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FORECASTING THE PASSAGE OF SELECTED SOUTHWARD-MOVING COLD FRONTS IN SUMMER AT WASHINGTON, D. C.

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ABSTRACT

Cases are selected which are thought to present the summertime problem of whether a cold front will pass Washington, D. C., from the north "tomorrow". Variables that measure the effective steering direction at 700 mb., the strength of zonal current at 700 mb., and the availability of cold air in Canada are found to be helpful in separating cases of effective frontal passage from other cases. The variables are combined in scatter diagrams to provide a systematic aid to forecasting the passage of the selected cold fronts.

INTRODUCTION

One of the more difficult forecasting problems along the east coast of the United States during the summer months is the forecasting of the maximum temperature at a given location for the following day, particularly during spells of hot weather when the public is seeking relief from the heat. An incorrect forecast of either continued hot weather or for cooling relief is widely publicized and results in considerable adverse criticism of the forecast. The success of a temperature forecast under these circumstances usually depends on the accuracy with which the movement of a threatening cold front is forecast. This study was undertaken with a hope that reliable criteria for frontal passage in summer could be established which could be applied by the forecaster to the data available up to 0130 EST when issuing a forecast of whether cooler temperatures can be expected at Washington, D. C., on the following day. However, the procedure which is developed applies only in the event that a front exists near or south of Sault Ste. Marie, Mich., but not south of Albany, N. Y. As will be made clear in the following section, there are certain types of frontal passage that are not included here due to the particular time lag selected for study and other reasons, but it is believed that the results will provide a useful guide when used as specified.

SYNOPTIC ASPECTS OF THE PROBLEM

The main criterion for the passage of a cold front from

the north or northeast *at or near the time of passage* was found by Hoover and Sanders [1] to be the presence of a High with a central pressure of at least 1020 mb. (sea level) behind the front to the north of Washington. To be of use in the 24-42 hour forecasts considered here, this and other criteria discussed by them would require a 24-hour forecast of the pressure pattern, and this in many cases would require a forecast of substantial anticyclogenesis over the period. The present study therefore was undertaken looking to the possibility that the criteria for the passage of the front with its resultant cooling could be isolated directly by the forecaster from the 0130 EST map of the day previous to the passage. Thus the criteria as of this time will consist largely of factors tending to describe the availability of the cold air in Canada and the flow necessary to move the cold air from Canada to Washington.

It was assumed at the outset of this investigation that there exist certain types of situations wherein a cold front passage from the west and northwest can be predicted by straightforward computation, examination of the number of isobars crossing the front, etc. These types are not considered here. A more difficult problem is posed however by situations such as those illustrated in figures 1 and 2 in which the forecaster might justifiably and correctly predict that on the following morning the front would be lying with an east-west orientation through Pennsylvania. The forecast of further southward movement of the front however becomes more difficult and it

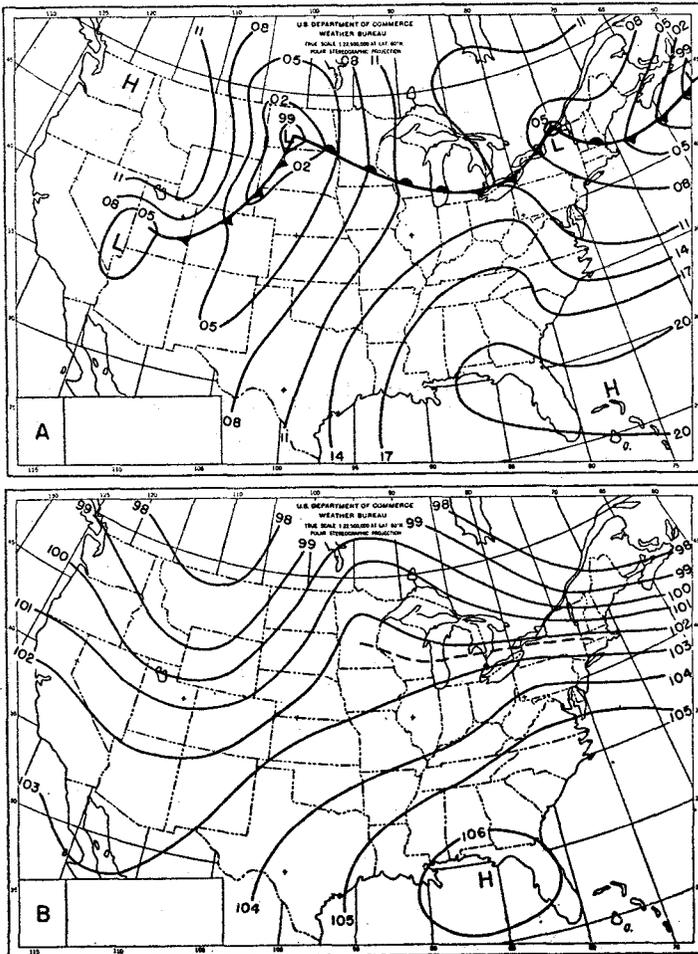


FIGURE 1.—Case 15 of table 1. (A) Sea level weather map for 0130 EST, June 27, 1949. (B) 700-mb. chart for 2200 EST, June 26, 1949.

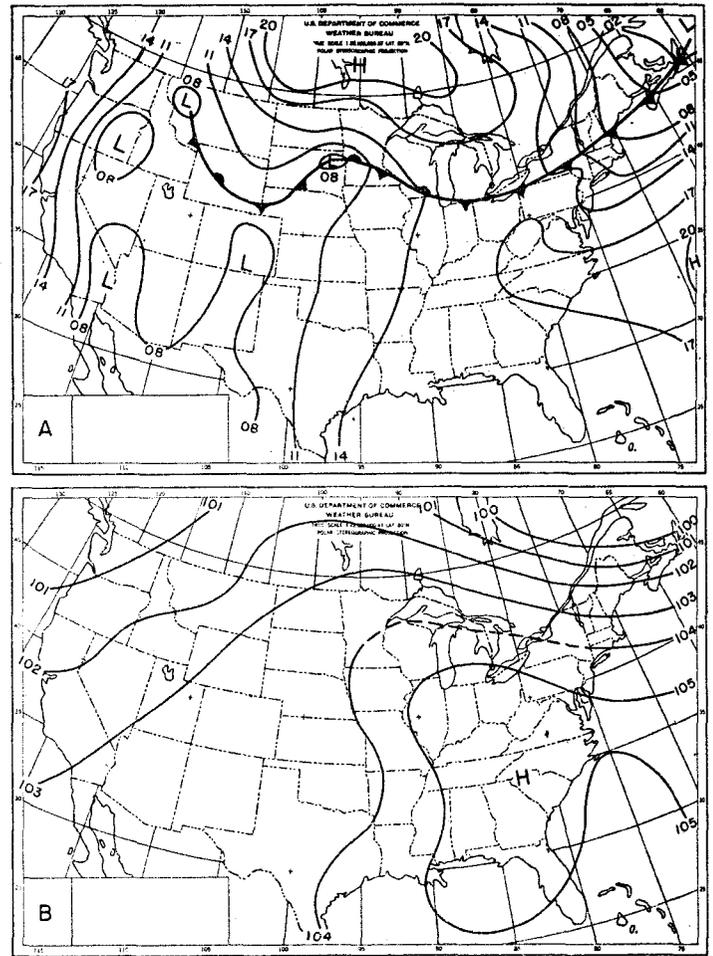


FIGURE 2.—Case 16 of table 1. (A) Sea level weather map for 0130 EST, July 5, 1949. (B) 700-mb. chart for 2200 EST, July 4, 1949.

is this and similar types of situations which have been selected for study at this time.

A preliminary examination of all 0130 EST maps for June, July, and August 1948 revealed 10 cases wherein this problem was posed. Examination of these cases, keeping in mind that the criteria should attempt to describe not only the availability of the cold air, but also its subsequent movement, showed a promising line of attack through the use of the following parameters:

1. The temperature difference at 700 mb. between Minneapolis-St. Cloud, Minn., and Churchill, Manitoba.
2. The temperature difference at 700 mb. between Albany, N. Y. and Moosonee, Ontario.
3. The temperature at 700 mb. over Moosonee.
4. The position of the 700-mb. height contour through Minneapolis-St. Cloud, Minn. relative to Toledo, Ohio and Albany, N. Y.

Factors 1 through 3 will be seen at once to be those selected to describe the potential availability of cold air in Canada. Factor 4 was then chosen as one which might describe the 700-mb. flow, within the type of situation studied, to determine the possibility of the steering of the cold air toward Washington in a manner

described by George [2]. In all cases included in this study, the High considered was usually centered west of Moosonee and the front generally near (i. e. approaching or south of) Sault Ste. Marie but not south of Albany. In cases wherein the High is east of Moosonee and the front south of Albany, the problem is more apt to be that of whether the front will pass "today" and is not discussed in this report.

DEVELOPMENT OF FORECASTING PROCEDURE

Following the preliminary selection of the parameters outlined in the preceding section, the indicated data were extracted from all 2200 EST 700-mb. charts for the months June, July, and August 1947, 1948, 1949, for those cases wherein an inspection of the accompanying 0130 EST surface chart indicated the possibility of the southward passage of a cold front "tomorrow". Table 1 is a catalog of all cases treated in the study including those selected from the summer of 1947.

As the study progressed it was felt that a more tangible measure of the flow east of Minneapolis could be obtained through the use of the latitude at which the 700-mb. contour through Minneapolis intersected the 75th and

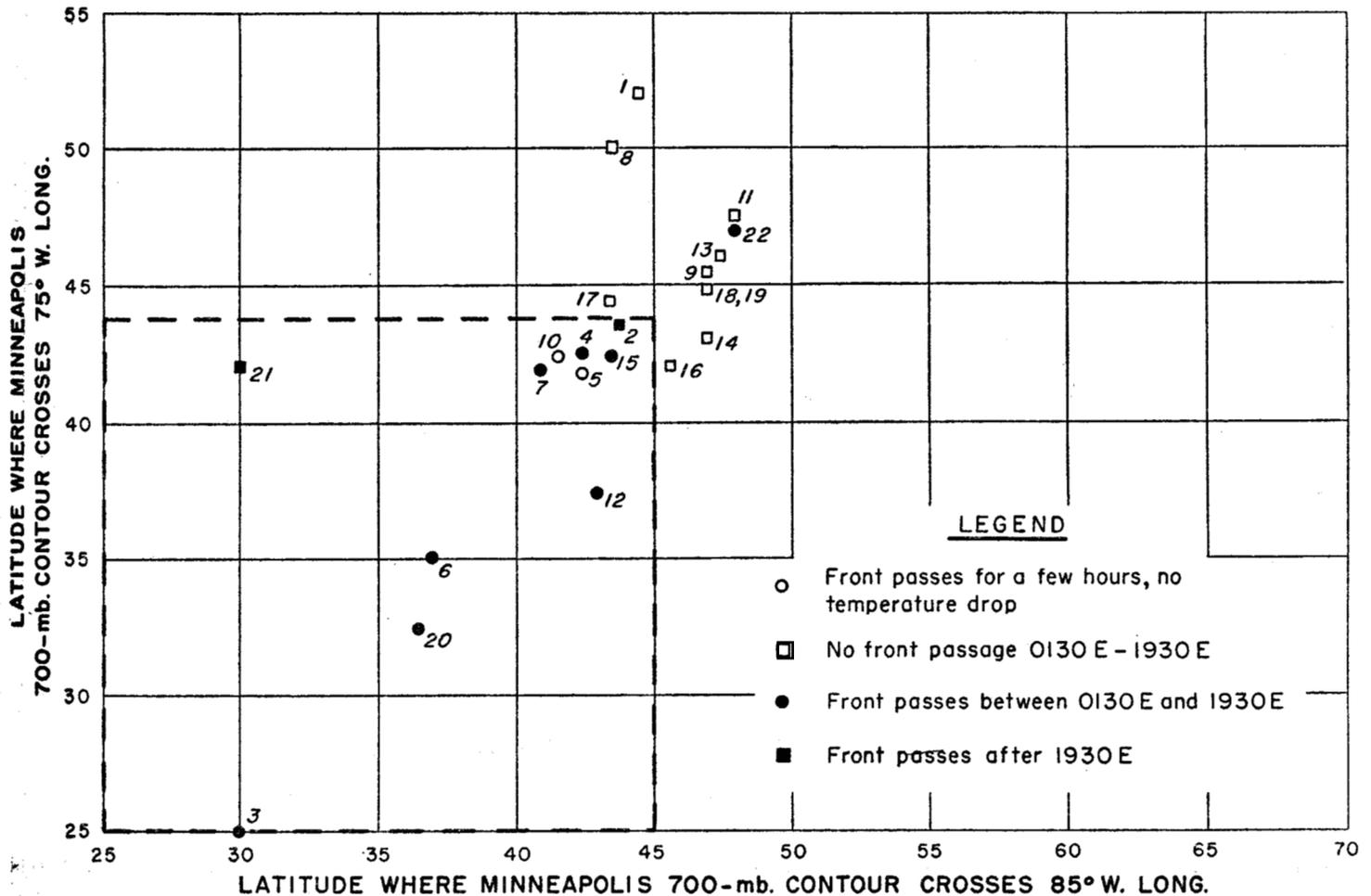


FIGURE 3.—Scatter diagram relating cases in table 1 to latitude at which the 700-mb. height contour through Minneapolis crossed 75° W. and 85° W. longitude 28 hours before beginning of forecast period, 0130-1930 EST. The block in the lower left separates cases of frontal passage from those of no frontal passage.

TABLE 1.—Catalogue of cases used in developing forecast procedure

Case No.	Date of 2200 EST 700-mb. chart	Independent variables *				Dependent variable **
		1	2	3	4	
1	Aug. 14, 1947	44.5	52.0	-10	25	X
2	Aug. 27, 1947	44.0	43.5	-19	36	L
3	June 3, 1948	30.0	25.0	-7	3	P
4	June 14, 1948	42.5	42.5	-19	15	P
5	June 24, 1948	42.5	42.0	-6	25	I
6	July 5, 1948	37.0	35.0	?	7	P
7	July 12, 1948	41.0	42.0	-10	-4	X
8	July 17, 1948	43.5	50.0	-6	21	P
9	July 20, 1948	47.0	45.5	-12	4	X
10	July 27, 1948	41.5	42.5	-6	13	I
11	Aug. 25, 1948	48.0	47.5	-7	5	X
12	Aug. 29, 1948	43.0	37.5	-14	15	P
13	June 11, 1949	47.5	46.0	-10	10	X
14	June 18, 1949	47.0	43.0	-13	16	X
15	June 26, 1949	43.5	42.5	-11	11	P
16	July 4, 1949	45.5	42.0	-16	1	X
17	July 19, 1949	43.5	44.5	-7	28	X
18	Aug. 8, 1949	47.0	45.0	-9	12	X
19	Aug. 10, 1949	47.0	45.0	-10	7	X
20	Aug. 17, 1949	36.5	32.5	-2	3	P
21	Aug. 22, 1949	30.0	42.0	-13	21	X
22	Aug. 18, 1947	48.0	47.0	-6	13	P†

* Independent variables:
 1. Latitude at which 700-mb. contour through Minneapolis crosses longitude 85° W.
 2. Latitude at which 700-mb. contour through Minneapolis crosses longitude 75° W.
 3. Moosonee 700-mb. temperature plus Churchill 700-mb. temperature minus Minneapolis 700-mb. temperature.
 4. 700-mb. zonal index: Omaha 700-mb. height minus International Falls 700-mb. height.
 ** Dependent variable:
 5. Passage during forecast period.
 P = Definite passage at Washington.
 X = Definitely does not pass.
 L = Passes after forecast period.
 I = Ineffective passage for short time.
 † Front passed near end of forecast period.

85th west longitude meridians. Therefore this item is shown in the catalog rather than item 4 of the preceding section.

Figure 3 is a scatter diagram showing whether a front passage occurred at Washington during the period beginning at 0130 EST and ending at 1930 EST on the following day as a function of the parameters selected to describe the 700-mb. contour through Minneapolis. In this figure it will be seen that all of the actual passages during the specified period occurred when the flow, as indicated by the contour through Minneapolis, intersected the 85th meridian south of 45° N. and the 75th meridian south of 43.5° N.

However within this area, which is outlined by heavy lines on the chart, there exist two cases in which the front did not pass until after 1930 EST on the following day, plus two more cases in which the front actually passed, but only for a few hours and without any change to cooler weather. An attempt was then made, without success, to separate these four cases from the others by means of the temperature parameters indicated by items 1-3 in the preceding section.

At this point, some thought was given to the problem of why, under otherwise similar circumstances, the cold air moves southward or does not. When it was recalled

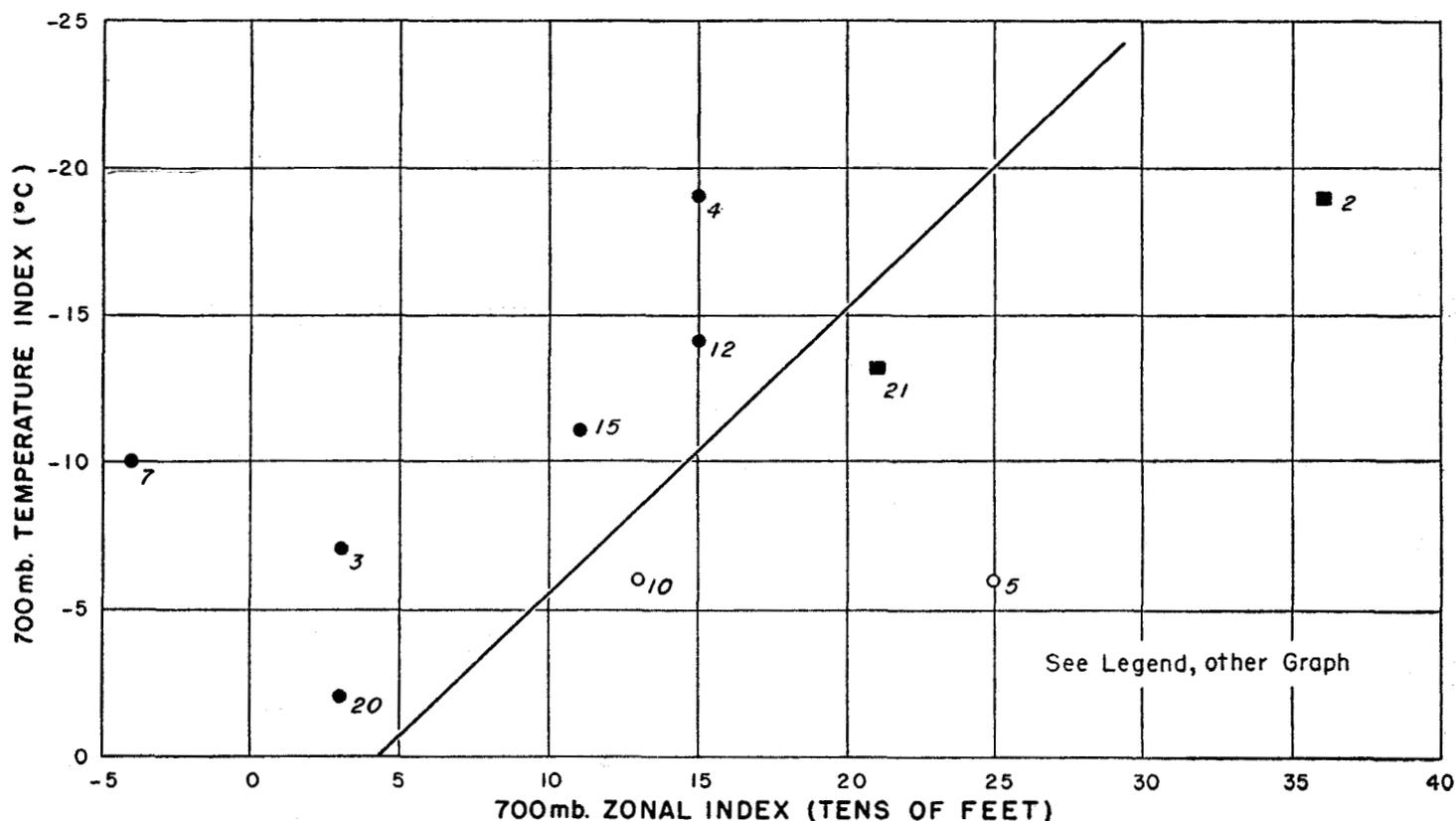


FIGURE 4.—Scatter diagram relating cases from lower left block of figure 3 to 700-mb. zonal index (700-mb. height at Omaha minus height at International Falls) and 700-mb. temperature index (algebraic sum of temperature at Moosonee plus temperature at Churchill minus temperature at Minneapolis) 28 hours before beginning of forecast period. Note: Case 6 is not plotted due to missing 700-mb. temperature at Moosonee.

that the strength of the westerly flow, as indicated by some sort of zonal index, has been used to indicate whether or not cold air could be expected to move southward (c.f., Namias [2]), a factor of this type was tabulated and tested. The strength of the flow was, in this problem of forecasting a day ahead, estimated somewhat to the west of Washington and at 700 mb. by taking the difference between the heights of the 700-mb. surface at Omaha and International Falls.

It was soon found that this variable was producing some of the desired separation, in that in only one case when the difference was 150 feet or less among the cases studied, did the front fail to pass decisively. It was then thought that this variable, along with a measure or index of the cold air to the northward would produce jointly a better separation than either could produce alone. An arbitrary temperature index was obtained by adding algebraically the 700-mb. temperature at Moosonee plus 700-mb. temperature at Churchill minus the 700-mb. temperature at Minneapolis. This temperature index was plotted against the Omaha-minus-International Falls "zonal" index in figure 4. A line is sketched which separates all cases of outright frontal passages from those which passed after 1930 EST or passed for only a few hours without lowering the temperature.

USE OF THE CHARTS FOR FORECASTING

With the aid of the 2200 EST 700-mb. chart and the scatter diagrams (figs. 3 and 4) which have been developed,

passage or nonpassage at Washington of a summer cold front of the specified type on the 0130 EST sea level map may be rapidly forecast as follows:

1. Enter figure 3 with the appropriate coordinate values. Front is forecast not to pass in the specified forecast period unless the Minneapolis-St. Cloud 700-mb. contour crosses the 85th meridian south of 45°N . and the 75th meridian south of 43.5°N . If the plotted point falls in the block in lower left portion of diagram, the front is forecast to pass Washington and figure 4 then is checked for effectiveness of the passage during the forecast period.
2. If the case in question falls in the lower left block of figure 3, enter figure 4 to determine whether front will go sufficiently far south and remain long enough to bring in cooler air. The sloping line on figure 4 divides the effective fronts from those that are ineffective or pass after the end of the forecast period. For all cases which fall to the *left* of the sloping line, effective frontal passages are forecast.

CONCLUSIONS

In connection with the summertime problem of whether a front will pass Washington, D. C. from the north "tomorrow" (0130 to 1930 EST) a number of cases have been selected which were thought to present the problem. The

following variables were found helpful in separating those which passed from those which did not: (1) The effective steering direction at 700 mb.; (2) an estimate of the strength of the zonal current at 700 mb. west of Washington; and (3) an index of the availability of cold air in Canada. If the scatter diagrams (figs. 3 and 4) involving these variables are applied to cases of the specified type, it is believed that the results will provide a useful guide in forecasting cold frontal passages at Washington in summer 24 to 42 hours in advance.

ACKNOWLEDGMENT

Thanks are due to Mr. Conrad Mook for assistance in

the preparation of this report and in selecting cases to be included in the study.

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2. J. J. George, *On the Relationship Between the 700 Millibar Surface and the Behavior of Pressure Patterns at the Ground*, Eastern Air Lines, Inc., Atlanta, Ga., August 1949.
3. J. Namias, "Characteristics of the General Circulation over the Northern Hemisphere during the Abnormal Winter 1946-1947", *Monthly Weather Review*, vol. 75, No. 8, August 1947, pp. 145-152.

A TEST OF SCHMIDT'S METHOD OF FORECASTING THE PASSAGE OF SELECTED SOUTHWARD-MOVING COLD FRONTS

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In the foregoing study, Schmidt describes a method for forecasting the passage of selected cold fronts at Washington, D. C., during summer months. The summer months of 1945 and 1946 were set aside for test purposes, but due to the lack of a completely objective description of the type of situation described in the report, it was felt that such testing upon independent data should be left to someone other than the originator of the method.

The present writer, though perhaps not qualified to act as a completely independent judge of this technique since he helped select the cases in the original study, has undertaken such a test and suggests that others may wish to run the same experiment after reading Schmidt's paper and compare the results with those shown here. Altogether during the examination of all 0130 EST maps for June, July, and August of 1945 and 1946, seven cases were found which fit the definition of the type of situation to which this aid is applicable.

The following table lists the seven cases along with the data which are required for the test. The legend is the same as that shown above in Schmidt's table 1, except that column 5 contains the forecast and column 6 states whether or not an "effective" frontal passage occurred.

Though there may be some question as to the advisability of including case 6, it appears to be one in which a forecaster could logically attempt to apply the method. The question of a frontal passage at Washington must be considered in making the forecast and the decision to include it here is based largely upon the rapid eastward movement of a Low in the northern Great Lakes region. Such movement made it appear that future southward

Test case No.	Date of 2200 EST 700-mb. chart	Independent variables				Dependent variable	
		1	2	3	4	Forecast 5	Observed 6
1	July 20, 1945	46.5	41.0	---	---	X	X
2	Aug. 17, 1945	36.0	38.0	-6	12	I	(*)
3	Aug. 28, 1945	45.0	45.0	---	---	X	X
4	June 6, 1946	46.0	43.0	-27	36	X	X
5	June 23, 1946	45.5	45.0	---	---	X	X
6	July 13, 1946	43.5	42.0	-24	28	P	P
7	Aug. 16, 1946	42.5	40.0	-11	9	P	P

* The front in question underwent frontolysis, so possibly the fact that an effective frontal passage was not forecast and none occurred justifies a statement that a correct forecast was made.

movements of the cold air would occur behind the Low as it moved east of the Lakes, and that the cold front would approach Washington from the north rather than from the northwest or west.

In general all of these forecasts are correct and therefore it appears that the method can be relied upon for use under the circumstances for which it is designed. However, these results are not intended to convey the impression that similar accuracy will be possible at all times, since one should expect an occasional error to occur due to unusual developments, etc., which have not occurred within the periods covered. Furthermore, one must point out the fact that there are some "back door" frontal passages at Washington for which the antecedent conditions differ from those specified by Schmidt. The method and the test are applicable under a particular set of conditions which, according to Schmidt, often precede by approximately one day the passage of southward-moving cold fronts at Washington, D. C.