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AN ANALYSIS OF THE FORECAST ERRORS
ARISING FROM OPERATIONAL USE
OF THE JARVIS TECHNIQUE
AT THE ATLANTIC WEATHER CENTRAL
OCTOBER 1, 1965 TO MARCH 31, 1966

BY
R.V. TYNER

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CANADA - DEPARTMENT OF TRANSPORT - METEOROLOGICAL BRANCH
315 Bloor Street, West,
Toronto 5, Ontario.

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ABSTRACT

The surface lows for which 24-hour forecasts of displacement and central pressure were prepared at the Atlantic Weather Central by use of the Jarvis and Ostby-Veigas techniques for the winter of 1965-66 are classified according to the type of 500 mb. flow in which they are embedded, and an analysis of the forecast errors in each of these situations is carried out. Conclusions are drawn from the results of these forecasts concerning the relative value of these forecast techniques in the several situations described.

ANALYSE DES ERREURS DE PRÉVISION RÉSULTANT DE
L'UTILISATION DE LA TECHNIQUE DE JARVIS AU CENTRE
RÉGIONAL DE L'ATLANTIQUE DE 1^{er} OCTOBRE 1965 AU 31 MARS 1966

par

R. V. Tyner

RÉSUMÉ

Les dépressions en surface pour lesquelles des prévisions de déplacement et de pression centrale, valables pour 24 heures, ont été établies au centre météorologique régional de l'Atlantique, au moyen des techniques de Jarvis et d'Ostby-Veigas, pour l'hiver de 1965-1966, sont classifiées d'après le type de courant de 500 mb dont elles font partie et l'auteur analyse les erreurs de prévision dans chacun de ces cas. Des résultats de ces prévisions, il tire des conclusions au sujet de la valeur relative de ces techniques de prévision dans les différentes situations décrites.

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(Manuscript Received March 17, 1967)

1. Introduction

In a previous paper by Tyner (1), a brief analysis was made of the forecast errors resulting from use of the Jarvis technique at the Atlantic Weather Central. The technique was again used as a forecast aid during the winter of 1965-66 since it was felt that the greater familiarity of the Atlantic Weather Central meteorologists with the technique and the necessary modification to it would result in forecasts much improved over those of the 1964-65 winter season.

In carrying out this analysis, errors in displacement were analyzed and compared with the corresponding displacement errors obtained by use of the Ostby-Veigas statistical technique.

It was suggested by Jarvis (3) that in situations where the diabatic processes are weak (i. e., zonal flows)

"the observed position (of the low) is shifted in the direction of the location predicted by the primary displacement field" (viz., the forecast position obtained by use of the Wilson grid.)

This hypothesis was also tested. Finally, each forecast was analyzed to determine the kind of situation in which the forecast-technique failed or succeeded.

2. Procedure

Errors in forecast central pressure and displacement (measured in degrees of latitude at 60° North) were obtained for forecasts based on the Jarvis technique and on the Ostby-Veigas technique.

The displacement errors resulting from forecasts based on the Jarvis technique were considered negative if the forecast displacement was less than observed, positive if greater than observed. Of the 64 forecasts attempted during the 1965-66 winter season, 43 showed a negative displacement error averaging five degrees, and 21 showed a positive displacement error averaging 3.6 degrees.

An examination of those forecasts demonstrating a large (>5 degrees of latitude) negative error disclosed that 13 of these forecasts were of surface lows embedded in a moderate (35 kt.) to strong (>50 kt.) zonal flow at 500 mb. Average negative displacement error in these thirteen forecasts was 7.2 degrees of latitude. Use of the Wilson grid to forecast the 24-hour motion of these lows resulted in more accurate forecasts with an average error of 3.3 degrees. This finding would seem to confirm Jarvis's hypothesis that in such situations the primary displacement should provide a more accurate forecast of the low than the complete technique. Further examination of the characteristics of the 500 mb. flow in which the surface low was embedded disclosed that there were some 27 forecasts made of surface lows embedded in a zonal or near-zonal flow and that twelve of these forecasts resulted in an acceptable error (<5 degrees of latitude).

Upon examining these forecasts and relating the magnitude of the error in forecast displacement to the magnitude of the diabatic processes affecting the low, it was apparent that the greater the magnitude of the diabatic processes --- measured roughly by the 24-hour deepening of the surface low --- the greater was the forecast error resulting from use of the Wilson grid, but that no such general statement could be made of the errors arising from use of the Jarvis technique (Table 1).

It was observed that in several instances the Jarvis forecast of a surface low embedded in the zonal flow and located from three to five degrees of latitude downstream from a low-amplitude short-wave at 500 mb. resulted in a good forecast, and in fact nine of the twelve satisfactory forecasts in Table 1 were of this type. Unfortunately, one cannot generalize from this since, of

TABLE 1

Comparison of the Errors in Forecasts Prepared by use of the Jarvis Technique and the Wilson Grid with the Strength of the Diabatic Processes Affecting the Development of the Low.

<u>Date/Time</u>	<u>Displacement Error (Degs. Lat.) Wilson Grid</u>	<u>Displacement Error (Degs. Lat.) Jarvis Technique</u>	<u>Strength of Diabatic Processes</u>	<u>24-hr. Deepening</u>
1 Dec/65, 0000Z	10.0	2.5	Strong	31 mb.
17 Dec/65, 1200Z	11.0	4.6	Strong	18 mb.
20 Jan/66, 0000Z	7.5	4.8	Moderate	9 mb.
2 Feb/66, 0000Z	4.5	4.0	Moderate	8 mb.
9 Nov/65, 0000Z	9.4	4.3	Moderate	8 mb.
1 Nov/65, 0000Z	6.5	1.6	Moderate	6 mb.
28 Dec/65, 1200Z	4.0	3.0	Moderate	6 mb.
14 Dec/65, 1200Z	5.2	3.3	Moderate	6 mb.
2 Feb/66, 1200Z	4.0	4.2	Slight	2 mb.
31 Dec/65, 0000Z	2.0	4.2	Slight	1 mb.
21 Nov/65, 0000Z (a)	6.5	3.5	Slight	0 mb.
21 Nov/65, 0000Z (b)	2.2	4.3	Slight	0 mb.

the thirteen forecasts in which application of the technique resulted in a displacement error of more than five degrees of latitude, six were of this type.

Previous experience with the use of the technique had indicated that it was generally successful when applied to surface lows embedded in a southwesterly flow at 500 mb. It was, therefore, disappointing to discover three cases in which large displacement errors of more than five degrees of latitude were obtained by use of the technique. However, twelve forecasts of lows embedded in this kind of flow showed displacement errors averaging 3.25 degrees of latitude, so that the technique can be considered as moderately reliable when applied to surface lows embedded in a strong southwesterly flow. If explosive deepening of the surface low (more than 20 mb. deepening in 24 hours) takes place, the technique provides a very reliable forecast (error less than three degrees of latitude). The technique is apparently well suited to this situation, and if explosive deepening of the surface low is indicated, by examination of vorticity and thermal advection fields and the stability and moisture characteristics of the warm air, the Jarvis technique can be used with confidence.

If the low does not have the necessary support for explosive deepening, the forecast is likely to be considerably in error and, generally speaking, the less the deepening the greater the forecast error. To illustrate this, in Table 2, the displacement errors resulting from application of the Jarvis technique have been compared with the amount of deepening of each of six lows.

George (4) has described a situation in which the surface low is "captured" by the 500 mb. low in the later stages of the life history of the surface low. This invariably occurs if explosive surface deepening is involved, and frequently if the surface low is within 300 mi. downstream of the upper centre. In such a situation, the upper low will appear within the grid upstream from the surface low, and Jarvis has suggested that in these situations, application of his technique will result in a forecast displacement which is too small. Not including instances of explosive deepening, there were fourteen occasions during the winter of 1965-66 when the surface low was "captured" by the 500 mb.

TABLE 2

Comparison of the Displacement Errors of Forecasts of Surface Lows using the Jarvis Technique with the 24-hour Deepening of these Lows:

<u>Date/Time</u>	<u>Initial Position of Low (T)</u>	<u>Forecast Position of Low(T+24hr)</u>	<u>Observed Position of Low(T+24hr)</u>	<u>Displacement Error (Deg. lat)</u>	<u>24-hour Deepening (mb.)</u>
25 Feb/66, 0000Z	37 N 74 W	44 N 67 W	43 N 67 W	1.0 deg.	32 mb.
5 Dec/65, 0000Z	44.5N 65 W	55 N 61 W	53 N 64 W	2.5 deg.	23 mb.
4 Dec/65, 1200Z	40 N 72 W	49 N 66 W	48 N 60 W	3.5 deg.	21 mb.
22 Nov/65, 1200Z	37.5N 77 W	44 N 69.5 W	45 N 60 W	6.8 deg.	10 mb.
2 Dec/65, 1200Z	36 N 60.5W	40 N 62 W	41 N 50 W	8.8 deg.	8 mb.
24 Sept/65, 1200Z	38 N 80 W	43 N 79 W	52 N 64.5W	12.8 deg.	8 mb.

low. For the most part, the Jarvis technique provided a useful forecast of these lows, the exception being the forecasts of 1200Z, 23 January 1966, and 1200Z, 27 January 1966. In seven of the cases the forecast displacement was too small, as suggested by Jarvis; in the remaining seven cases, the forecast displacement was too large.

3. Comparison of the Success of the Jarvis and Ostby-Veigas Techniques

In comparing the relative success of the Ostby-Veigas and Jarvis forecast techniques, the forecasts were grouped into the following classes:

- (a) forecasts of surface lows which showed explosive deepening.
- (b) forecasts of surface lows embedded in a zonal or near-zonal 500 mb. flow.
- (c) forecasts of those surface lows, embedded in a southwesterly flow at 500 mb., which did not deepen explosively.
- (d) forecasts of lows in capturing situations.

The errors resulting from forecasts based on the Jarvis and Ostby-Veigas techniques of lows which underwent explosive deepening are compared in Table 3. Based on the results of these six forecasts, the Jarvis technique appears to be only slightly less successful in forecasting the position of the low than does the Ostby-Veigas technique, but considerably less likely to provide a reliable forecast of the depth of the centre.

The displacement errors resulting from forecasts of surface lows embedded in a zonal flow at 500 mbs. and based on the Jarvis technique, the Wilson Grid and the Ostby-Veigas technique are displayed in Table 4, and indicate a clear superiority of the Ostby-Veigas technique over the Jarvis technique and a minor improvement over the Wilson grid forecast in this type of situation. Neither the Ostby-Veigas nor the Jarvis technique was particularly

TABLE 3

Comparison of the Errors Resulting from use of the Jarvis and Ostby-Veigas Techniques in Situations in which the Surface Low showed "Explosive" Deepening

<u>Date/Time</u>	<u>Displacement Errors(deg. lat)</u>		<u>Central Pressure Errors</u>	
	<u>Jarvis Technique</u>	<u>Ostby-Veigas Technique</u>	<u>Jarvis Technique</u>	<u>Ostby-Veigas Technique</u>
14 Nov/65. 0000Z	11.9	5.5	13 mb.	6 mb.
22 Nov/65, 1200Z	6.8	.8	5 mb.	8 mb.
4 Dec/65, 1200Z	3.5	1.5	1 mb.	1 mb.
5 Dec/65, 0000Z	2.5	5.0	3 mb.	4 mb.
30 Jan/66, 0000Z	6.3	4.0	12 mb.	9 mb.
25 Feb/66, 0000Z	1.0	2.5	19 mb.	3 mb.
AVERAGE ERROR	3.7	3.2	8.9 mb.	5.2 mb.

TABLE 4

A Comparison of Errors Resulting from use of the Ostby-Veigas Technique, the Wilson Grid, and the Jarvis Technique to Forecast the 24-hour Position and Central Pressure of Surface Lows Embedded in a Zonal Flow at 500 mb.

Date/Time	Displacement Errors (Deg. Lat.)			Central Pressure Errors	
	Ostby-Veigas Technique	Wilson Grid	Jarvis Technique	Jarvis Technique	Ostby-Veigas Technique
6 Oct/65, 1200Z	1.0	6.0	10.0	0 mb.	2 mb.
10 Oct/65, 0000Z	3.5	5.0	6.5	11 mb.	6 mb.
15 Oct/65, 1200Z	4.0	2.5	7.2	0 mb.	4 mb.
1 Nov/65, 0080Z	5.0	6.5	1.6	24 mb.	19 mb.
8 Nov/65, 1200Z	2.0	5.0	6.7	5 mb.	6 mb.
9 Nov/65, 0000Z	5.0	9.4	4.3	13 mb.	7 mb.
13 Nov/65, 0000Z	6.0	8.0	6.2	26 mb.	4 mb.
21 Nov/65, 0000Z	.8	6.5	3.5	12 mb.	14 mb.
21 Nov/65, 1200Z	4.5	2.2	4.3	10 mb.	11 mb.
22 Nov/65, 0000Z	4.0	2.5	6.0	1 mb.	9 mb.
2 Dec/65, 1200Z	1.5	2.0	8.8	22 mb.	4 mb.
14 Dec/65, 0000Z	1.5	2.0	5.8	5 mb.	1 mb.
14 Dec/65, 1200Z	1.0	5.2	3.3	10 mb.	0 mb.
15 Dec/65, 1200Z	3.0	2.5	7.8	0 mb.	5 mb.
17 Dec/65, 1200Z	4.0	11.0	4.6	12 mb.	1 mb.
18 Dec/65, 0000Z	3.5	10.0	2.5	8 mb.	7 mb.
20 Dec/65, 0000Z	2.0	1.0	5.7	13 mb.	4 mb.
22 Dec/65, 0000Z	.5	4.2	5.9	0 mb.	2 mb.
28 Dec/65, 1200Z	2.0	4.0	3.0	15 mb.	5 mb.
31 Dec/65, 0000Z	4.0	2.0	4.2	18 mb.	2 mb.
1 Jan/66, 0000Z	4.0	4.2	6.8	2 mb.	6 mb.
16 Jan/66, 1200Z	4.0	8.5	7.8	27 mb.	30 mb.
20 Jan/66, 0000Z	3.5	7.5	4.8	5 mb.	4 mb.
2 Feb/66, 0000Z	6.0	4.5	4.0	0 mb.	13 mb.
2 Feb/66, 1200Z	6.0	4.0	4.2	2 mb.	5 mb.
5 Feb/66, 1200Z	6.0	1.0	7.9	7 mb.	25 mb.
13 Feb/66, 1200Z	5.5	1.6	6.5	0 mb.	3 mb.

successful in forecasting the central pressure of the lows, although the Ostby-Veigas technique provided a somewhat more reliable or, at least, less erratic estimate of the central pressure.

The results of forecasts of surface lows embedded in a southwesterly flow, but which did not deepen explosively, are set out in Table 5. Considering the average error, the Ostby-Veigas technique appears to be slightly better than the Jarvis technique, although the latter appears to be more reliable in that no forecast displacement error is as great as five degrees of latitude. The forecasts of central pressure obtained by both techniques show a quite unacceptable error.

In the capturing situations examined (Table 6), the Ostby-Veigas technique provided a more reliable forecast of displacement and central pressure than did the Jarvis technique. Neither method was particularly successful in forecasting central pressure, and use of the Jarvis technique resulted in some very large errors.

In carrying out this test of the success of the Jarvis and Ostby-Veigas forecast technique for the winter of 1965-66, each technique was used to forecast the motion and depth of storms which were expected to affect the area of responsibility of the Atlantic Weather Central, so that almost half of the forecasts were of lows not in the area considered as valid for application of the Ostby-Veigas technique. Despite this, the technique provided surprisingly good forecasts in most situations except for those out-of-area surface lows which did not deepen explosively, yet were embedded in a strong southwesterly flow aloft.

To check the value of the central pressure computation employed in the Jarvis technique, perfect prognostics (T + 24 hour actuals) of the surface and 500 mb. charts were used to verify the accuracy of the computation. Under these optimum conditions the average error in forecast central pressure was 14.8 mb. --- considerably less successful than the operational forecasts based on the numerical prognostics.

TABLE 5

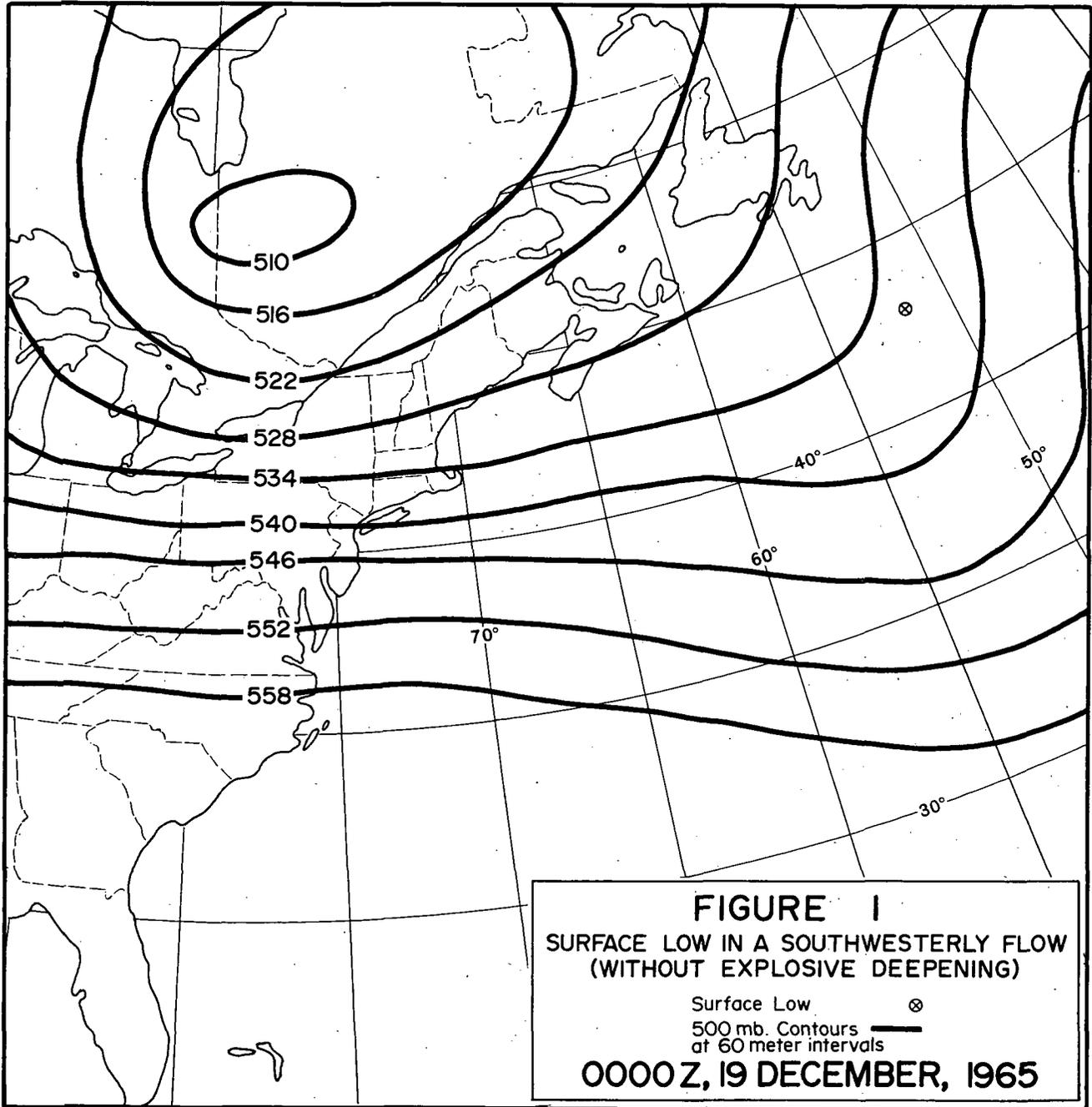
Forecast Errors of Surface Lows, Embedded in a Moderate to Strong Southwesterly Flow at 500 mb., which did not Deepen Explosively.

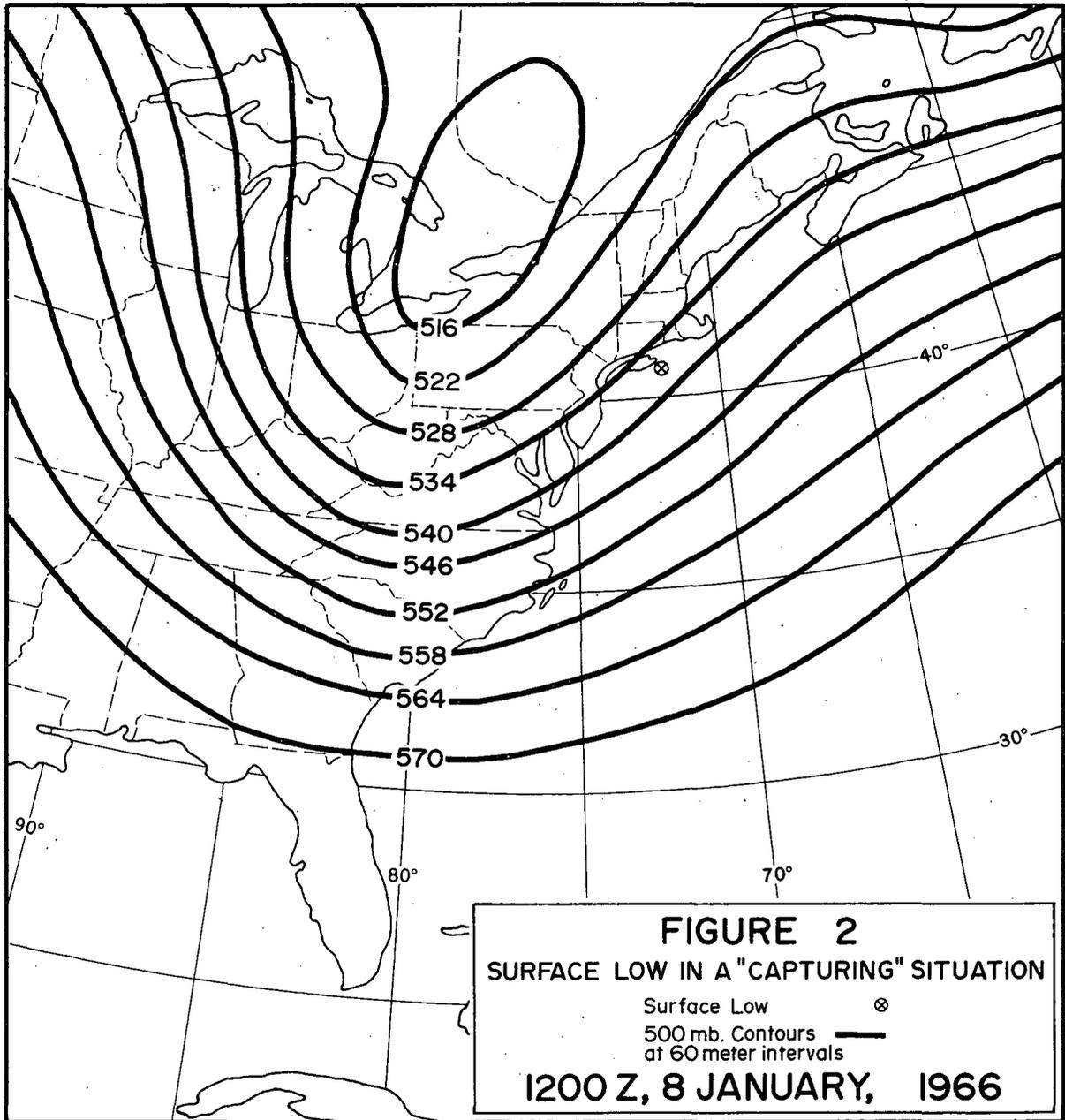
<u>Date/Time</u>	<u>Displacement Errors</u> (Degrees latitude)		<u>Central Pressure Errors (mb.)</u>	
	<u>Jarvis</u> <u>Technique</u>	<u>Ostby-Veigas</u> <u>Technique</u>	<u>Jarvis</u> <u>Technique</u>	<u>Ostby-Veigas</u> <u>Technique</u>
23 Nov/65, 0000Z	3.5	.8	12	5
23 Nov/65, 1200Z	4.8	5.3	2	19
6 Dec/65, 1200Z	1.5	5.5	32	13
19 Dec/65, 0000Z	2.4	7.5	10	33
30 Dec/65, 0000Z	4.8	3.5	36	7
31 Dec/65, 0000Z	3.0	4.5	18	2
22 Jan/66, 1200Z	1.0	1.0	11	7
27 Jan/66, 0000Z	4.5	2.5	10	14
14 Feb/66, 1200Z	4.5	3.5	4	12
16 Feb/66, 1200Z	3.9	2.5	3	1
25 Feb/66, 1200Z	2.5	2.0	0	9
28 Feb/66, 1200Z	3.6	1.0	9	6
10 March/66, 0000Z	3.9	5.0	19	13
31 March/66, 0000Z	3.1	7.0	11	7
AVERAGE ERROR	3.4	3.7	12.7	10.6

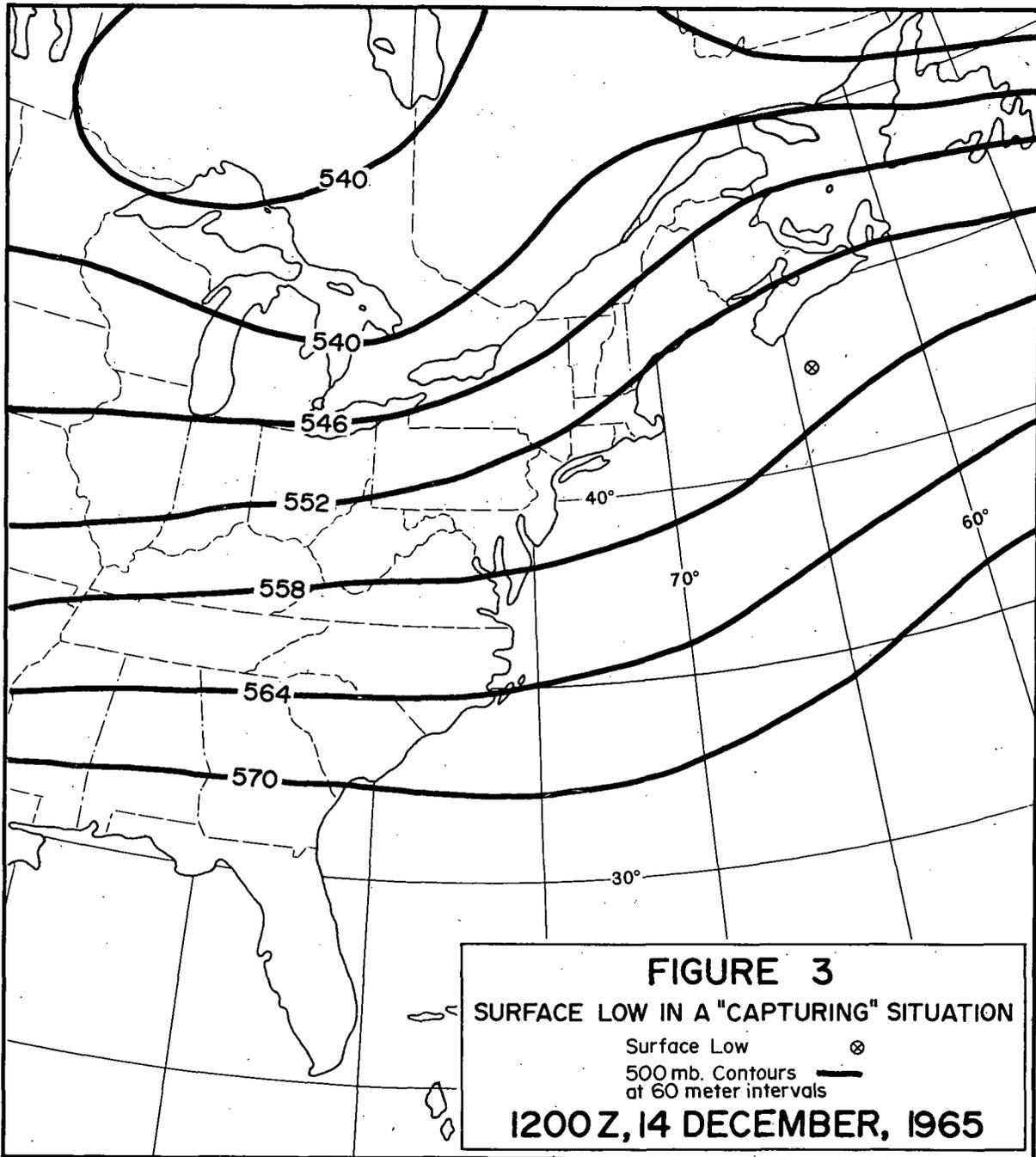
TABLE 6

Forecast Errors of Surface Lows "Captured" by the 500 mb. Low.

<u>Date/Time</u>	<u>Displacement Errors</u> (Degrees latitude)		<u>Central Pressure Errors (mb.)</u>	
	<u>Jarvis</u> <u>Technique</u>	<u>Ostby-Veigas</u> <u>Technique</u>	<u>Jarvis</u> <u>Technique</u>	<u>Ostby-Veigas</u> <u>Technique</u>
4 Oct/65, 1200Z	5.0	1.8	24	7
17 Nov/65, 0000Z	2.5	2.5	8	1
17 Nov/65, 1200Z	1.0	2.0	20	15
18 Nov/65, 0000Z	3.5	3.5	23	9
3 Jan/66, 0000Z	4.0	4.0	6	3
4 Jan/66, 0000Z	1.0	3.0	9	0
8 Jan/66, 1200Z	3.5	2.0	32	12
17 Jan/66, 0000Z	5.2	6.0	5	19
23 Jan/66, 1200Z	7.0	5.5	2	0
27 Jan/66, 1200Z	8.0	4.0	2	10
14 Feb/66, 0000Z	5.7	1.5	3	2
10 March 66, 1200Z	3.9	4.0	19	14
AVERAGE ERROR	4.6	3.3	12.8	7.7







4. Conclusions

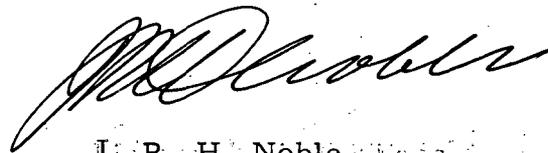
This operational test confirms the results of the previous test for the winter of 1964-65 in demonstrating the fact that a generally successful forecast can be obtained by use of the Jarvis technique when applied to surface lows embedded in a southwesterly flow (without explosive deepening), and in this situation is more successful in forecasting the position of the low than the Ostby-Veigas technique. An example of this type of situation favouring use of the Jarvis technique is given in Figure 1.

Furthermore, it is apparent from the results of this test that the Jarvis technique provides a fairly reliable forecast of displacement of the surface low in "capturing" situations (Figure 2).

The Jarvis technique does not provide a reliable forecast of the displacement of surface lows embedded in a zonal or near-zonal flow at 500 mb. (Figure 3), and in such situations the Ostby-Veigas technique is likely to prove the more successful.

Finally, use of the Jarvis technique to forecast the central pressure of the low is likely to result in an unacceptably large error, and the Ostby-Veigas technique should be preferred for this calculation.

APPROVED,



J. R. H. Noble,
Director,
Meteorological Branch.

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