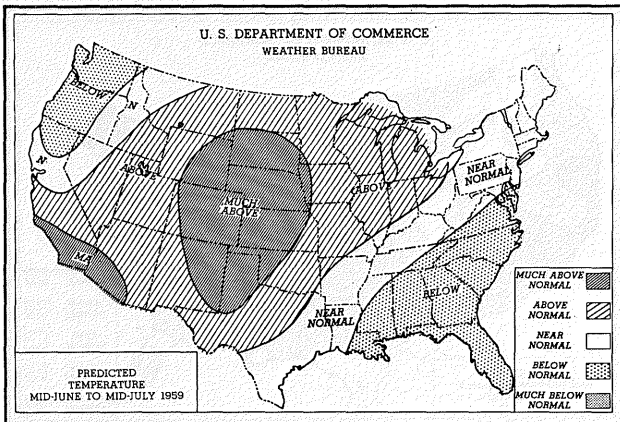
Precipitation Score: 37 % in the correct class (of three)

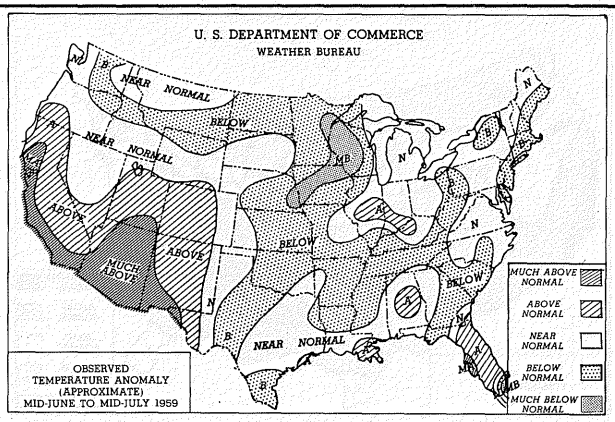




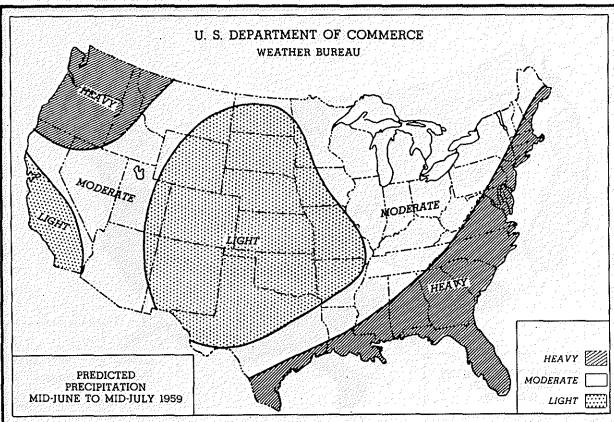
700 mb Anomaly Pattern Correlation Coefficients:

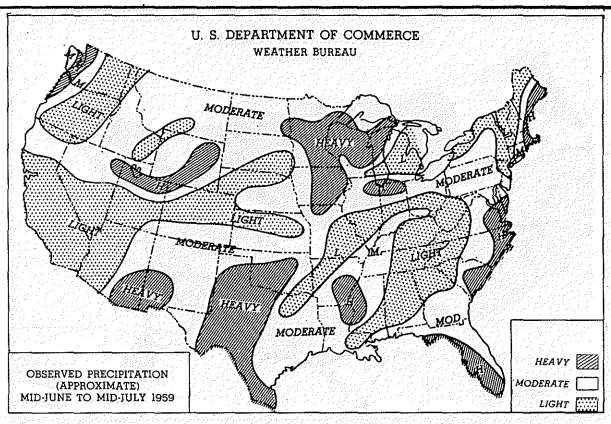
Atlantic	+0.73
North America	+0.38
Pacific	-0.04



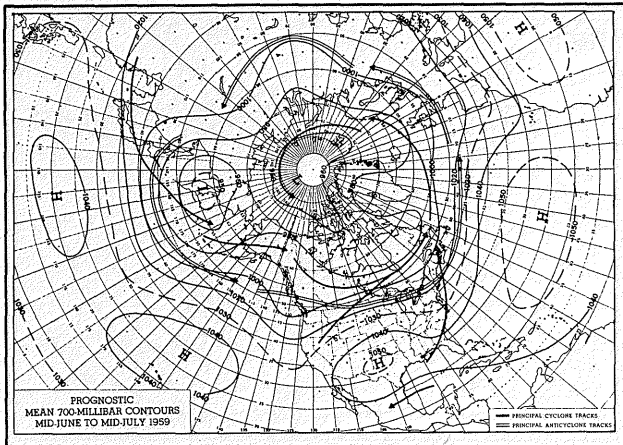


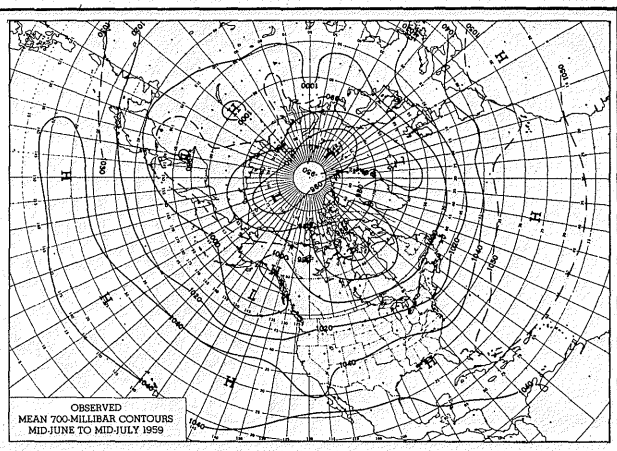
Temperature Score: 72 % within 1 class (of five)





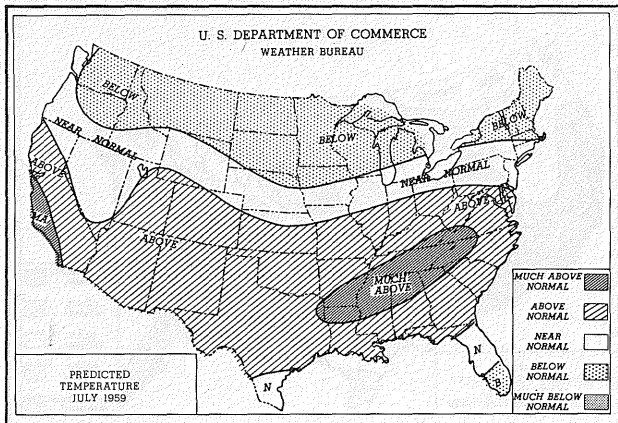
Precipitation Score: 29 % in the correct class (of three)

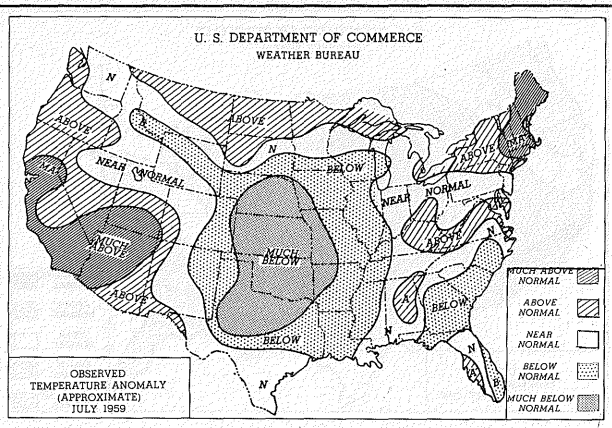




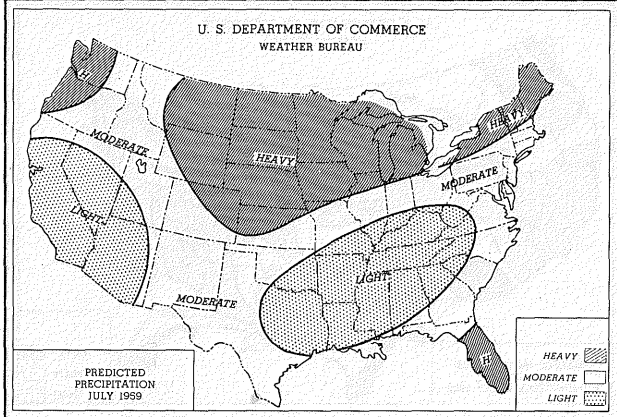
700 mb Anomaly Pattern Correlation Coefficients:

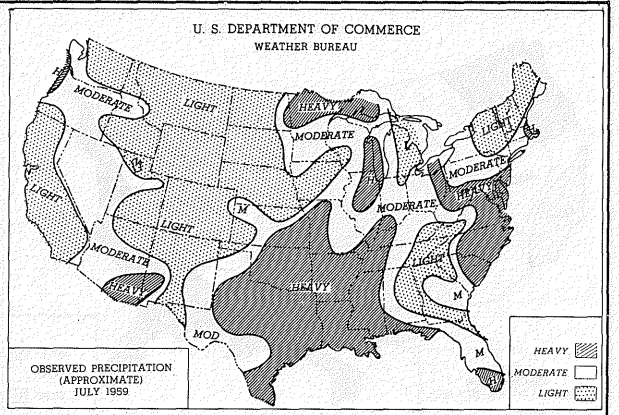
Atlantic	+0.35
North America	+0.53
Pacific	-0.16



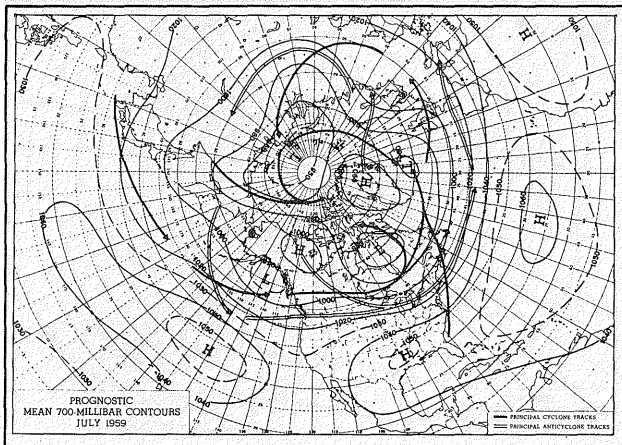


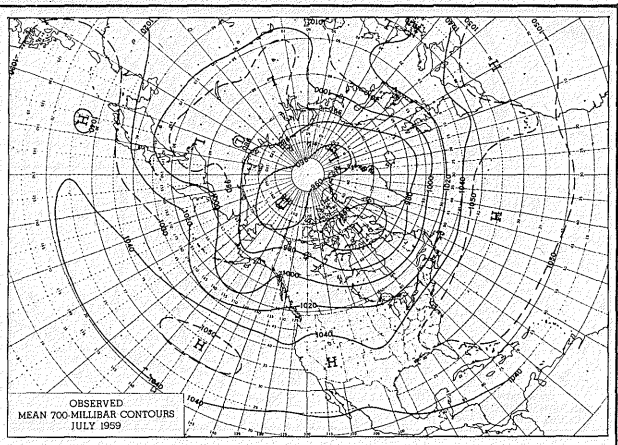
Temperature Score: 62 % within 1 class (of five)





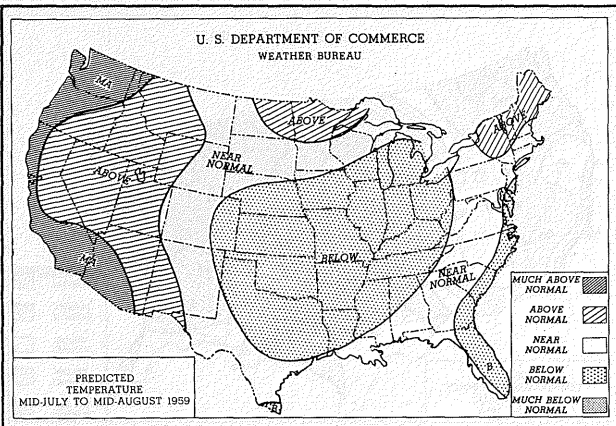
Precipitation Score: 23 % in the correct class (of three)

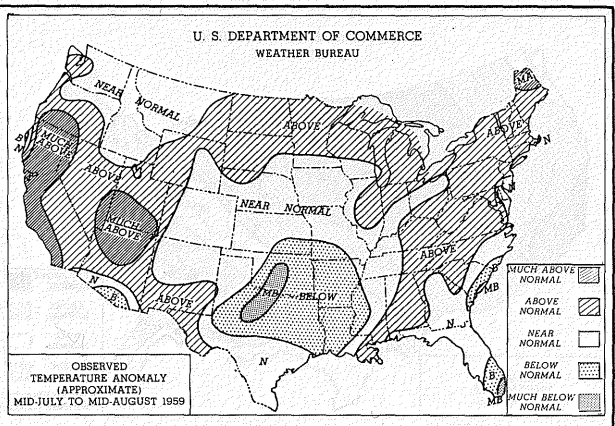




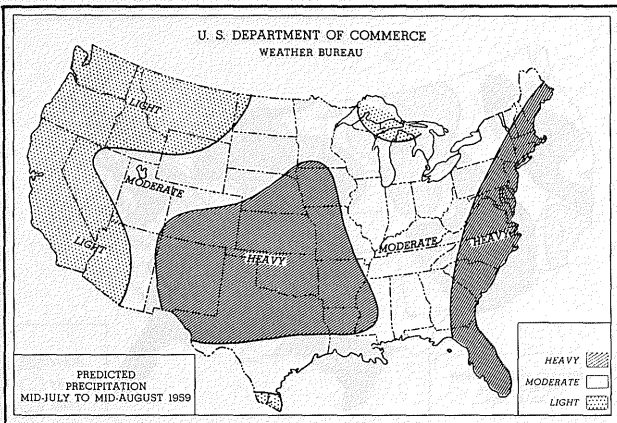
700 mb Anomaly Pattern Correlation Coefficients:

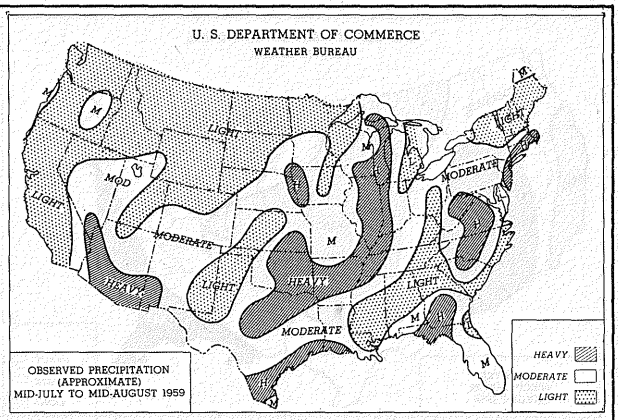
Atlantic	-0.35
North America	-0.40
Pacific	+0.18



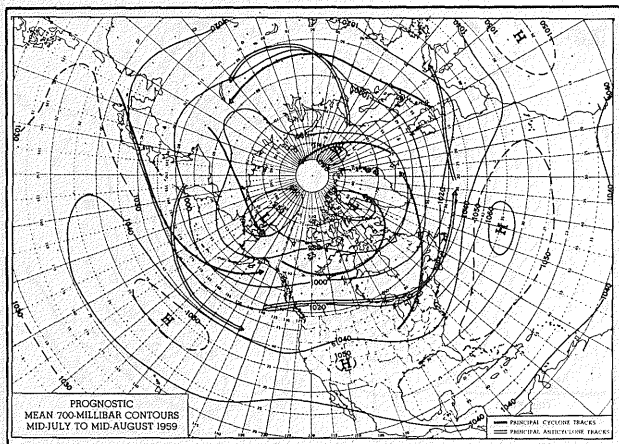


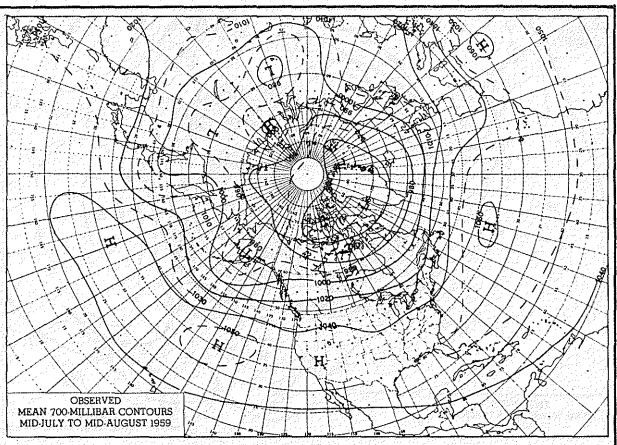
Temperature Score: 83 % within 1 class (of five)





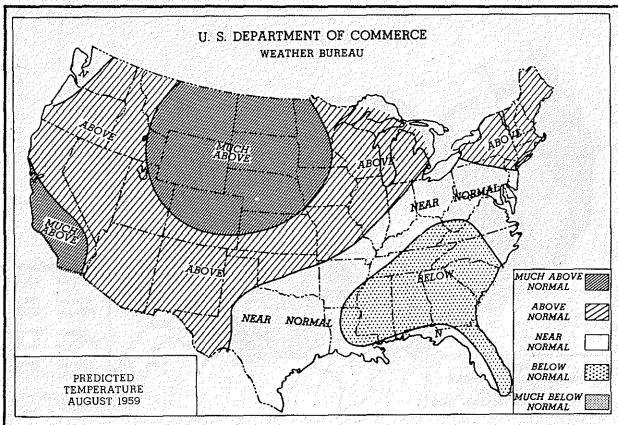
Precipitation Score: 47 % in the correct class (of three)

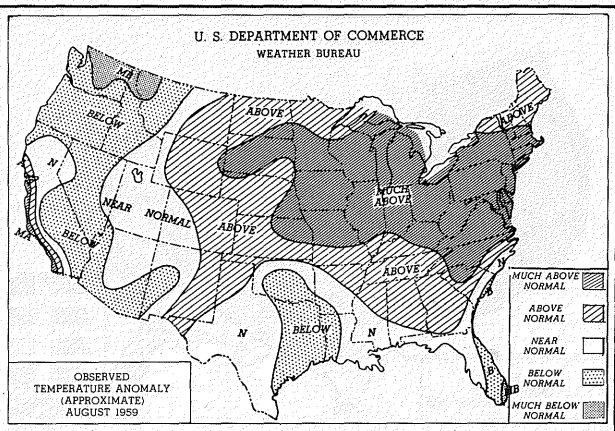




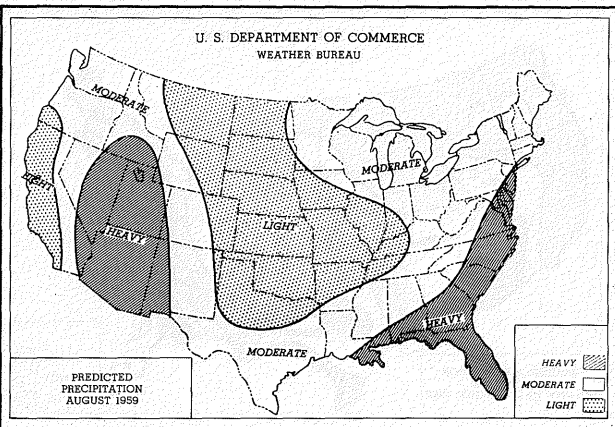
700 mb Anomaly Pattern Correlation Coefficients:

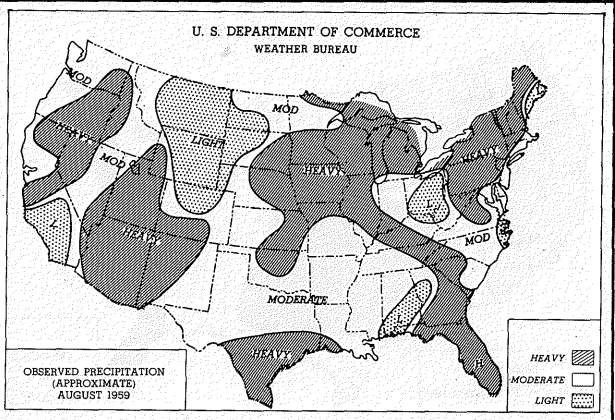
Atlantic	+0.72
North America	+0.48
Pacific	+0.41



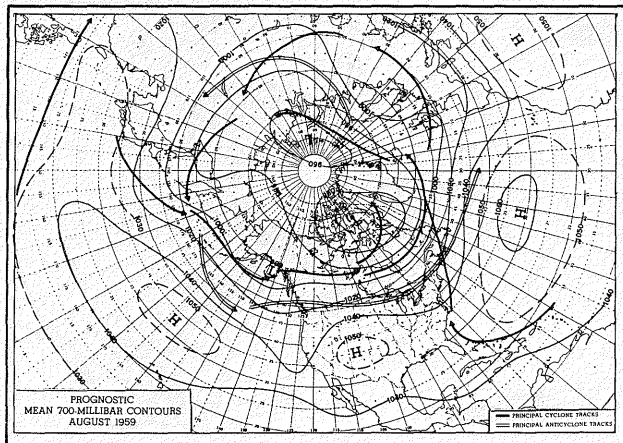


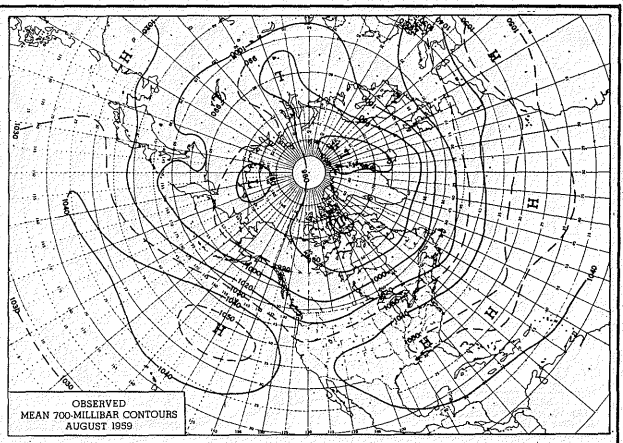
Temperature Score: 67 % within 1 class (of five)





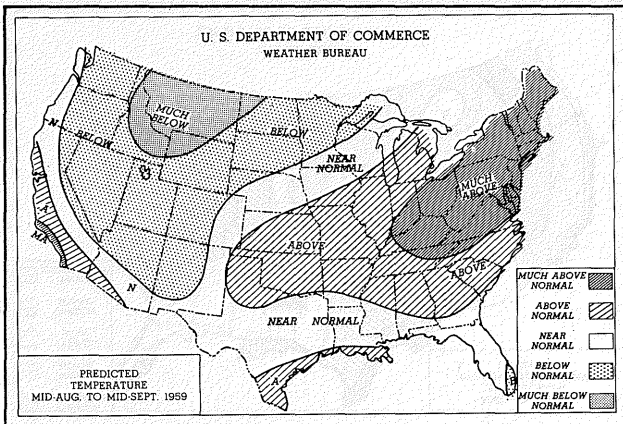
Precipitation Score: 38 % in the correct class (of three)

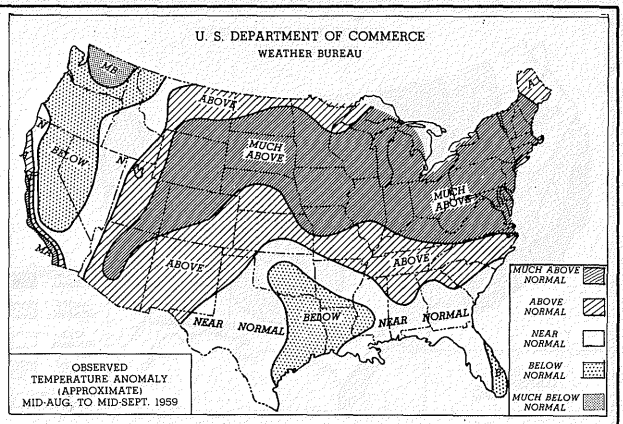




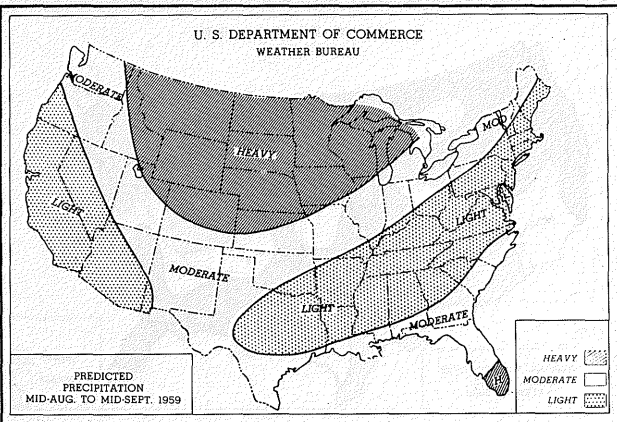
700 mb Anomaly Pattern Correlation Coefficients:

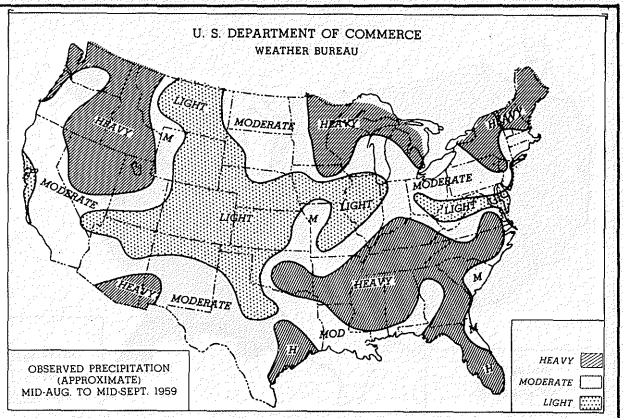
Atlantic	-0.23
North America	+0.29
Pacific	+0.61



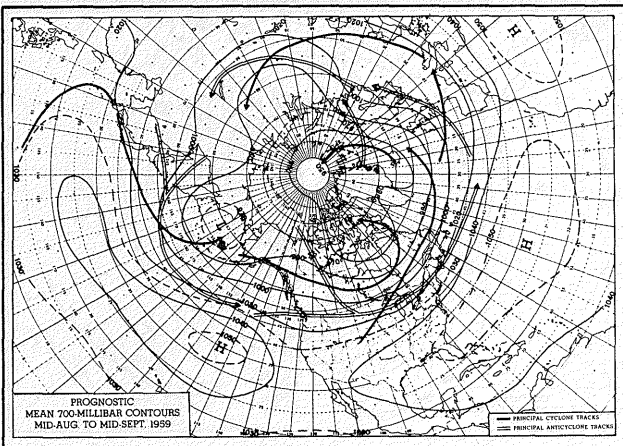


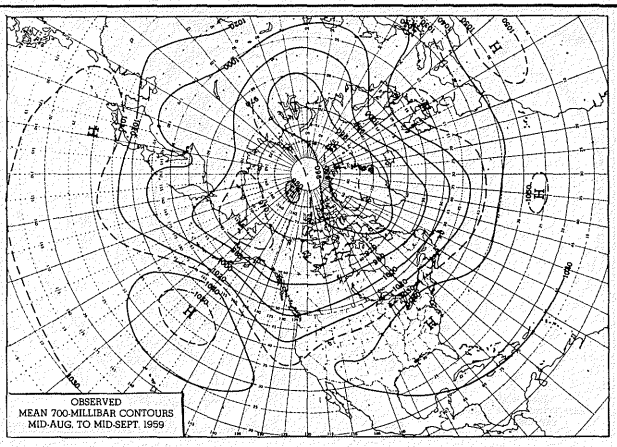
Temperature Score: 74 % within 1 class (of five)





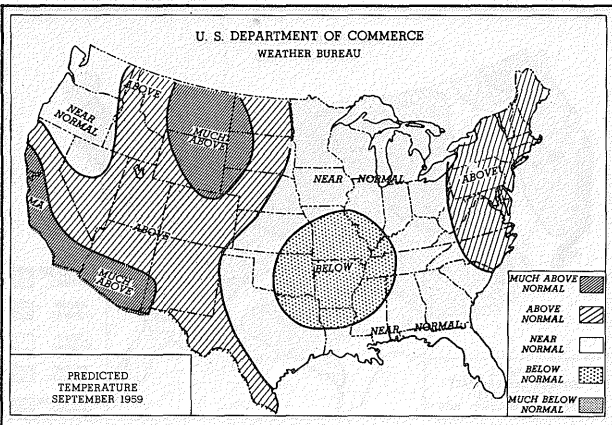
Precipitation Score: 32 % in the correct class (of three)

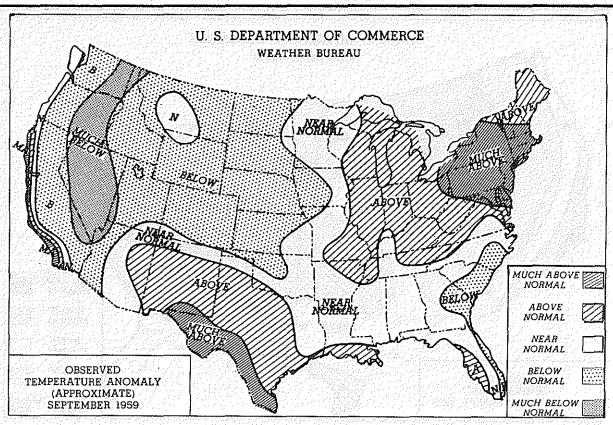




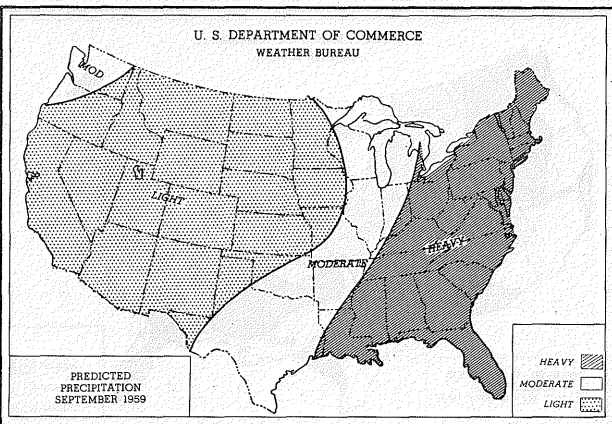
700 mb Anomaly Pattern Correlation Coefficients:

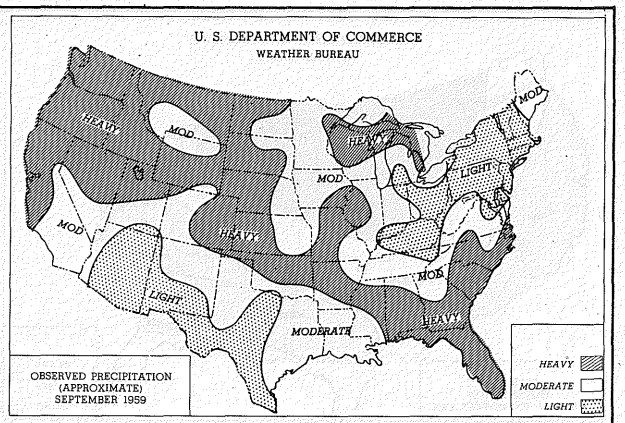
Atlantic	-0.05
North America	+0.24
Pacific	-0.06



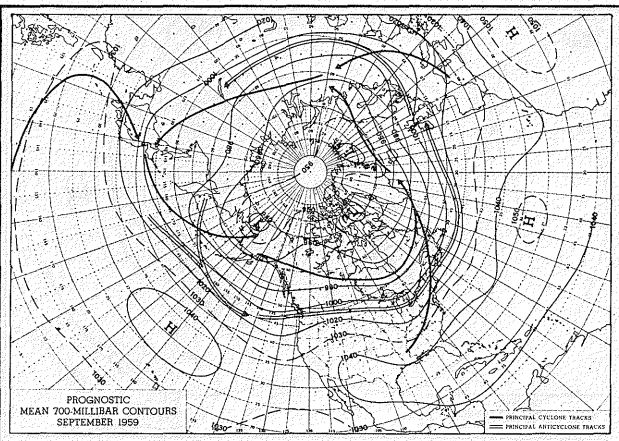


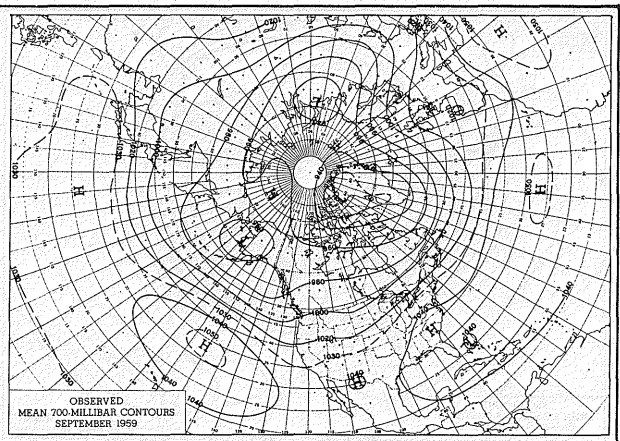
Temperature Score: 65 % within 1 class (of five)





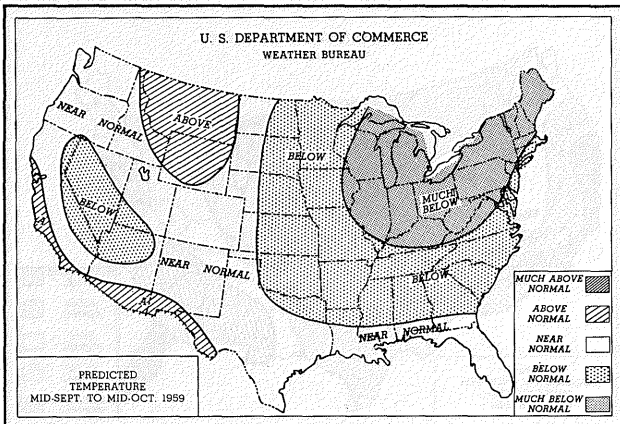
Precipitation Score: 23 % in the correct class (of three)

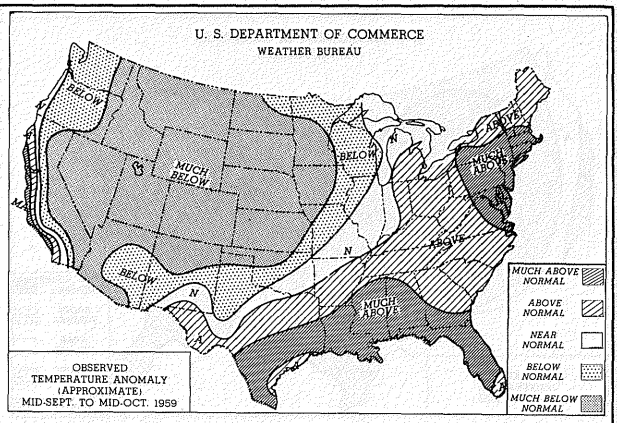




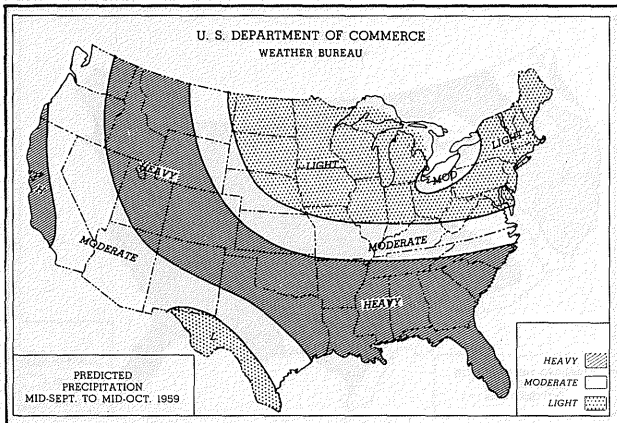
700 mb Anomaly Pattern Correlation Coefficients:

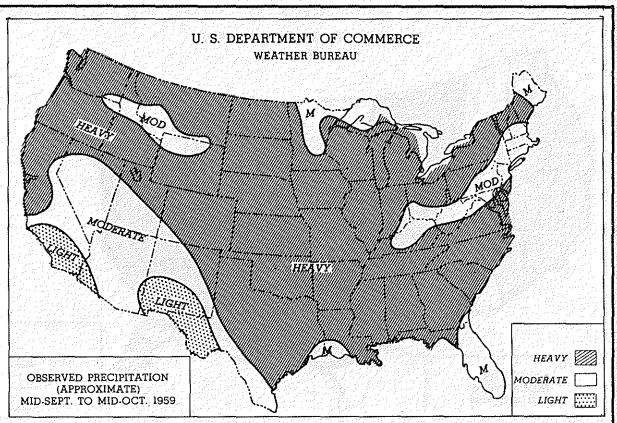
Atlantic	-0.03
North America	+0.14
Pacific	+0.33



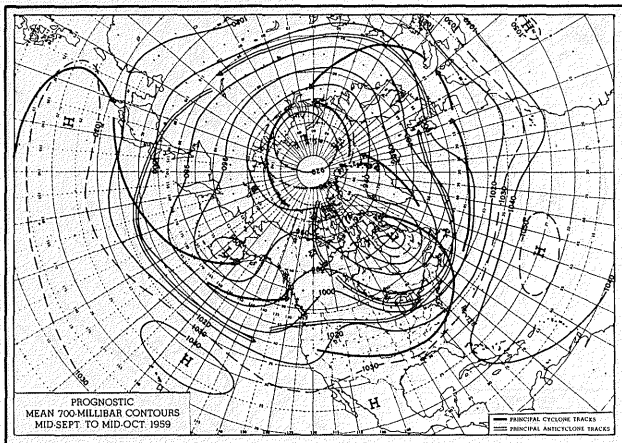


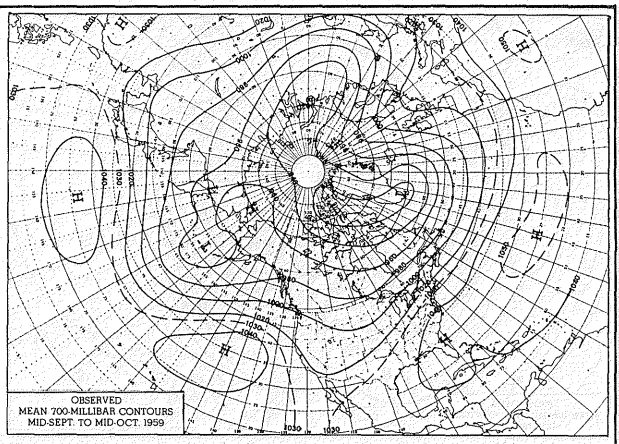
Temperature Score: 37 % within 1 class (of five)





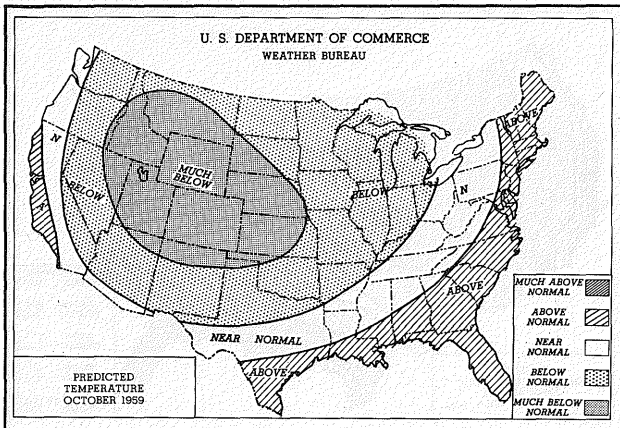
Precipitation Score: 39 % in the correct class (of three)

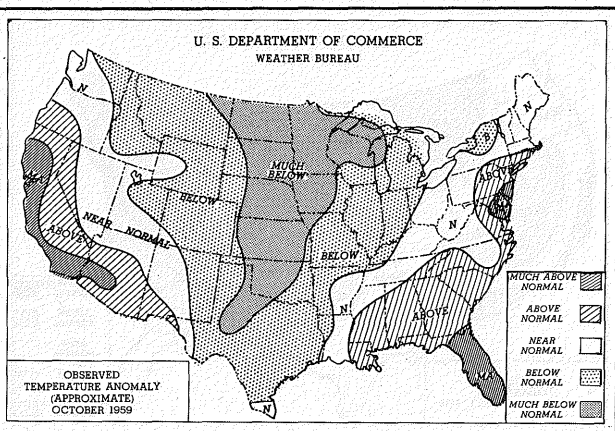




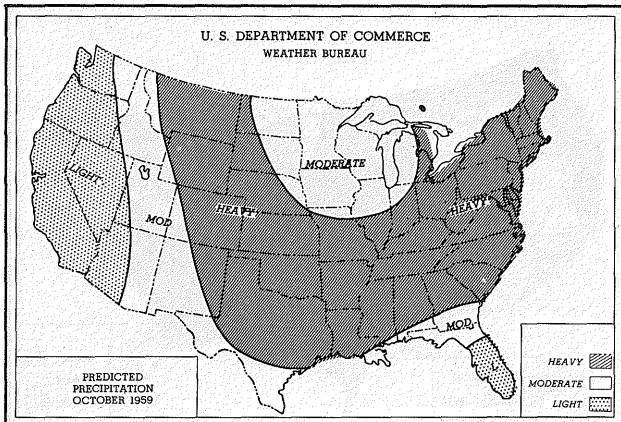
700 mb Anomaly Pattern Correlation Coefficients:

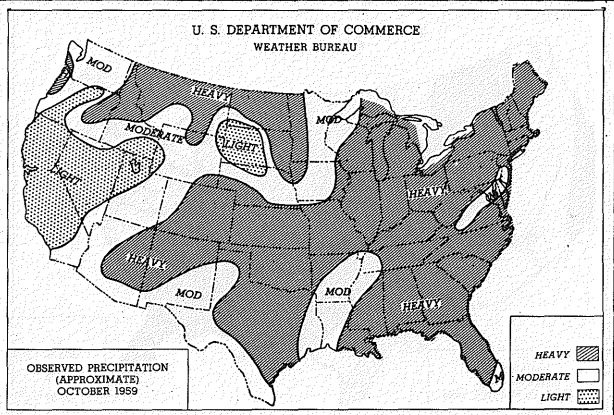
Atlantic	0.00
North America	-0.23
Pacific	+0.40



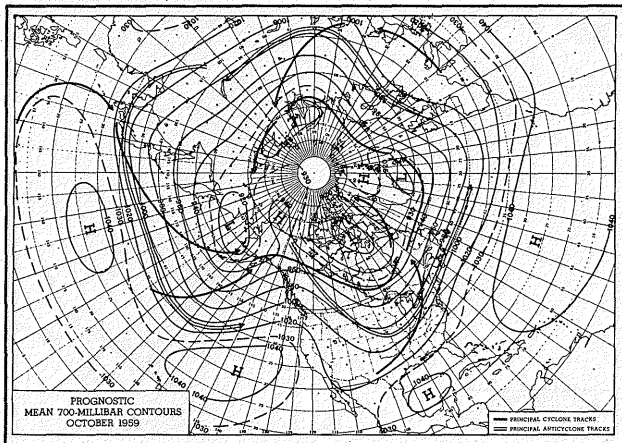


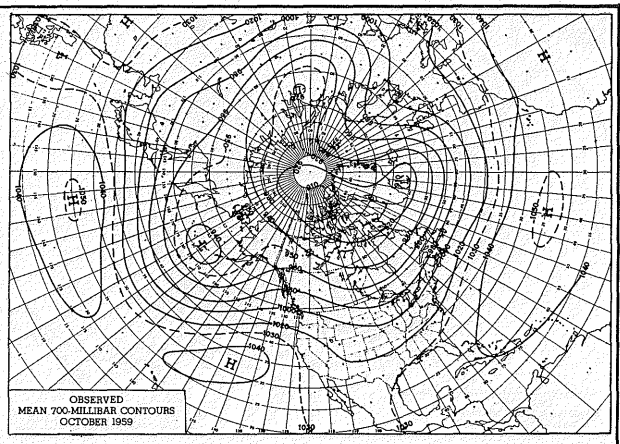
Temperature Score: 93 % within 1 class (of five)





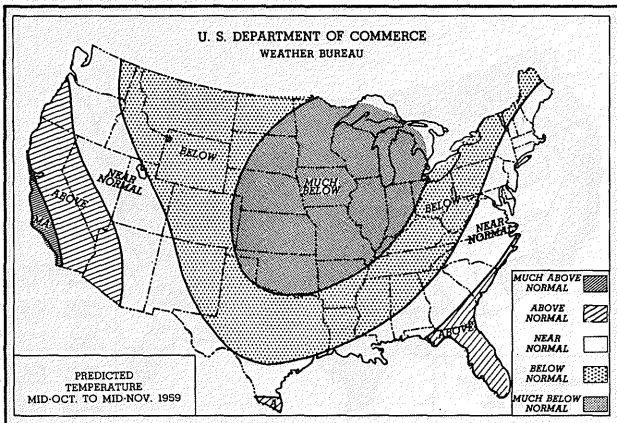
Precipitation Score: 67 % in the correct class (of three)

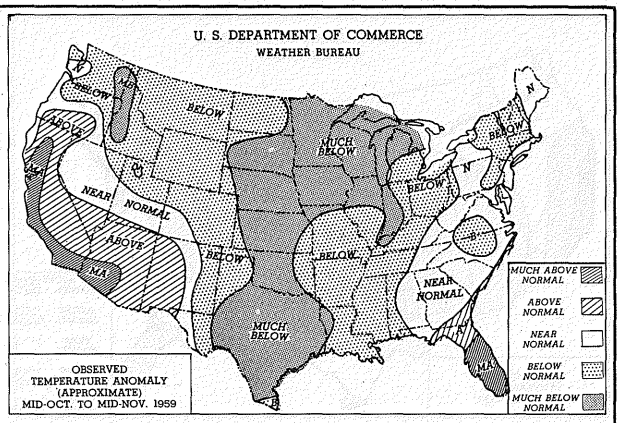




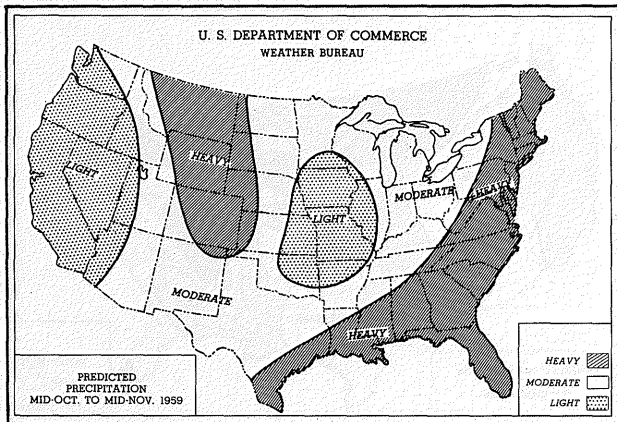
700 mb Anomaly Pattern Correlation Coefficients:

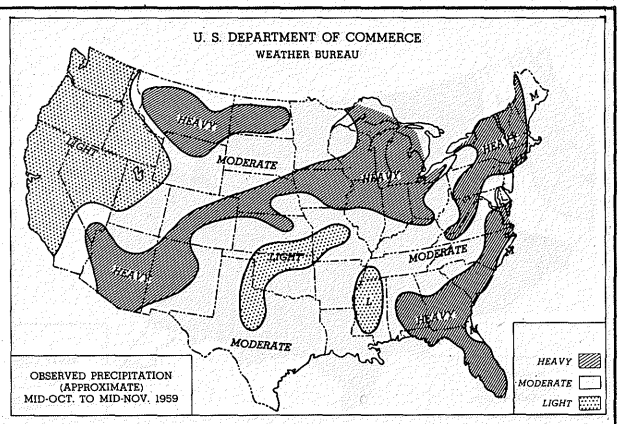
Atlantic	+0.74
North America	+0.93
Pacific	+0.54



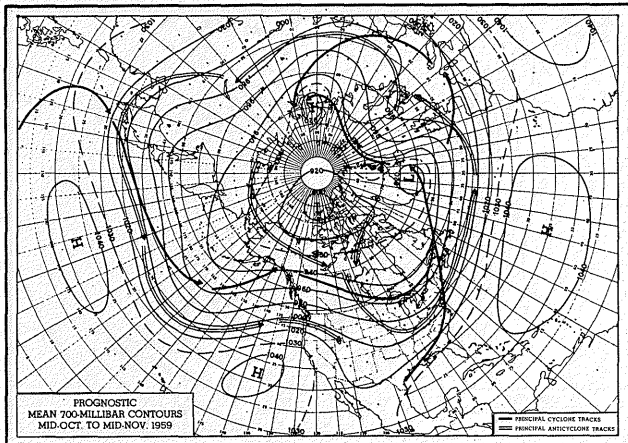


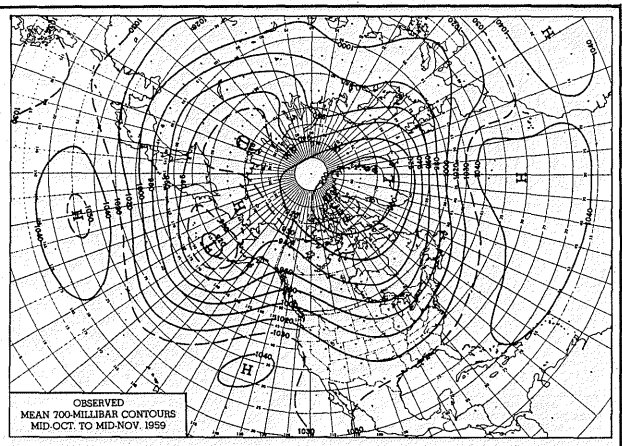
Temperature Score: 95 % within 1 class (of five)





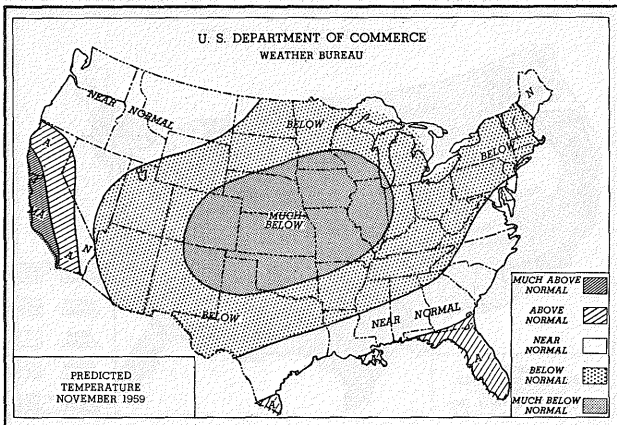
Precipitation Score: 51 % in the correct class (of three)

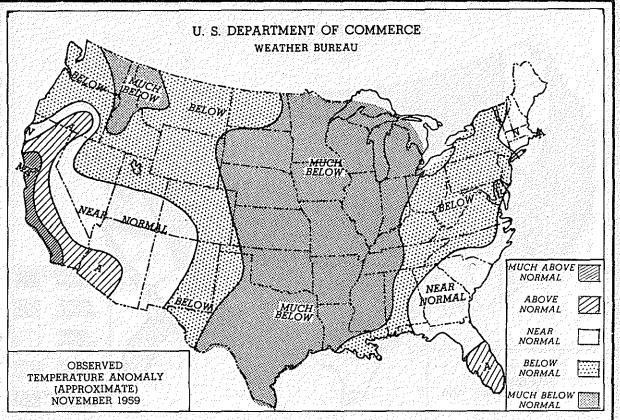




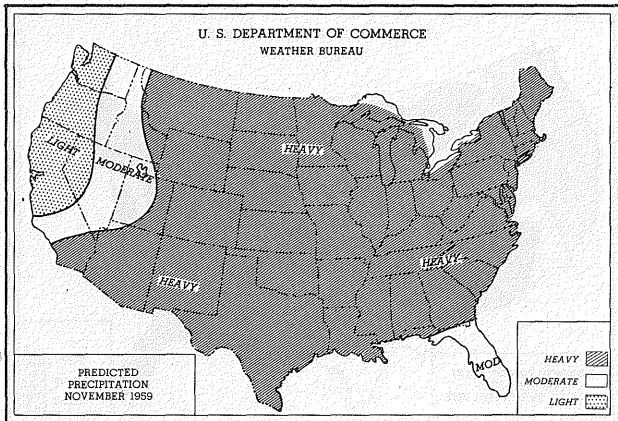
700 mb Anomaly Pattern Correlation Coefficients:

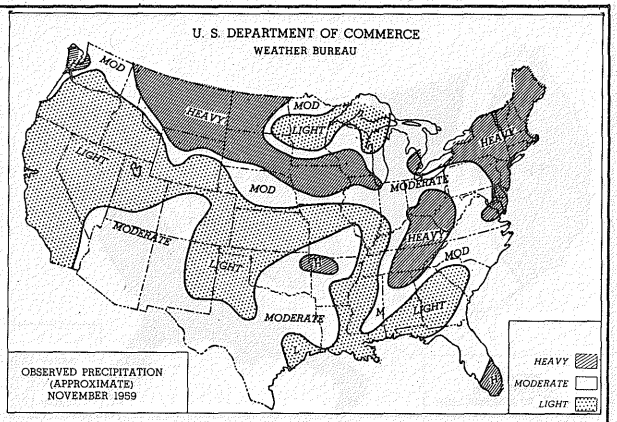
Atlantic	-0.24
North America	+0.46
Pacific	+0.35



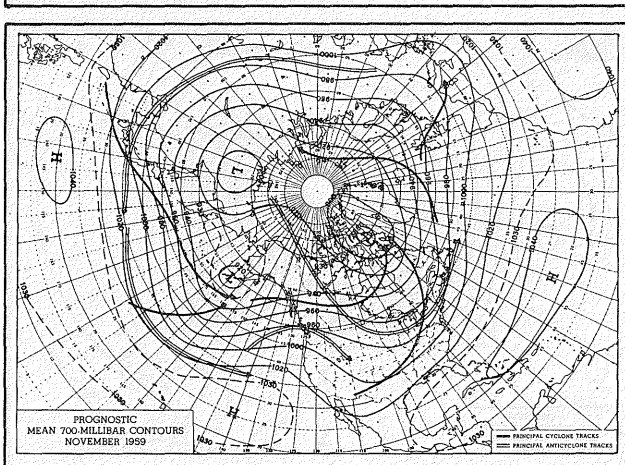


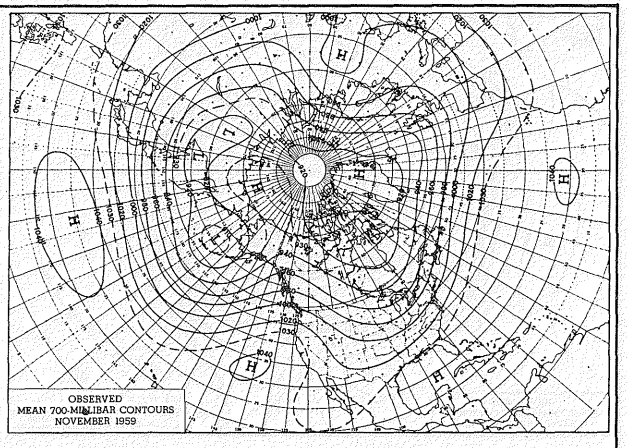
Temperature Score: 88 % within 1 class (of five)





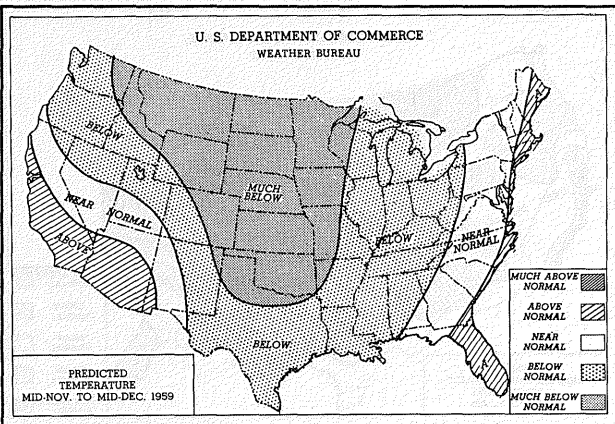
Precipitation Score: 31 % in the correct class (of three)

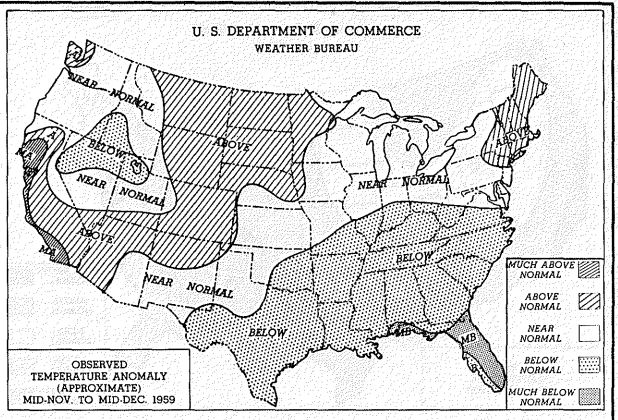




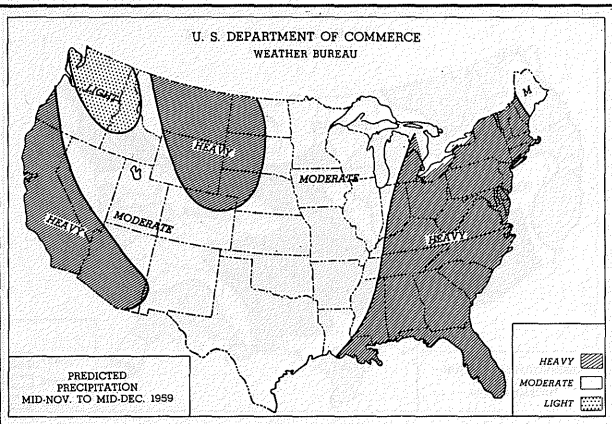
700 mb Anomaly Pattern Correlation Coefficients:

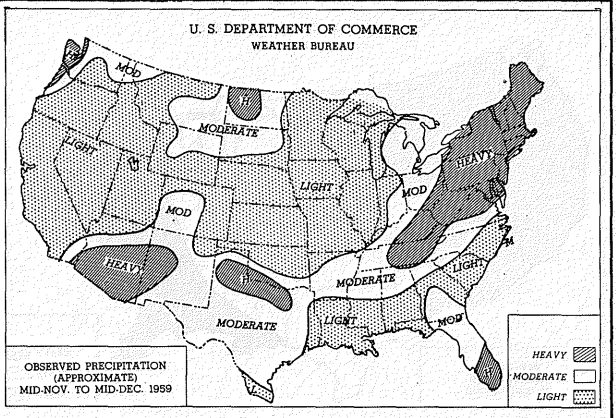
Atlantic	+0.48
North America	+0.32
Pacific	+0.37



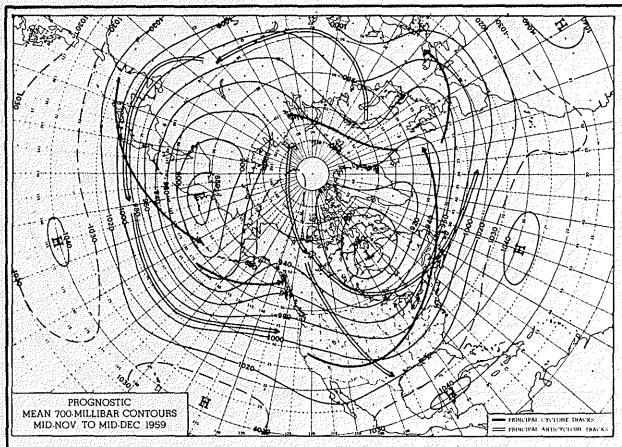


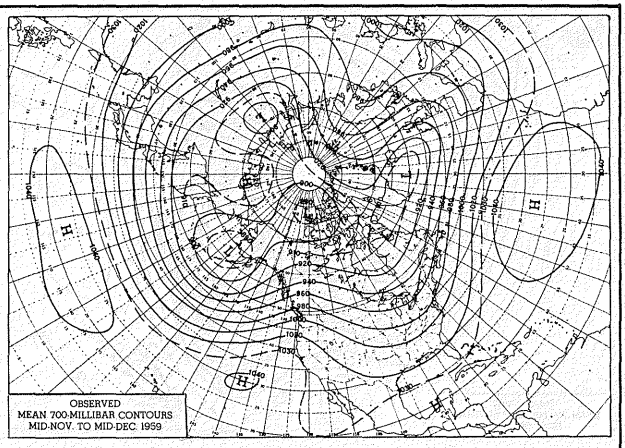
Temperature Score: 68 % within 1 class (of five)





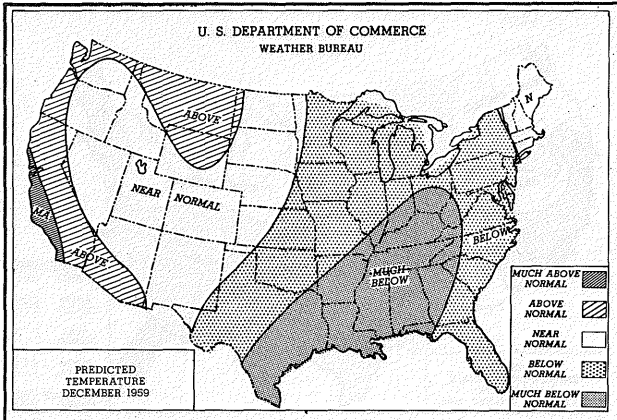
Precipitation Score: 34 % in the correct class (of three)

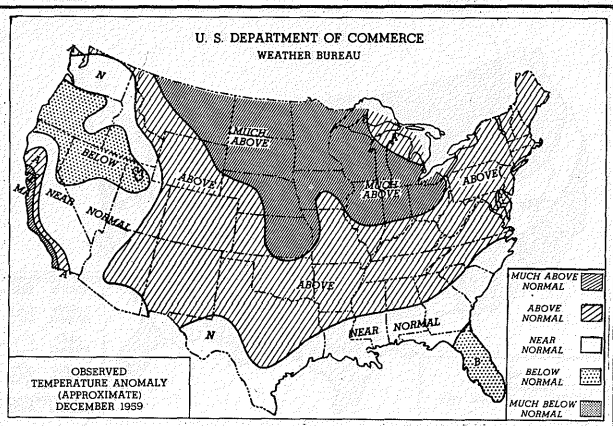




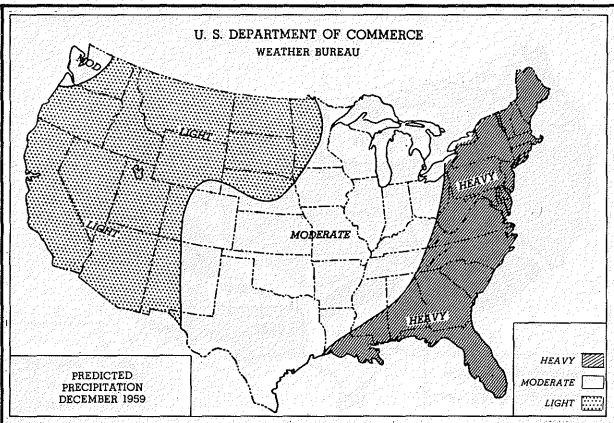
700 mb Anomaly Pattern Correlation Coefficients:

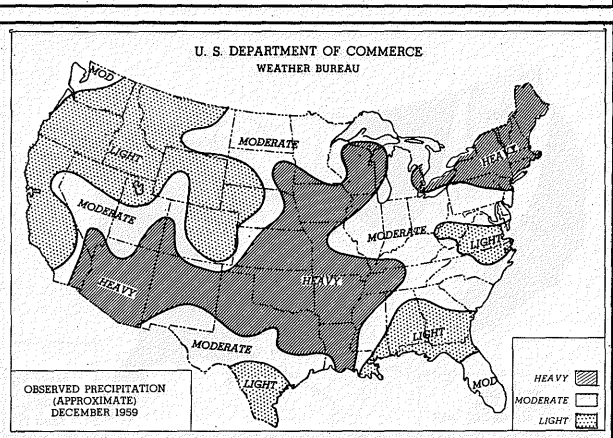
Atlantic	+0.84
North America	+0.08
Pacific	+0.19



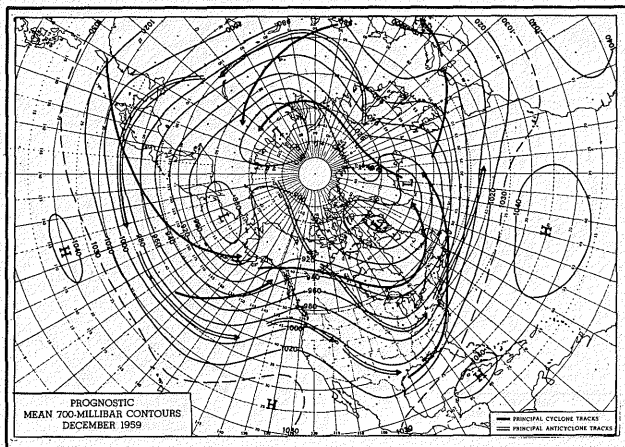


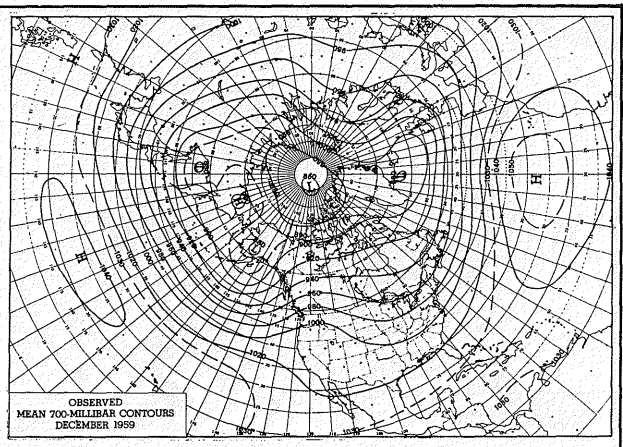
Temperature Score: 45 % within 1 class (of five)





Precipitation Score: 41 % in the correct class (of three)





700 mb Anomaly Pattern Correlation Coefficients:

Atlantic	+0.72
North America	+0.06
Pacific	+0.34

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