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DEPARTMENT OF TRANSPORT
METEOROLOGICAL BRANCH
TORONTO WEATHER OFFICE
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Technical Memoranda

AN EXAMINATION OF THE SUCCESS OF THE QUANTITATIVE PRECIPITATION FORECASTS BASED ON SUPPORTING CHARTS SUPPLIED BY THE CENTRAL ANALYSIS OFFICE, MONTREAL DECEMBER 1, 1966 TO MAY 15, 1967 – ATLANTIC WEATHER CENTRAL

BY

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AN EXAMINATION OF THE SUCCESS OF THE QUANTITATIVE PRECIPITATION FORECASTS BASED ON SUPPORTING CHARTS SUPPLIED BY THE CENTRAL ANALYSIS OFFICE, MONTREAL 1 DECEMBER 1966 TO 15 MAY 1967 -- ATLANTIC WEATHER CENTRAL

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ABSTRACT

Quantitative precipitation forecasts prepared at the Atlantic Weather Central, based on supporting charts supplied by the Central Analysis Office, Montreal, for the period 1 December 1966 to 15 May 1967, are discussed with respect to the success of these forecasts in predicting the location, intensity and occurrence of precipitation.

EXAMEN DU SUCCÈS DES PRÉVISIONS QUANTITATIVES DE PRÉCIPITATION ÉTABLIES À PARTIR DE CARTES POUR LA PÉRIODE DU 1er DÉCEMBRE 1966 AU 15ième MAI 1967 FOURNIES PAR LE BUREAU CENTRAL D'ANALYSE DE MONTREAL - CENTRE METEOROLOGIQUE REGIONAL DE L'ATLANTIQUE

par

R. V. Tyner

RESUME

L'auteur présente des prévisions quantitatives de précipitation préparées au Centre météorologique régional de l'Atlantique et établies à partir de cartes fournies par le Bureau central d'analyse de Montréal pour la période allant du 1er décembre 1966 au 15 mai 1967. Il évalue le succès de ces prévisions en ce qui concerne le lieu, l'intensité et le nombre de cas de précipitation.

AN EXAMINATION OF THE SUCCESS OF THE QUANTITATIVE PRECIPITATION FORECASTS BASED ON SUPPORTING CHARTS SUPPLIED BY THE CENTRAL ANALYSIS OFFICE, MONTREAL 1 DECEMBER 1966 TO 15 MAY 1967 -- ATLANTIC WEATHER CENTRAL

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1. Introduction

24-hour prognostics of vertical motion and thickness fields provided by Central Analysis Office (C.A.O.) were employed for the period 1 December 1966 to 15 May 1967 to obtain 6-hour precipitation-rate forecasts for the area of responsibility of the Atlantic Weather Central (A.W.C.), and an evaluation of these forecasts was undertaken.

2. Method

In the evaluation, the forecast precipitation field obtained from the C.A.O. prognostics by procedures outlined by Harley (1) was compared to the observed 6-hour precipitation field as analyzed at the Atlantic Weather Central with respect to:

(a) areal extent of the fields (measured in square degrees of latitude, true at 60° North),

(b) location of the maximum 6-hour precipitation rate (measured in inches per six hours).

(c) magnitude of the 6-hour precipitation rate.

The degree of instability present in the air mass was estimated subjectively with the decision based on:

(1) analysis of appropriate radiosonde ascents in or near the precipitation areas.

(2) examination of satellite photographs of cloud development in the precipitation areas.

(3) evidence provided by surface observations

From this estimation an assessment was reached of the validity of the instability modifications suggested by Harley (2).

The success of the C.A.O. quantitative precipitation forecasts in predicting the fields of large-scale vertical velocity and of 1000 mb.-500 mb. thickness was also examined, since it is these fields which determine the location, area and intensity of the forecast precipitation field.

To assess the forecast 1000 mb.-500 mb. thickness field in the area of responsibility of the A.W.C. (Fig. 1), the forecast field was compared with the 1000 mb.-500 mb. thickness field appearing on the C.A.O. 500 mb. analysis for the valid time of the forecast with respect to

(a) the location of major troughs and ridges,

(b) the thickness value at a central point in the area (46^{o}N 65^{o}W).

The forecast field of vertical velocity was compared with the computed field with respect to

(a) intensity (in 10^{-3} mb. sec.$^{-1}$),

(b) location,

(c) area (in square degrees of latitude, true at 60^{o} north, polar sterographic projection).

3. Procedure

Comparison of the Precipitation Fields

In Comparing the areas of observed and forecast precipitation fields, only those areas within the .10 in. per 6-hour isopleth were considered. Frequently, the observed precipitation field consisted of several small areas reporting .10 in. per 6-hour of precipitation. In such cases, the largest of these small areas was considered in making the areal comparison.

For the most part, the extent of the observed field was considerably smaller than that of the forecast field, although there were several occasions when this was not the case. Situations in which there was a large difference in area between forecast and observed precipitation fields were then examined to determine, if possible, the cause of these discrepancies.

Comparison of precipitation intensities (measured in inches of precipitation per six hours) was based upon the observed and forecast precipitation maxima, with the forecast maxima determined for minimum instability. In situations where the observed values greatly exceeded the forecast values, the forecast precipitation rate was modified to take into account the existence of instability in the air-mass. Reference was made to appropriate radiosonde ascents, satellite photographs or significant

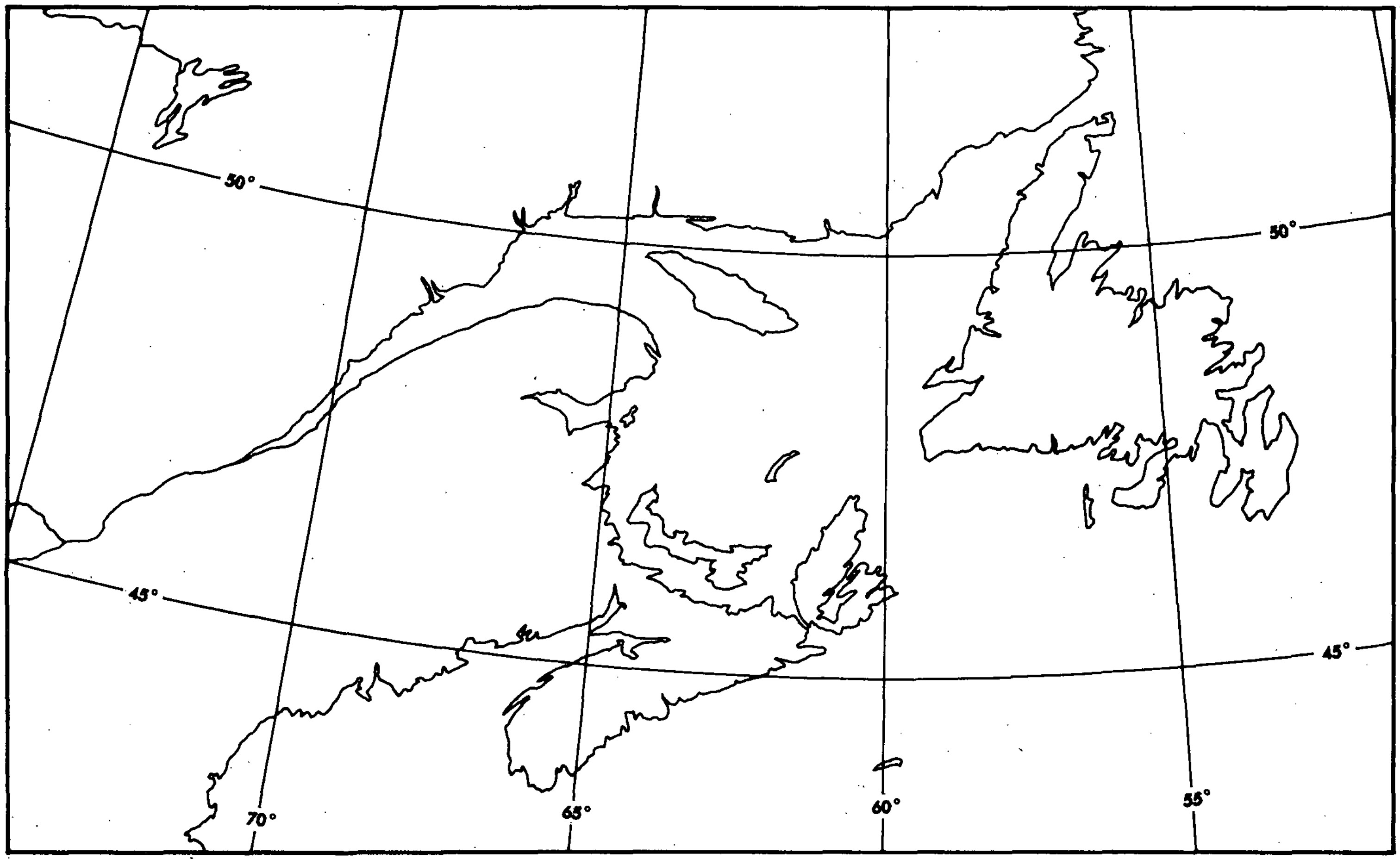

Figure 1
Area of Precipitation Analysis.

surface phenomena to determine the degree of instability present and which of the regression equations:

(a) $y = 1.86x + .09 \pm .07$.

(b) $y = 1.06x + .06 \pm .06$.

suggested by Harley (2) should provide the better estimation of precipitation intensity.

On several occasions large precipitation intensities were reported which were not forecast, even assuming the presence of maximum instability in the air-mass. These situations were examined in more detail to determine the cause of the discrepancies.

The position of the forecast or observed precipitation area was taken to be the approximate geometrical centre of the area within the innermost isohyet. Position errors of the forecast precipitation fields related to the observed fields were expressed in terms of displacement, measured in degrees of latitude, true at 60°N on a polar stereographic projection, and in terms of direction from the centre of observed field, measured in degrees of angle.

Comparison of the 1000 mb.-500 mb. Thickness Fields

In carrying out this comparison, the 1000 mb.-500 mb. thickness field appearing on the appropriate C.A.O. 500 mb. analysis was used as the basis for the comparison. The displacement error of the thickness ridge (trough) was measured in degrees of latitude from the central point of the forecast ridge (trough) to the central point of the observed ridge (trough).

The value of the 1000 mb.-500 mb. thickness at 46°N 65°W, approximately the geographic centre of the Maritime Provinces, was obtained from the appropriate C.A.O. 500 mb. analysis. This was compared with the forecast value of the thickness at that point for that time.

Comparison of the Observed and Computed Precipitation Fields

To evaluate the Penner-Harley technique of quantitative precipitation forecasting, the precipitation field based on computed large-scale vertical velocity and observed thickness was compared with the observed precipitation field for the same time. Computed and observed precipitation fields were compared as in 3. with respect to area, intensity and location.

4. Discussion of the Analyses

Comparison of the Locations of Forecast and Observed Precipitation Fields

Forecast and observed precipitation areas for the period 1 December, 1966, to 15 May 1967, are set out in Table 1. On the average, the forecast precipitation area is about 30% larger than the observed area. This is not surprising, when the frequency of small areas of reported precipitation, frequently not related to any large-scale vertical velocity field, is considered. If precipitation areas greater than five square degrees of latitude are considered, the difference between forecast and observed precipitation areas is reduced to a little over 10%.

A cursory glance at Table 1 will, however, show many marked differences between the size of forecast precipitation areas and those actually observed.

A detailed study of each of these large discrepancies (some eighty in all) was carried out, and indicated that these forecast errors could be ascribed to one or more of the following:

(1) The presence of a strong, cold surface high pressure ridge, usually oriented in a northeast to southwest direction along the Atlantic coast of North America, which deflects storms away from the coast or which strongly retards their northeastward motion. (22 events).

(2) Errors in the forecast speed and direction of the vertical motion area in the absence of a cold surface high pressure ridge along the Atlantic coast.

(12 events in which the forecast speed was too great,
1 event in which the forecast speed was too small,
13 events in which the forecast direction was too far south).

(3) Situations in which the vertical motion forecast was essentially correct, but where the moisture supply was insufficient to produce a precipitation rate $\geq$ .1 per 6 hours or where the lower layers of the atmosphere were so dry that evaporation reduced the precipitation reaching the surface to less than .1 in. per 6 hours (10 events).

(4) The unforecast development of frontal waves along the Atlantic coast which affected the Maritimes within the forecast period (10 events).

(5) The occurrence of large areas of light precipitation occurring with low-level instability in a strong, predominantly north or northeast circulation (8 events).

(6) Precipitation associated with passage of sharp cold fronts where the vertical velocity forecasts indicated subsidence (4 events).

In a previous paper (3) it was pointed out that the presence of a cold high pressure area along the Atlantic Coast deflects towards the north, lows moving east from the region of the Great Lakes, and to force lows approaching from the southwest out over the Atlantic south of the Maritimes. The failure to take this effect into account proved to be the most serious weakness of the forecast technique for East Coast cyclones suggested by Jarvis (4), and appears also to be the most serious defect in the forecasts of vertical motion.

In those situations where forecast errors in displacement occurred in the absence of a cold high along the Atlantic Coast, the vertical motion areas where forecast too rapidly eastward and with insufficient northward displacement.

The rapid formation and intensification of frontal lows off the east coast of North America is a well known phenomenon, but the vertical motion forecast was not ordinarily successful in anticipating developments of this nature.

There were several occasions when the vertical motion forecast was essentially correct, both as to location and intensity of the vertical velocity field, but where the correction employed for initial unsaturation resulted in a large reduction in size of the forecast precipitation area.

(a) 1200Z 11 December 1966. The precipitation area was associated with a wave on the maritime front causing an extensive area of precipitation over Labrador and eastern Quebec. The precipitation area corresponded closely to the field of large-scale vertical velocity within the zero velocity contour. Based on the recommended corrections to the forecast vertical velocity for initial unsaturation (2), a forecast precipitation field of $\geq$ .1 in. per 6 hours measuring four square degrees of latitude was obtained. Based on the 1200Z 11 December 1966 ascent at Sept Iles (811), which indicated almost complete saturation, the correction for initial unsaturation was modified to show the effective vertical velocity (ignoring terrain effects) equal to the large-scale vertical velocity for values of the large-scale vertical velocity in excess of 1×10^{-3} mb. sec.$^{-1}$. With this modification, a precipitation field of 28 square degrees of latitude was arrived at, as compared with the observed field of 27 square degrees.

(b) 0000Z 24 February 1967. Complete saturation of the airmass was indicated below 700 mb. on the Portland, Maine (606) ascent for 0000Z 24 February. Making the same assumptions as in (a), an increase in the forecast precipitation area to 18 square degrees of latitude as compared to the original forecast of 6 square degrees of latitude was obtained. This compares with an observed precipitation field of 43 square degrees of latitude.

(c) 0000Z 8 March 1967. Again with a nearly saturated airmass, the effective vertical velocity was considered to be equal to the large-scale vertical velocity for values of the large-scale vertical velocity in excess of 1×10^{-3} mb. sec.$^{-1}$. This resulted in an increase in the forecast precipitation area from 12 square degrees of latitude to 28 square degrees of latitude as compared with an observed field of 30 square degrees of latitude.

In all of these situations, the forecast vertical motion field was well-located, and the necessity for modifying the correction for initial unsaturation might have been inferred from the historical development of the storm.

The usefulness of the quantitative precipitation forecasts based on a precipitation-no precipitation comparison appears in Tables 2a and 2b. The probability of a correct forecast, using the quantitative precipitation progs, for precipitation or no precipitation anywhere in the A. W. C. area of forecast responsibility appears to be approximately .52.

Comparison of the Observed and Forecast Precipitation Intensity

Precipitation intensities of less than .1 in. per 6 hours are of very frequent occurrence in the Maritimes, particularly during the winter and spring months, and are usually the result of low-level instability and/or onshore flow. Such small intensities are of no significance as far as verifying the quantitative precipitation forecast is concerned and were, therefore, ignored. Table 3 is the record of forecast and observed precipitation intensities for the period under consideration.

The success of the quantitative precipitation forecast should also be judged by the frequency with which it forecasts correctly the observed precipitation intensities. That it failed to do so on a large percentage of occasions is apparent from Table 4.

Examination of the 90 stations in which precipitation rates $\geq$ .10 in. per 6 hours were forecast and were observed (Table 5), shows that in 40 of these occurrences the observed precipitation intensities were within 50% of the minimum forecast intensities, in 22 occurrences the observed intensities were within 50% and 150% of the minimum forecast intensities, and in 28 occurrences the observed intensities differed from the minimum forecast intensities by more than 150%.

If the 37 occurrences of observed precipitation intensity differing by 100% or more from the forecast precipitation intensity are compared on the assumption of an instability between the minimum and maximm values for that parameter, then 27 of these occurrences fall within ±50% of the forecast precipitation intensity.

To determine whether modification was justified in these occurrences, appropriate tephigrams were analyzed and, whenever possible, the existence of realized instability was checked by analysis of available satellite photographs. Based on analysis of appropriate radiosonde data, satellite photographs and observed weather, the instabiltiy was subjectively determined to be strong if:

(1) On the appropriate tephigram, potential or absolute instability was indicated with the possibility of extensive vertical development,

(2) Thunderstorms or occurrences of heavy precipitation were reported in the area concerned,

(3) Extensive vertical development was shown in the satellite photographs.

Instability was considered to be moderate if:

(a) potential instability was indicated on the appropriate tephigram, with cumulonimbus development unlikely,

(b) no thunderstorms or occurrences of heavy precipitation were reported, and precipitation intensity reports were at most moderate,

(c) vertical cloud development in the satellite photographs was confined largely to heavy cumulus.

Instability was considered to be slight if:

(a) potential instability was absent, or was realizable through comparatively shallow layers,

(b) there were no reports of precipitation intensities greater than light,

(c) there was little or no indication of vertical development apparent in the satellite photographs.

Modification of the forecast intensities for the presence of instability resulted in a forecast within ±50% of the observed value in 27 cases. A comparison of the observed and forecast precipitation intensities, along with an estimation of the degree of instability for each of these 27 events, appears in Table 6A.

Although this assessment of instability is admittedly imprecise, particularly in the case of moderate instability, application of the appropriate regression equation (2) to correct for instability, appears to yield a result reasonably close to the observed precipitation intensity.

However there were several occurrences (set out in Table 6B) where the instability correction failed to account for the large excess of observed over forecast precipitation intensity.

Computation of the large-scale vertical velocities, based on Penner's equation, and of corresponding precipitation rates, based on the method suggested by Harley, were carried out for each of these occurrences. From Table 7 it can be seen that errors in the forecast large-scale vertical velocity account adequately for the errors in the forecast precipitation intensity except for the two occurrences of 0000Z 21 December 1966, and 0000Z 8 February 1967.

No significant error in the forecast precipitation intensity could be ascribed to forecast thickness error which, for 0000Z 8 February, was less than 10 m. and for 0000Z 21 December, less than 30 m. For 0000Z 8 February, the forecast position of the large-scale vertical velocity field was almost correct, and for 0000Z 21 December, the strongest computed vertical velocity field located over Cape Cod corresponded well with the forecast field. Unfortunately, the heaviest precipitation occurred over southeastern Newfoundland where only a weak vertical velocity field existed.

It seemed likely then that low-level convergence had in these cases contributed locally to increase the total vertical velocity well above the computed large-scale vertical velocity. To test this hypothesis, surface streamlines were drawn for 0000Z 8 February (Fig. 2A), 0600Z 8 February (Fig. 2B) and 0600Z 21 December (Fig. 2C). The correspondence of areas of heaviest precipitation with those of streamline convergence is very close in all of these examples. Similar correspondence between the area of maximum precipitation rate and the location of the negative asymptote is shown on streamline analyses for 1800Z 29 December 1966, 1200Z 5 February 1967, and 0600Z 6 February 1967 (Fig. 3 a, b. c).

The close association of areas of heavy precipitation with areas of surface streamline convergence and, in particular, in the region of the negative asymptote, would suggest that on many occasions areas of surface streamline convergence are also areas of surface velocity convergence, and that

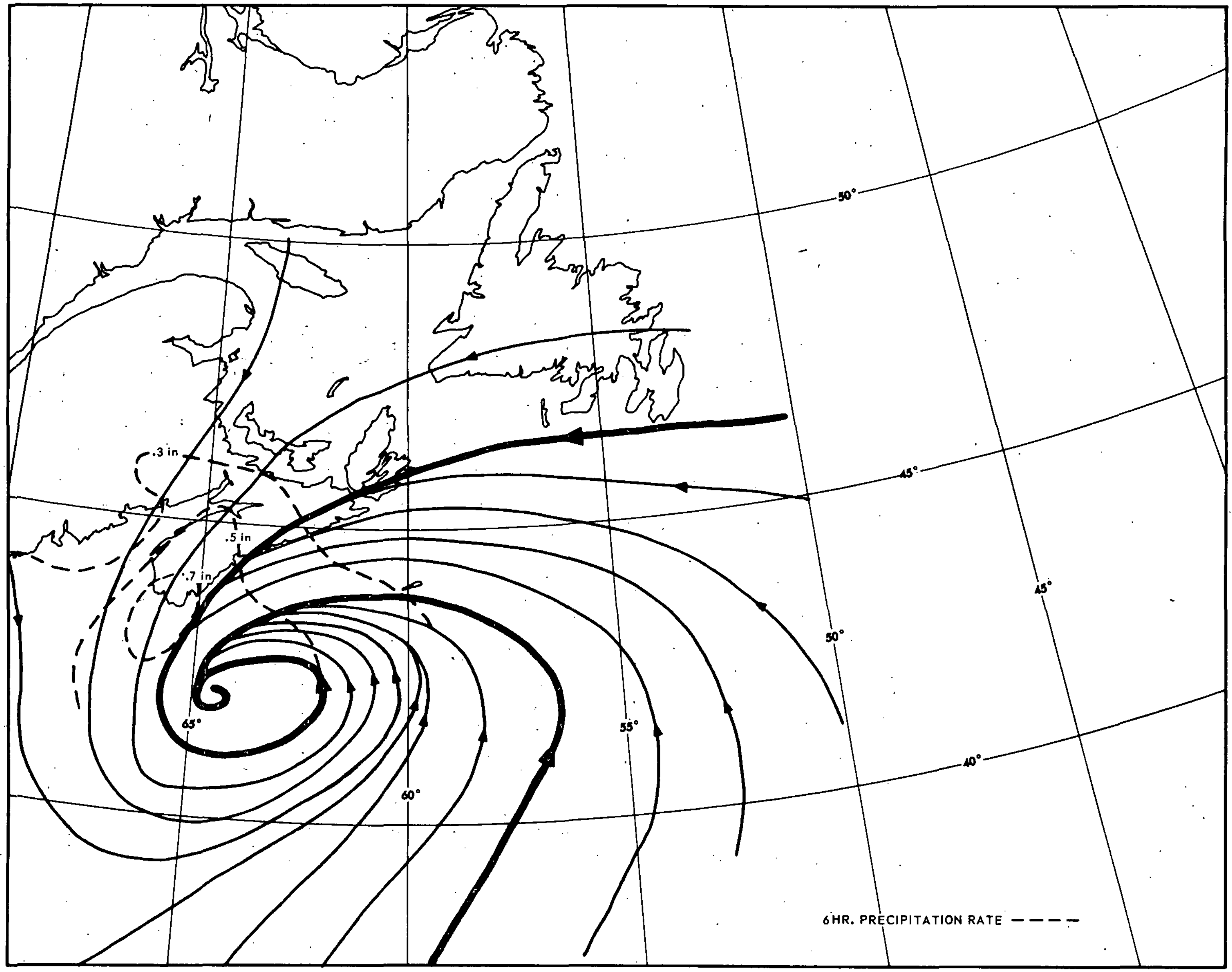

Figure 2A.
Streamline Analysis 0000Z, 08 February, 1967.

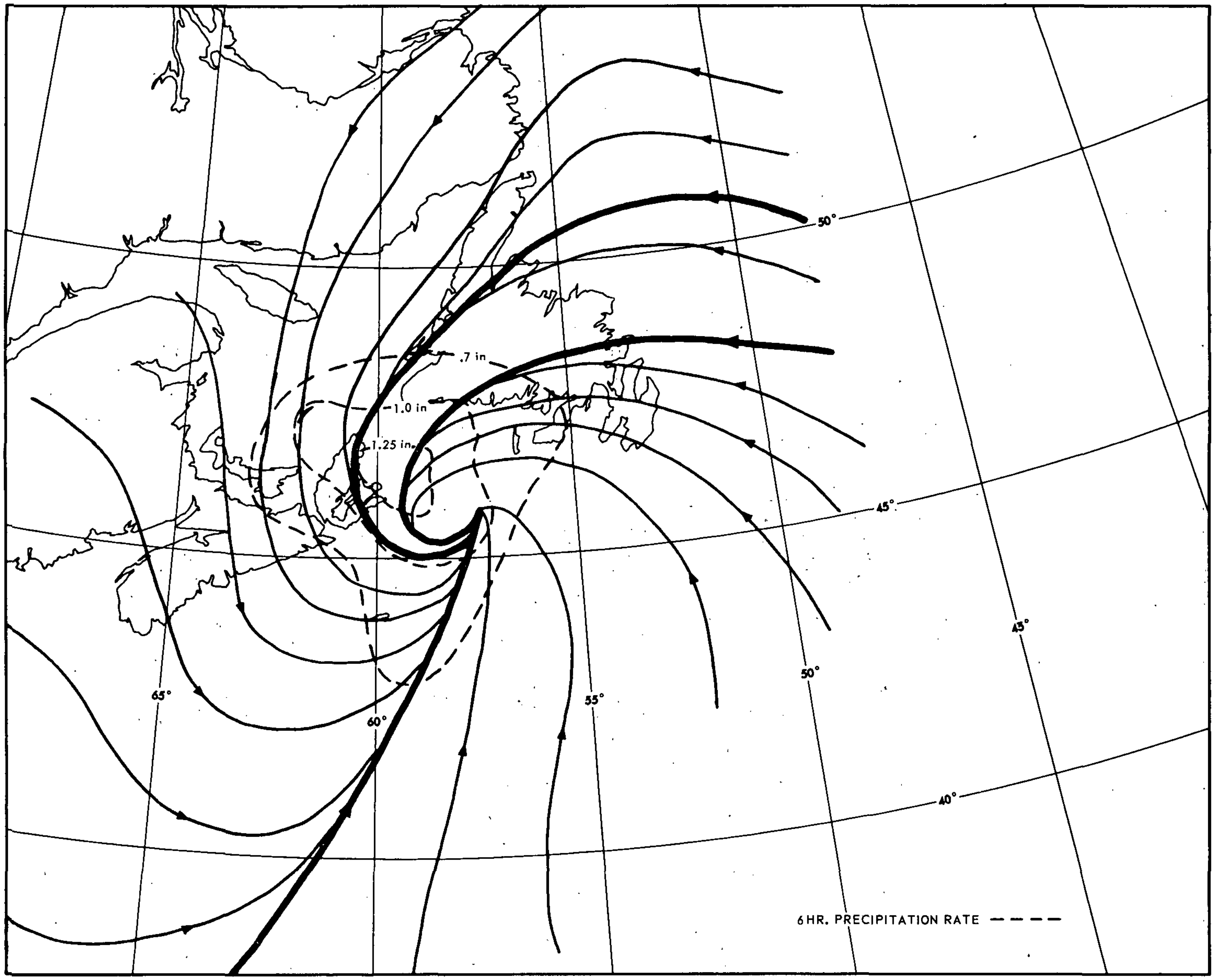

Figure 2B.
Streamline Analysis 0600Z, 08 February, 1967.

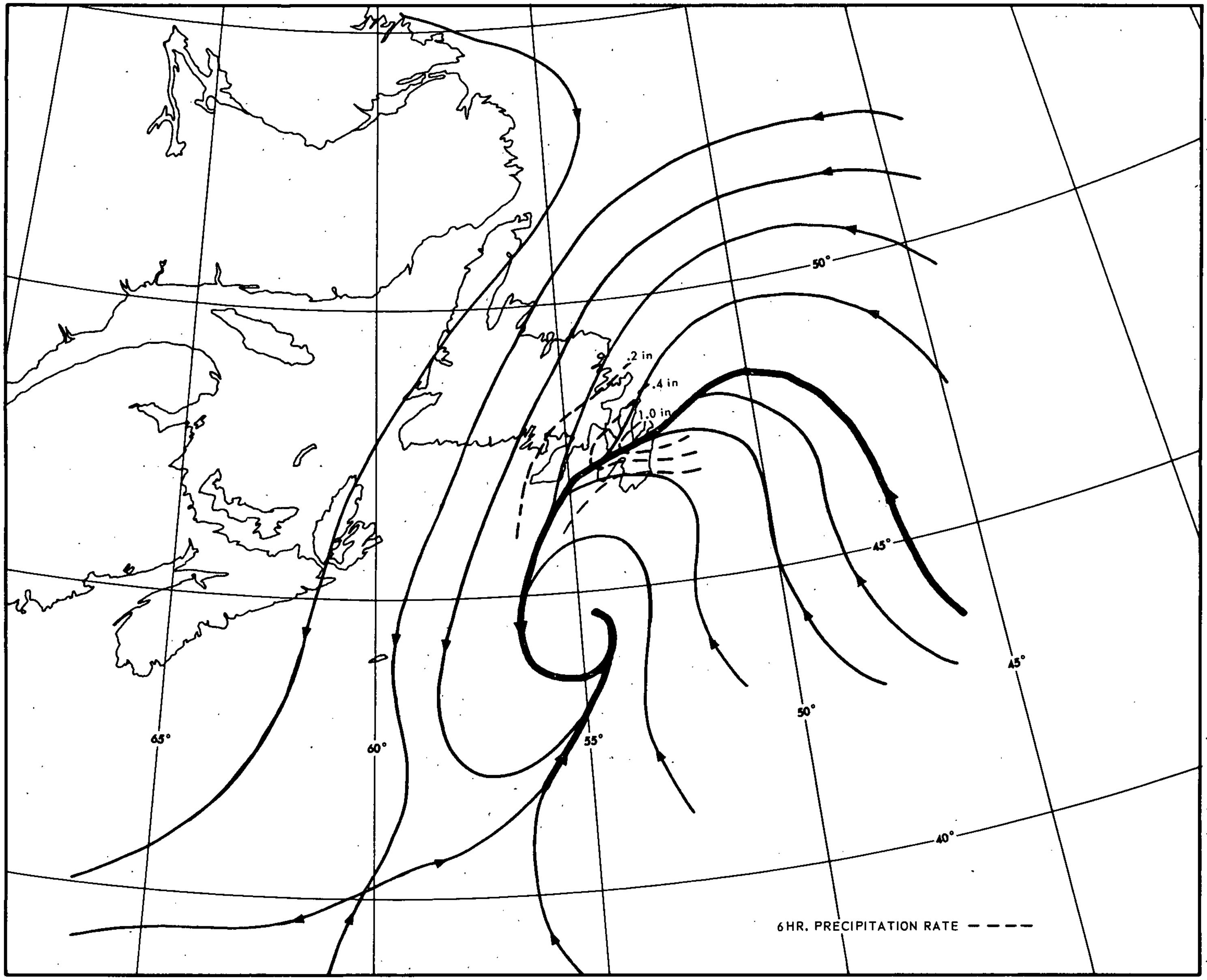

Figure 2C.
Streamline Analysis 0600Z, 21 December, 1966.

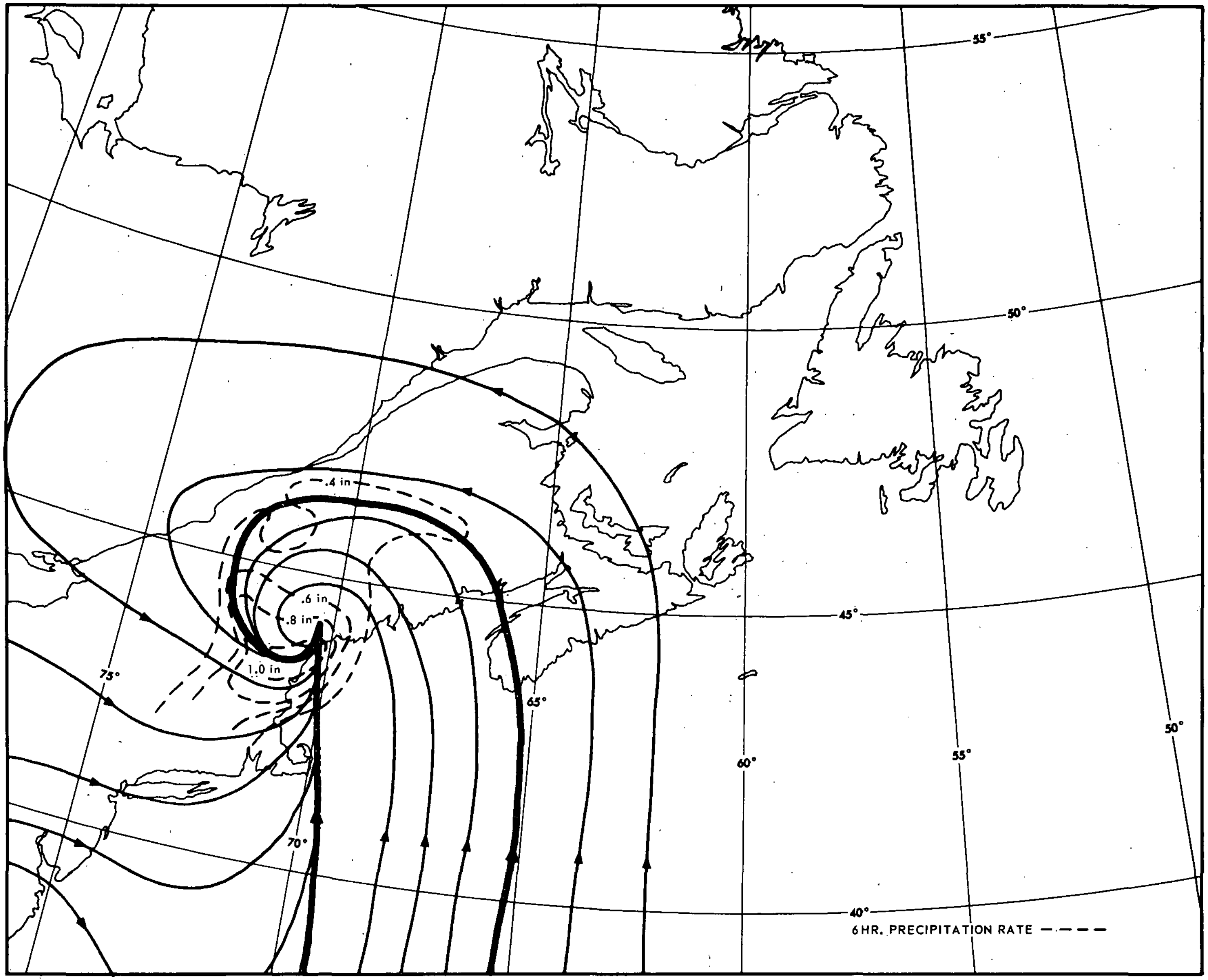

Figure 3A.
Streamline Analysis 1800Z, 29 December, 1966.

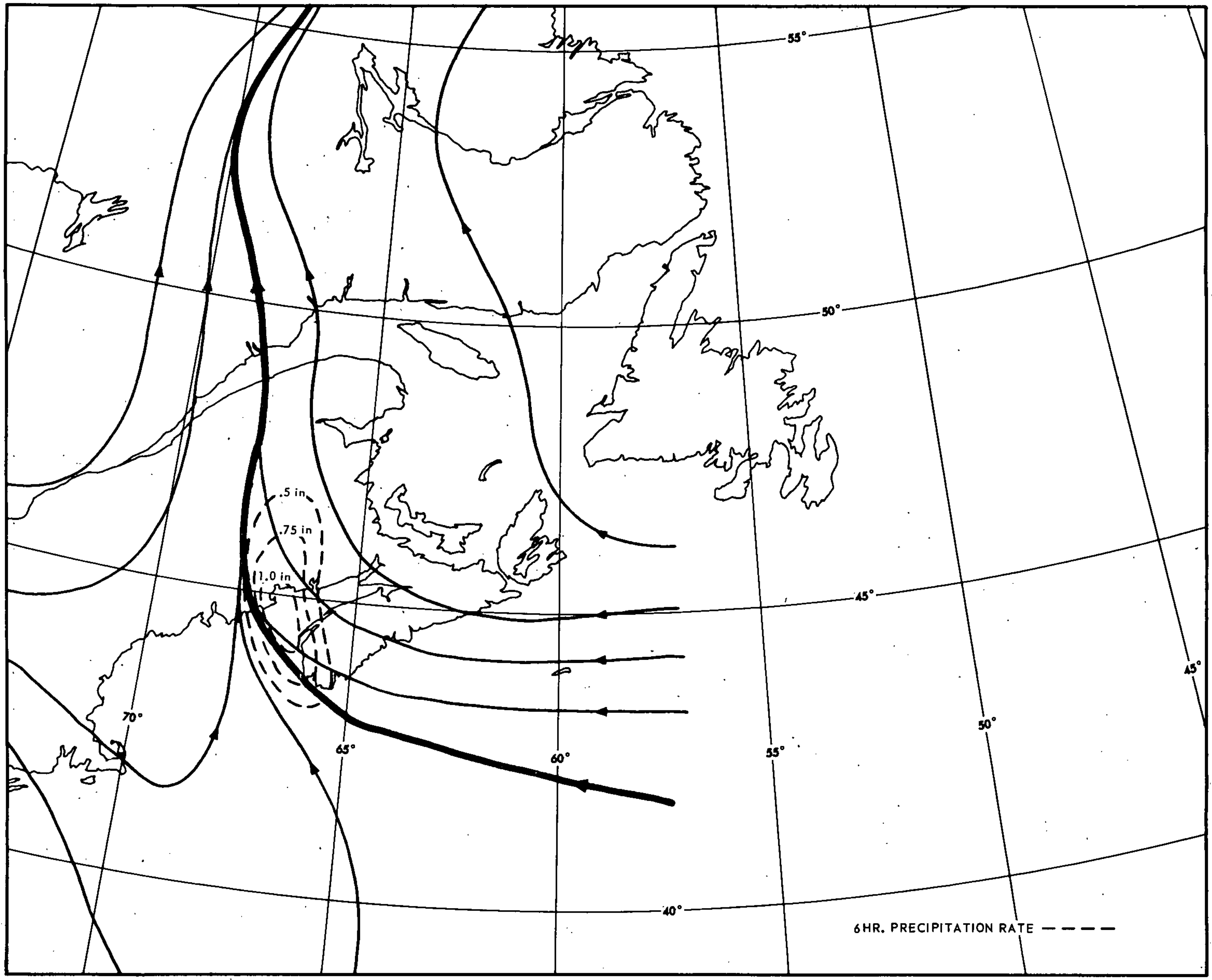

Figure 3B.
Streamline Analysis 1200Z, 05 February, 1967.

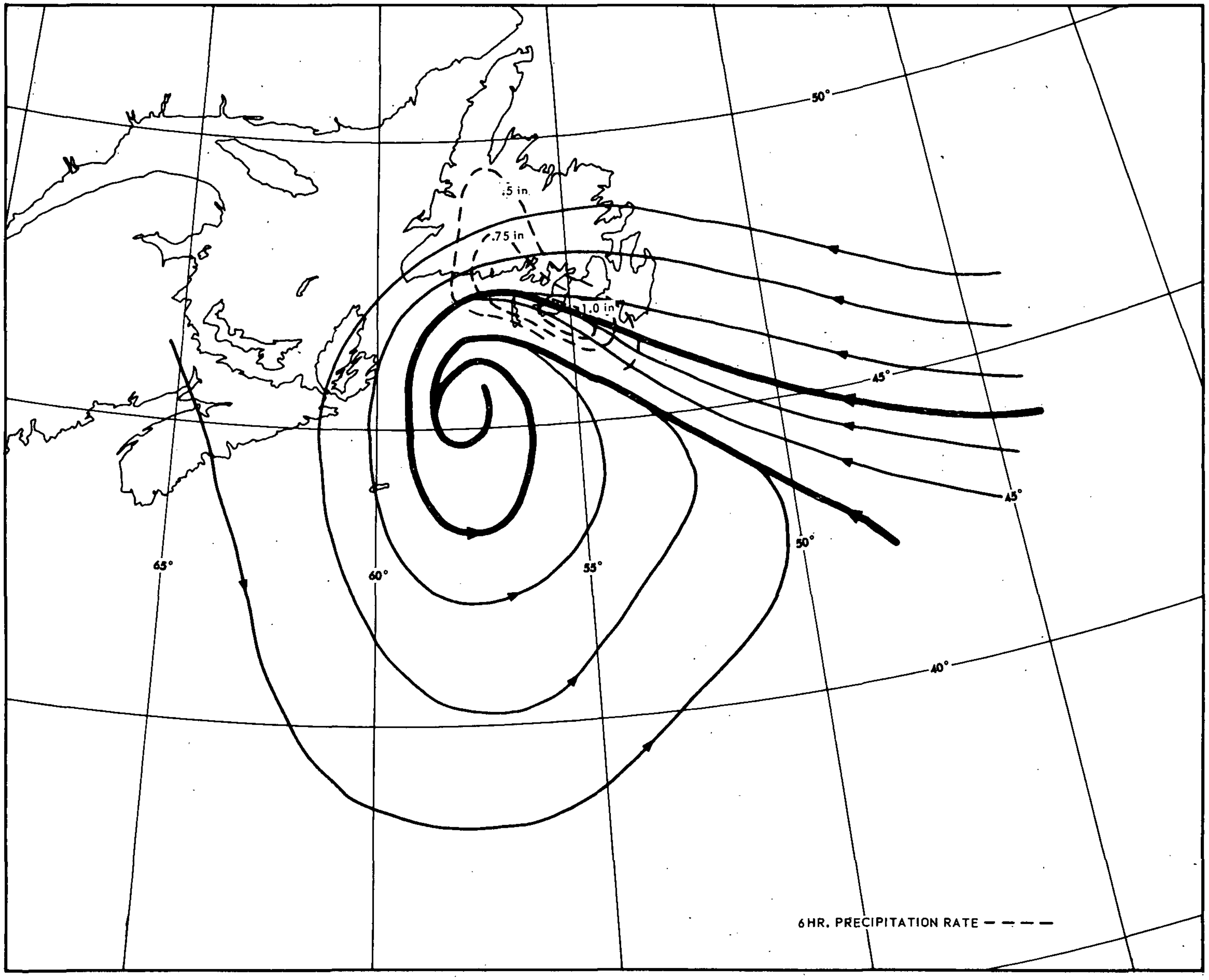

Figure 3C.
Streamline Analysis 0600Z, 06 February, 1967.

this velocity convergence contributes to a considerable increase in total vertical velocity and through this to an increased precipitation rate. The association of velocity and streamline convergence has been pointed out by Palmer (5) while the location of areas of heavy precipitation to the north of the negative asymptote has been described by Mook (6).

Comparison of the Locations of Forecast and Observed Precipitation Fields

The location errors of the centres of the forecast precipitation fields, measured in degrees of latitude and degrees of angle from the centre of the observed field are displayed in Figure 4.

From the diagram it is quite apparent that the quantitative precipitation forecast most frequently errs in ascribing too fast a motion (43 out of 64 occasions) to the precipitation area. The mean displacement error for this error distribution was 4.5 degrees of latitude. The standard deviation was 2.7 degrees of latitude and the ratio of standard deviation to mean deviation was 1.4. If we resolve the error vectors into their east-west and north-south components, 43 of the errors have an east component, 14 a west component, 28 a north component and 27 a south component, indicating the excessive easterly motion ascribed by the prognostics to the precipitation fields.

Comparison of the Observed and Forecast Thickness Fields

Over a sample of 218 forecasts the forecast thickness error at 46^{o}N. 65^{o}W. was found to have an arithmetic mean of +10.6 m. with a standard deviation σ of 58 m., a mean deviation,

$$|e| = \frac{\sum_{i=1}^{i=n} |x_i - m|}{N}$$

of 48 m. and a $\frac{\sigma}{e}$ ratio of 1.22. Median and mode for this error distribution were +7.0 m. and 0 m. respcetively. The histogram for this error distribution is displayed in Figure 5. These values of arithmetic mean and standard deviation indicate a reasonable expectation of accuracy for the forecasts with 71% of the forecasts between $|\sigma|$ of the mean and 95.5% within $|2\sigma|$ of the mean, confirming the implication of the $\frac{\sigma}{|e|}$ ratio that the error distribution is approximately normal. For the most part, thickness error over the Maritimes was not an important factor in forecast precipitation error.

Values of the mean, standard deviation, mean deviation, $\sigma \div |e|$ ratio, and percentage of errors within $|\sigma|$ of the mean, for the displacement errors in the forecast thickness ridges and troughs are displayed in Table 8.

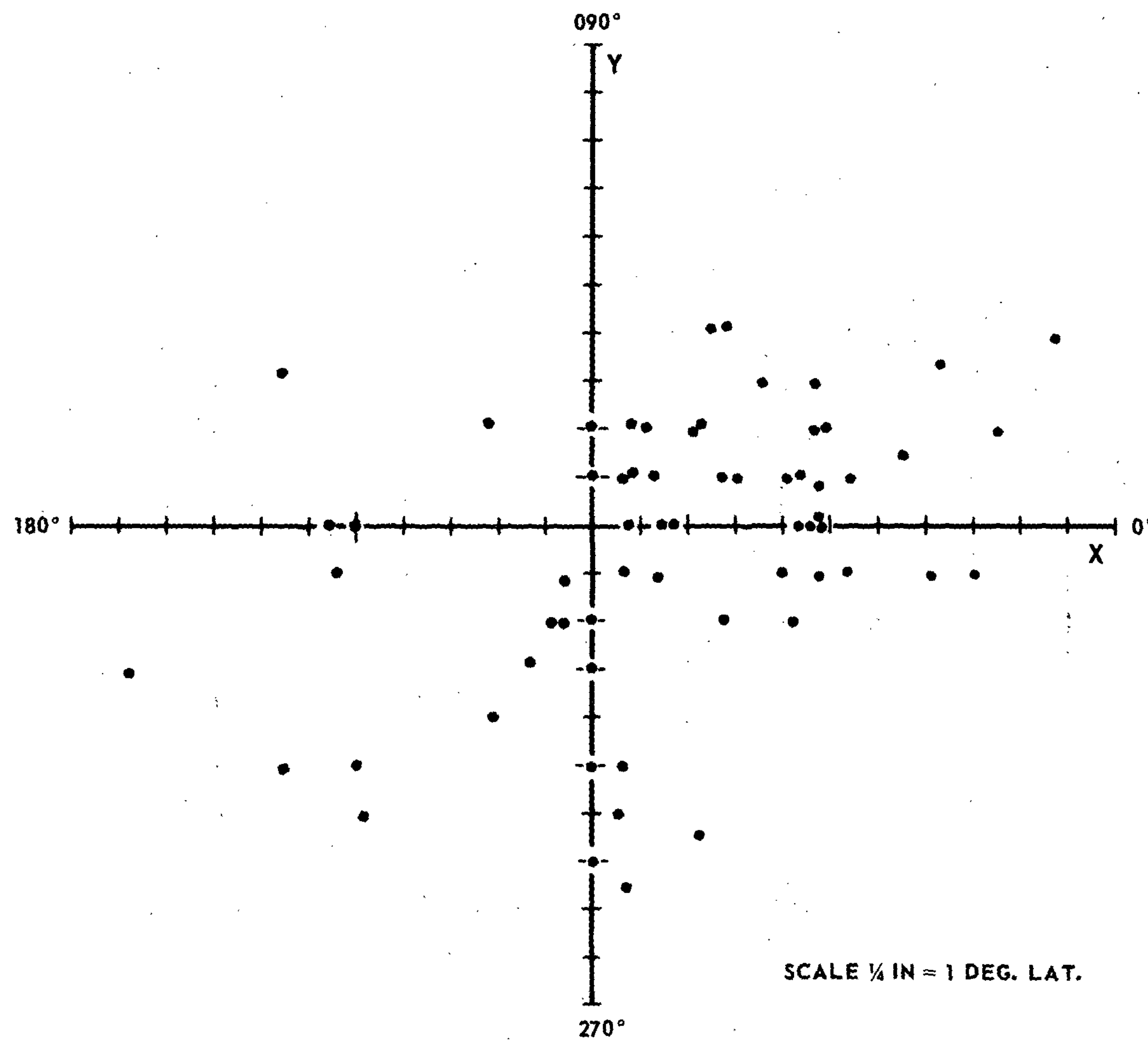

Figure 4
Errors in Location of Forecast Precipitation Fields (Degs. Lat.)

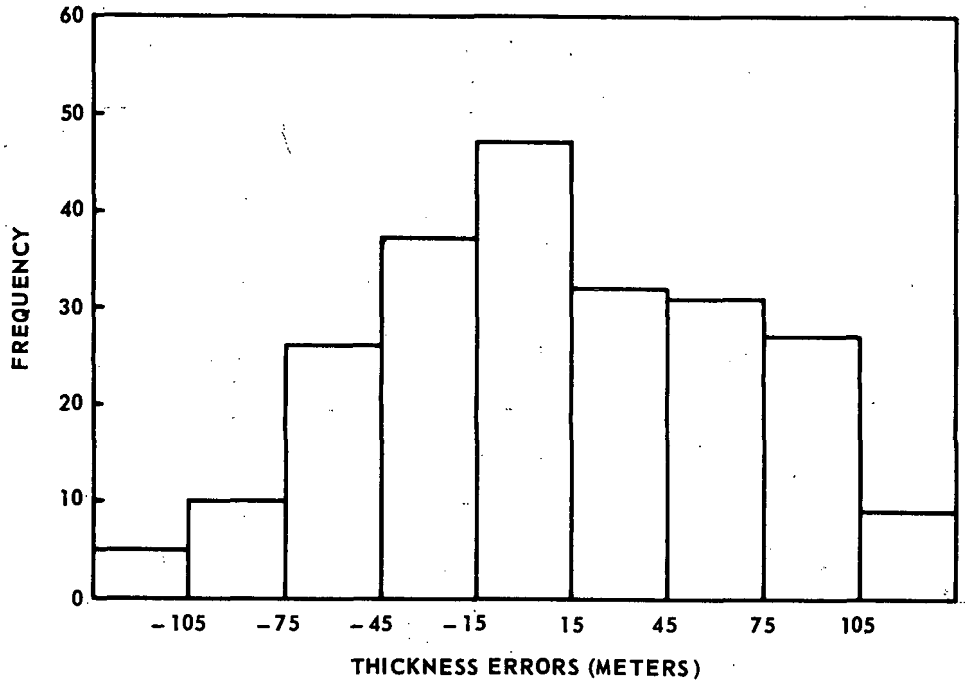

Figure 5.
Thickness Errors (Meters).

Two hundred and twenty forecasts of ridges and troughs were examined. Histograms for the error distributions for thickness troughs and ridges appear in Figure 6 A, B.

Generally, the thickness prognostics over-forecast the speeds of thickness ridges and troughs with 58% of the forecasts indicating too great a displacement of the thickness ridge, and 47 % indicating too great a displacement of the thickness trough. Correct positions for both the thickness ridge and trough were observed in 11% of the forecasts. Mean errors for over-forecasts were 4.1 degrees of latitude for the thickness ridge, 4.0 degrees of latitude for the thickness trough, while mean errors for under-forecasts were 3.7 degrees of latitude for the thickness ridge, 2.9 degrees of latitude for the thickness trough.

C. Comparison of the Areas of Computed and Observed Precipitation Fields

Computations of precipitation fields for December 1966, were based on the current values of vertical velocity and precipitable water supplied by the C.A.O. Computed and observed precipitation areas and intensities for December 1966, are set out in Table 9. Comparison of the monthly averages of the precipitation areas and intensities would suggest that, based on the data obtained from the C.A.O. charts, the method underestimates the precipitation area, intensity, and frequency. This statement should not infer an outright condemnation of the method, for several check computations employing the Fjortoft technique for obtaining the $Z - \overline{Z}$ field, and using the Ferguson advection scale to obtain values for the $Z - \overline{Z}$ and thickness advection, resulted in computed precipitation fields that corresponded well as regards both location and intensity with the observed fields, with the exception of 21 December as previously noted.

Over the 60 events considered in the month of December 1966, for the area in which the analysis was carried out, there were 40 occurrences of precipitation exceeding .1 inch per 6 hours as compared with 30 occasions when the computation indicated precipitation of this intensity in the valid area.

Considering only those events when precipitation was computed and observed (Table 10), it can be seen that the computed field is, on the average, about 20 per cent smaller in area than the observed field, with 17 of the 25 of these corresponding events showing a smaller computed area than observed.

For the most part, an assumption of moderate instability provides a computed precipitation rate which most frequently approximates the observed rate. The computation, however, did not provide a good approximation to precipitation intensity in those cases where observed precipitation intensity was in excess of one inch per six hours.

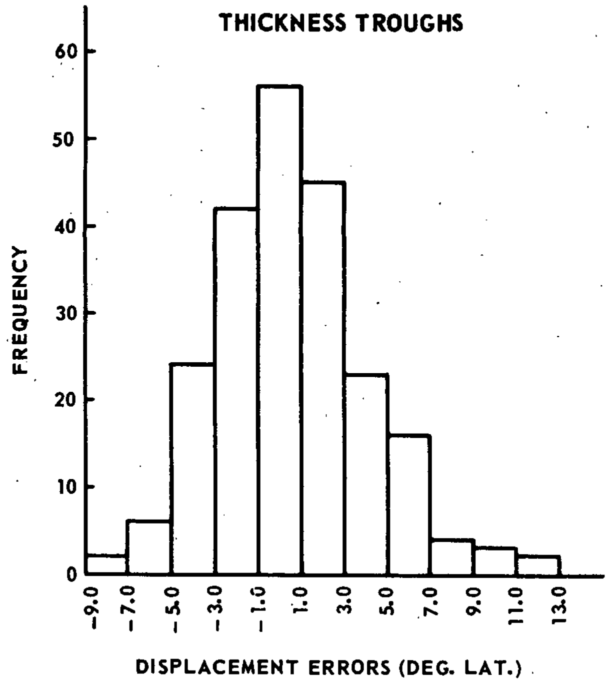

Figure 6A.

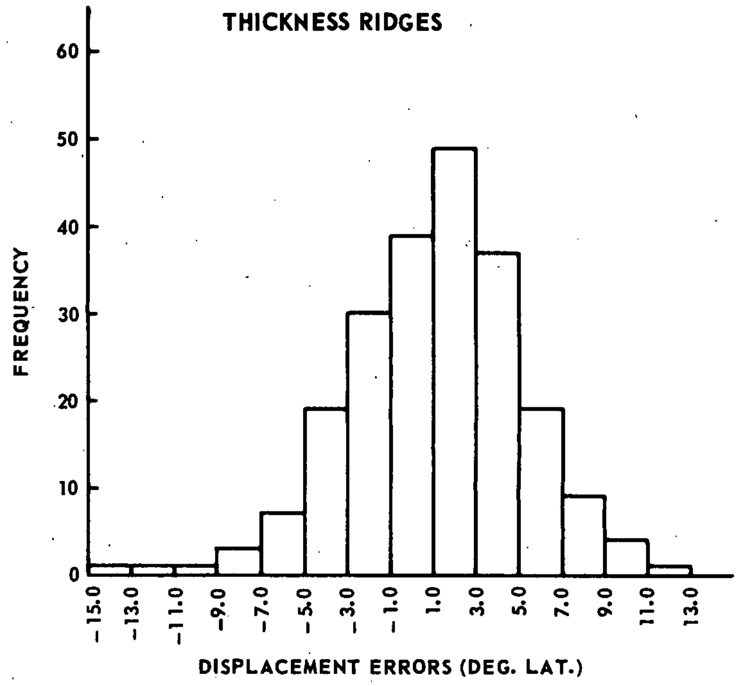

Figure 6B.

Judged on the occurrence or non-occurrence of computed precipitation, the success of the method is disappointing, with 25 per cent of these precipitation computations being in error.

	Precipitation Observed	Precipitation Not Observed
Precipitation Computed	34	7
No Precipitation Computed	8	11

The computation of the precipitation field from the current vertical motion field and field of precipitable water resulted in displacement errors of approximately the same magnitude as those shown by the forecast precipitation field. The displacement error-scatter diagram for the computed precipitation field (Figure 7) is very little different from that of the forecast precipitation field (Figure 4) while the values of the arithmetic mean, standard deviation and mean deviation for the two distribution are very smilar.

	Standard Deviation	Mean	Mean Deviation $\lvert e \rvert$	$\sigma / \lvert e \rvert$
Computed Precipitation Field	2.9 degs. lat.	4.3 degs. lat.	2.3 degs. lat.	1.26
Forecast Precipitation Field	2.7 degs. lat.	4.5 degs. lat.	1.9 degs. lat.	1.4.

5. Conclusions

This analysis of forecast and computed precipitation fields would indicate that in the area of the Atlantic Weather Central this method is not successful in predicting with an accuracy sufficient to make it a dependable forecast tool, either the occurrence or non-occurrence of precipitation, or the location of the precipitation area.

Ordinarily the forecasts indicate too fast a motion for the precipitation field, make no allowance in the forecast path for deflection of the low by a cold high pressure area along the Atlantic coast, and rarely predict the development of east coast storms.

The techinque appears to be only moderately successful in providing a reasonable indication of precipitation intensity (Table 6).

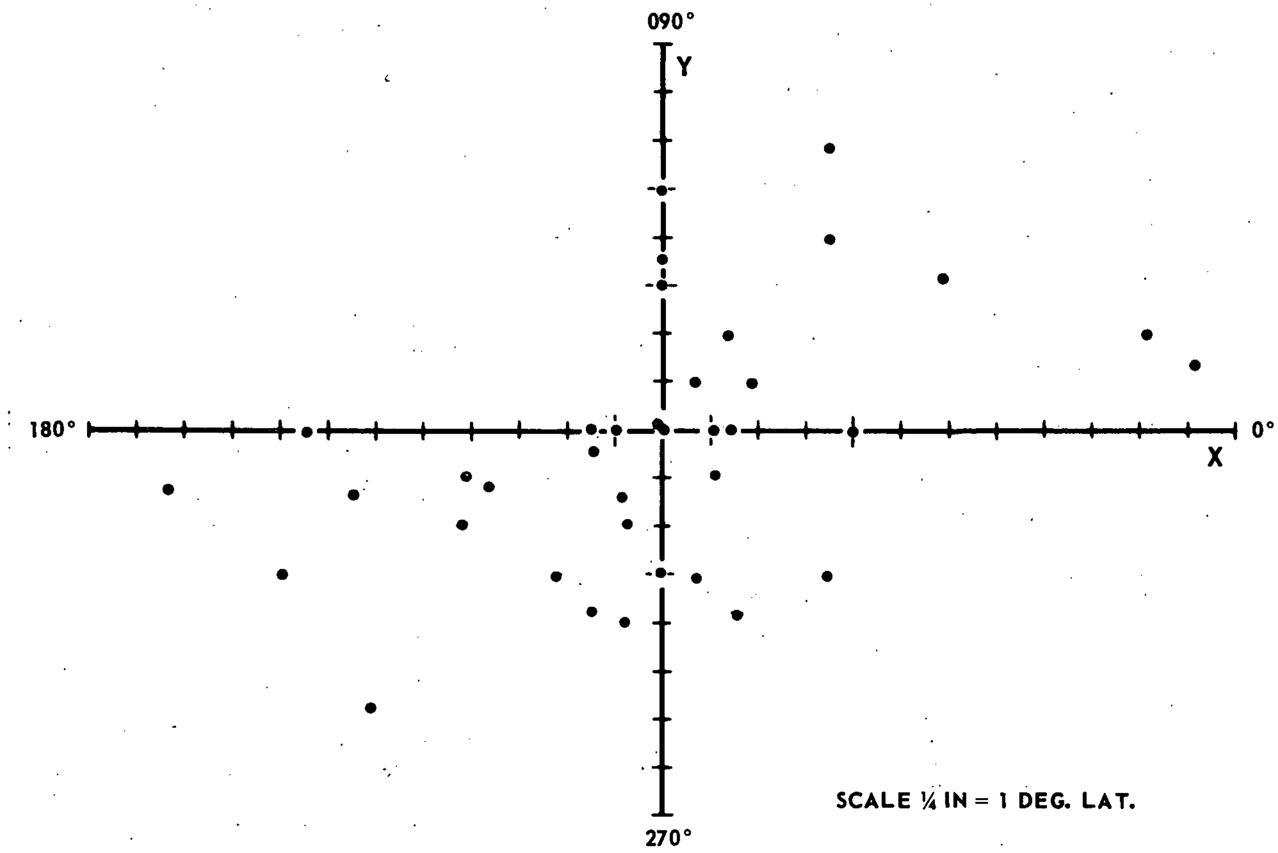

Figure 7
Errors in Location of Computed Precipitation Fields (Degs Lat.)

Based on examination of the observed precipitation fields for December 1966, the analyzed fields of vertical motion and precipitable water provided by the C.A.O. were disappointing in the success with which they indicate accurately the location of the precipitation areas and the occurrence or non-occurrence of precipitation.

APPROVED,

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

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TABLE 1

PRECIPITATION AREA (square degrees latitude)

Date/Time		December/66		January/67		February/67		March/67		April/67		May/67	
		Obsvd	Fcst	Obsvd	Fcst	Obsvd	Fcst	Obsvd	Fcst	Obsvd	Fcst	Obsvd	Fcst
01	00Z	50	Misg					20.0			82.0		9.0
	12Z	38.5					10.0	23.0		3.0	52.0	3.5	
02	00Z	6.5	7.0				27.0	3.0		8.0			
	12Z	0	7.0	23.0		16.0		7.0					
03	00Z	17	24.0	21.0	4.0	20.0			31.0	4.0		9.0	
	12Z	32	56.0	2.0		46.0				3.0		33.0	
04	00Z	0	12.0			19.0	13.0			16.0		37.0	
	12Z	0				8.0	44.0				28.0	15.0	
05	00Z	0	20.0	11.0	1.5	11.0	37.0					11.0	16.0
	12Z	0	30.0	34.0		23.0	19.0		11.0				
06	00Z	5	32.0	15.0		24.0	50.0	17.0		10.0		11.0	
	12Z	8	8.0	17.0		25.0	2.5	21.0	14.0	5.0	16.0	4.0	
07	00Z	0	14.0	6.0	10.0			20.0		12.0	8.0	2.0	
	12Z	16	10.0		32.0			18.0		6.0			
08	00Z	9	12.0	19.0	24.0	68.0	34.0	30.0	12.0			6.0	
	12Z	9	6.0	7.0		4.0		13.0	2.0			38.0	72.0
09	00Z	4	28.0	10.0					1.0			16.0	50.0
	12Z	13.5	0	23.0					36.0			9.0	
10	00Z	0	0	9.0					62.0	14.0	48.0	38.0	
	12Z	0	0			11.0	46.0		36.0	47.0		50.0	
11	00Z	24	0	6.0		20.0	18.0		8.0	33.0		4.0	
	12Z	32	4.0	14.0		17.0	2.5	9.0		25.0			4.0
12	00Z	19	0	1.0				24.0		12.0		12.0	
	12Z	5	0	13.0		6.0	2.5	5.0		11.0		22.0	30.0
13	00Z	0	0	2.0	32.0	10.0	2.0					25.0	32.0
	12Z	0	0		18.0	7.0	36.0		31.0		50.0	39.0	
14	00Z	0	30.0		4.0		15.0	16.0	34.0			10.0	
	12Z	19	16.0				8.5	28.0					
15	00Z	30	32.0			9.0	15.0	27.0					
	12Z	0		2.5	2.0	2.0		4.0		9.0	20.0	10.0	
16	00Z	2		14.0		6.0		5.0	24.0	2.0	36.0		
	12Z	8	58.0			54.0	48.0	34.0		7.0	2.0		
17	00Z	3	52.0		22.0	27.0		36.0		7.0			
	12Z	5		10.0	44.0	9.0		22.0		2.0			
18	00Z	6	20.0			8.0	3.0	24.0		8.0			
	12Z	7		22.0			3.5	24.0		20.0	18.0		
19	00Z	0						5.0		13.0	5.0		
	12Z	16							11.0	8.0			
20	00Z	27	12.0		4.0		6.0		13.0				
	12Z	7	30.0	5.0	4.5		3.5		25.0				
21	00Z	13	32.0	2.5	21.0	21.0	7.0		3.5	4.0			
	12Z	10	13.0	12.0	58.0	33.0				2.0			
22	00Z	7	10.0	13.0	7.0	94.0	10.0			5.0	9.0		
	12Z	35	10.0	14.0		30.0	16.0		6.0	3.0			
23	00Z	28	4.0		60.0					35.0	20.0		
	12Z	50		29.0		10.0	10.0			42.0	6.0		
24	00Z	30		38.0	65.0	43.0	6.0			16.0	8.0		
	12Z	0		2.0	10.0	84.0				2.0			
25	00Z	25	20.0			15.0				4.0			
	12Z	76			20.0	5.0				16.0	16.0		
26	00Z	40		16.0	78.0	11.0	45.0						
	12Z	10	13.0		24.0		28.0						
27	00Z	0	24.0										
	12Z	0			7.0						3.0		
28	00Z	0		14.0	60.0								
	12Z	0		50.0	42.0	28.0	17.0			4.0	10.0		
29	00Z	0	12.0	54.0	35.0					15.0			
	12Z	36	22.0	16.0	23.0					20.0	48.0		
30	00Z	56								22.0	42.0		
	12Z	36								40.0			
31	00Z	2			4.5								
	12Z	0	4.0										
Totals		872.5	684.0	547.0	716.5	824.0	585.0	435.0	360.5	515.0	527.0	404.5	213.0
Average		20.8	20.1	15.6	25.6	23.6	18.9	18.1	20.3	13.2	25.1	18.4	30.4

TABLE 2a

	December/66	January/67	February/67	March/67 (22 days)	April/67	May/67 (15 days)
Precipitation Forecast and Observed	25	18	23	5	17	5
Precipitation Not Forecast and Observed	15	17	12	19	22	17
Precipitation Forecast and Not Observed	9	10	8	13	4	2
Precipitation Not Forecast and Not Observed	11	17	13	7	17	6

TABLE 2b

	Precipitation Forecast	Precipitation Not Forecast
Precipitation Observed	93 events	102 events
Precipitation Not Observed	46 events	71 events

TABLE 3

PRECIPITATION INTENSITY (inches per 6 hours)

Date / Time		December / 66			January/67			February/67			March/67			April/67			May/67		
		Obsvd	Forecast Min	Max	Obsvd	Forecast Min	Max	Obsvd	Forecast Min	Max	Obsvd	Forecast Min	Max	Obsvd	Forecast Min	Max	Obsvd	Forecast Min	Max
01	00	.67	0	0	.02			.08			.49				.3	.72		.4	.90
	12	.12	0	0	.07				.3	.72	.34			.13	.6	1.27	.10		
02	00	.27	.4	.90	.08				.2	.53	.21			.25			.08		
	12	0	.2	.53	.38			.42			.60						.06		
03	00	.32	.5	1.08	.40	.2	.53	.41			.04	.6	1.27	.20			.27		
	12	.35	.5	1.08	.11			.58			.07			.23			.50		
04	00	0	.2	.53	.04			.42	.2	.53	.09			.48			.44		
	12	0						.33	.1	.35	.07				.2	.53	.36		
05	00	0	.1	.35	.48	.1	.35	.11	.1	.35	.08						.18	.2	.53
	12	.06	.1	.35	.61			1.02	.1	.35	.02	.3	.72						
06	00	.23	.1	.35	.59			.75	.1	.35	.40			.40			.27		
	12	.52	.2	.53	.52			.58	.1	.35	.27	.2	.53	.55	.4	.90	.22		
07	00	0	.1	.35	.16	.1	.35	.05			.32			.30	.4	.90	.17		
	12	.25	.1	.35	.23	.3	.72	.06			.52			.27					
08	00	.30	.1	.35	.30	.2	.53	1.32	.3	.72	.52	.2	.53	.06			.98		
	12	.20	.1	.35				.26			.29	.1	.35				.49	.4	.90
09	00	.15	.1	.35	.43			.03				.5	1.08				.36	.3	.72
	12	.25			.31							.2	.53				.55		
10	00	0			.62			.08				.3	.72	.26	.3	.72	.74		
	12	0						.42	.2	.53	.04	.2	.53	.51			.38		
11	00	.49			.20			.49	.4	.90		.2	.53	.60			.40		
	12	.48	.1	.35	.48			.33	.3	.72	.27			.34				.6	1.27
12	00	.34			.14			.04			.41			.22			.81		
	12	.16			.35			.18	.1	.35	.20			.28			1.03	1.0	2.01
13	00	0			.16	.2	.53	.26	.2	.53							.52	.2	.53
	12	0			.06	.2	.53	.20	.7	1.45		.1	.35		.3	.72	.20		
14	00	0	.1	.35	.02	.1	.35		.2	.53	.31	.1	.35				.23		
	12	.38	.2	.53	.07			.03	.2	.53	.95						.07		
15	00	.45	.3	.72	.03			.18	.2	.53	.91								
	12	0			.16	.1	.35	.13			.35			.33	.1	.35	.62		
16	00	.12			.37			.15			.22	.3	.72	.37	.6	1.27			
	12	.13	.2	.53	.08			.47	.2	.53	.47			.40	.3	.72			
17	00	.16	.2	.53	.03	.3	.72	.35			.42			.45					
	12	.20			.14	.3	.72	.20			.65			.26					
18	00	.18	.1	.35	.01			.20	.2	.53	.75			.48					
	12	.14			. 6			.04	.2	.53	.61			.70	.4	.90			
19	00	0			.09			.05			1.50			.53	.1	.35			
	12	.65			.08			.03			.04	.1	.35	.23					
20	00	1.00			.05	.2	.53	.05	.2	.53	.03	.2	.53	.09					
	12	.48	.2	.53	.40	.1	.35	.01	.2	.53	.03	.1	.35	.05					
21	00	1.45	.1	.35	.40	.2	.35	.31	.2	.53	.06	.2	.53	.26					
	12	.72			.40	.3	.53	.61			.04			.20					
22	00	.35	.1	.35	.34	.1	.35	.85	.3	.72				.44	.1	.35			
	12	.65			.28			.41	.3	.72	.27	.2	.53	.21					
23	00	.46			.02	.2	.53	.02						.64	.3	.72			
	12	.60			.50			.38	.4	.90				.41	.4	.90			
24	00	.26			.55	.4	.90	1.15	.1	.35				.26	.2	.53			
	12	0			.10	.1	.35	.50						.23					
25	00	.84	.2	.53				.28						.14					
	12	1.39				.3	.72	.49						.32	.3	.72			
26	00	.40			.50	.4	.90	.22	.3	.72				.08					
	12	.26	.2	.53	.06	.3	.72	.06	.3	.72									
27	00	0	.3	.72	.05														
	12	0			.02	.4	.90								.2	.53			
28	00	0			.45	.3	.72												
	12	0			.85	.2	.53	.38	.2	.53				.10	.1	.35			
29	00	0	.3	.72	.50	.3	.72							.37					
	12	1.43	.1	.35	.43	.2	.53							.64	.2	.53			
30	00	1.40			.05									.48	.1	.35			
	12	.54			.02									.37					
31	00	.24			.02	.1	.35												
	12	0	.2	.53	.05														
Totals		20.04	5.7	15.07	13.14	6.2	15.66	15.97	7.1	18.16	12.86	4.1	10.50	14.03	5.9	14.33	9.67	3.1	6.86
Average		.48	.19	.50	.23	.22	.56	.33	.23	.57	.35	.23	.58	.33	.28	.70	.39	.44	.98

TABLE 4

Effectiveness of Quantitative Precipitation Forecasts

	December/66	January/67	February/67	March/67	April/67	May/67
Precipitation ≥ .25 in/6 hr. but not forecast	18	13	9	17	13	12
Forecast Precipitation ≥ .25 in./6 hr. but no precipitation	0	0	1	4	2	2
Precipitation Intensity ≥ twice the maximum forecast intensity	3	0	4	0	0	0
Precipitation Intensities ≥ .75 in. per 6 hr. forecast as a fraction of occurrences	0/7	1/1	1/4	0/4	0/4	1/4
Percentage of unsatisfactory forecasts (=)	33%	20%	25%	50%	25%	50%

TABLE 5

PRECIPITATION INTENSITY (inches per 6 hours)

December / 66

Date / Time	Obs	Forecast Min	Forecast Max
02/00Z	.27	.40	.90
03/00Z	.32	.50	1.08
03/12Z	.35	.50	1.08
06/00Z	.23	.10	.35
06/12Z	.52	.20	.53
07/12Z	.25	.10	.35
08/00Z	.30	.10	.35
08/12Z	.20	.10	.35
09/00Z	.15	.10	.35
11/12Z	.48	.10	.35
14/12Z	.38	.20	.53
15/00Z	.45	.30	.72
16/12Z	.13	.20	.53
17/00Z	.16	.20	.53
18/00Z	.18	.10	.35
20/12Z	.48	.20	.53
21/00Z	1.45	.10	.35
22/00Z	.35	.10	.35
25/00Z	.84	.20	.53
26/12Z	.26	.20	.53
29/12Z	1.43	.10	.35

January / 67

Date / Time	Obs	Forecast Min	Forecast Max
03/00Z	.40	.20	.53
05/00Z	.48	.10	.35
07/00Z	.16	.10	.35
07/12Z	.23	.30	.72
08/00Z	.30	.20	.53
13/00Z	.16	.20	.53
15/12Z	.26	.10	.35
17/12Z	.14	.30	.72
20/12Z	.40	.10	.35
21/00Z	.40	.20	.53
21/12Z	.40	.30	.72
22/00Z	.34	.10	.35
24/00Z	.55	.40	.90
24/12Z	.10	.10	.35
26/00Z	.50	.40	.90
28/00Z	.45	.30	.72
28/12Z	.85	.20	.53
29/00Z	.50	.30	.72
29/12Z	.43	.20	.53

February / 67

Date / Time	Obs	Forecast Min	Forecast Max
04/00Z	.42	.20	.53
04/12Z	.33	.10	.35
05/00Z	.11	.10	.35
05/12Z	1.02	.10	.35
06/00Z	.75	.10	.35
06/12Z	.58	.10	.35
08/00Z	1.32	.30	.72
10/12Z	.42	.20	.53
11/00Z	.49	.40	.90
11/12Z	.33	.30	.72
12/12Z	.18	.10	.35
13/00Z	.26	.20	.53
13/12Z	.20	.70	1.45
15/00Z	.18	.20	.53
16/12Z	.47	.20	.53
18/00Z	.20	.20	.53
21/00Z	.31	.20	.53
22/00Z	.85	.30	.72
22/12Z	.41	.30	.72
23/12Z	.38	.40	.90
24/00Z	1.15	.10	.35
26/00Z	.22	.30	.72
28/12Z	.38	.20	.53

March / 67

Date / Time	Obs	Forecast Min	Forecast Max
06/12Z	.27	.20	.53
08/00Z	.52	.20	.53
08/12Z	.29	.10	.35
14/00Z	.31	.10	.35
16/00Z	.22	.30	.72

April / 67

Date / Time	Obs	Forecast Min	Forecast Max
01/12Z	.13	.60	1.27
06/12Z	.55	.40	.90
07/00Z	.30	.40	.90
10/00Z	.26	.30	.72
15/12Z	.33	.10	.35
16/00Z	.37	.60	1.27
16/12Z	.40	.30	.72
18/12Z	.70	.40	.90
19/00Z	.53	.10	.35
22/00Z	.44	.10	.35
23/00Z	.64	.30	2
23/12Z	.41	.40	.90
24/00Z	.26	.20	.53
25/12Z	.32	.30	.72
28/12Z	.10	.10	.35
29/12Z	.64	.20	.53
30/00Z	.48	.10	.35

May / 67

Date / Time	Obs	Forecast Min	Forecast Max
05/00Z	.18	.20	.53
08/12Z	.49	.40	.90
09/00Z	.36	.30	.72
12/12Z	1.03	1.00	2.01
13/00Z	.52	.20	.53

TABLE 6.A

Date/Time	Assessment of Instability	Bases for Assessment	Observed Pcpn	Forecast Pcpn No Instability	Forecast Pcpn Mdt Instability	Forecast Pcpn Stg Instability
Dec 6/12	Strong	R, S, W	.52	.20	.33	.53
Dec 7/12	Moderate	R, S	.25	.10	.22	.35
Dec 11/12	Moderate	R, S, W	.48	.10	.22	.35
Dec 18/00	Slight	R, W	.18	.10	.22	.35
Dec 20/12	Moderate	R, W	.48	.20	.33	.53
Dec 22/00	Moderate	S	.35	.10	.22	.35
Jan 3/00	Moderate	R, S, W	.40	.20	.33	.53
Jan 5/00	Strong	R, S, W	.48	.10	.22	.35
Jan 15/12	Slight	R, S	.26	.10	.22	.35
Jan 20/12	Strong	R, S, W	.40	.10	.22	.35
Jan 21/00	Moderate	R, W	.40	.20	.33	.53
Jan 22/00	Moderate	R, S, W	.34	.10	.22	.35
Jan 29/12	Moderate	R, W	.43	.20	.33	.53
Feb 4/00	Moderate	S, W	.42	.20	.33	.53
Feb 4/12	Moderate	S, W	.33	.10	.22	.35
Feb 10/12	Moderate	S, W	.42	.20	.33	.53
Feb 16/12	Moderate	R, S, W	.47	.20	.33	.53
Feb 22/00	Strong	R, S, W	.85	.30	.44	.72
Mar 8/00	Slight	R, W	.52	.20	.33	.53
Mar 8/12	Moderate	R, S, W	.29	.10	.22	.35
Mar 14/00	Slight	R, W	.31	.10	.22	.35
Apr 15/12	Moderate	R, S, W	.33	.10	.22	.35
Apr 19/00	Strong	R, W	.53	.10	.22	.35
Apr 22/00	Strong	R, S	.44	.10	.22	.35
Apr 23/00	Moderate	R, W	.64	.30	.44	.72
Apr 29/12	Strong	R, S, W	.64	.20	.33	.53
Apr 30/00	Strong	R, S, W	.48	.10	.22	.35
May 13/00	Strong	R, S, W	.52	.20	.33	.53

R, radiosonde; S, satellite; W, weather surface reports

TABLE 6B

Date/Time	Assessment of Instability	Bases for Assessment	Observed Pcpn	Precipitation No Instability	Forecast Pcpn Moderate Instability	Forecast Precipitation Strong Instability
Dec 21/00Z	Strong	R, W	1.45 in/ 6 hr.	.10 in./6 hr.	.22 in/6 hr.	.35 in./6 hr.
Dec 25/00Z	Strong	R, W	.84 in/ 6 hr.	.20 in/6 hr.	.33 in/6 hr.	.53 in/6 hr.
Dec 29/00Z	Moderate	R, S, W	1.43 in /6 hr.	.10 in/6 hr.	.22 in/6 hr.	.35 in/6 hr.
Jan 28/12Z	Moderate	R, W	.85 in /6 hr	.20 in/6 hr.	.33 in/6 hr.	.53 in/6 hr.
Feb 5/12Z	Moderate	S, W	1.02 in /6 hr	.10 in/6 hr.	.22 in/6 hr.	.35 in/6 hr.
Feb 6/00Z	Moderate	R, W	1.21 in /6 hr	.10 in/6 hr.	.22 in/6 hr.	.35 in/6 hr
Feb 6/12Z	Moderate	R, S, W	.58 in/ 6 hr	.10 in/6 hr.	.22 in/6 hr.	.35 in/6 hr
Feb 8/00Z	Strong	S, W	1.32 in /6 hr	.30 in/6 hr.	.44 in/6 hr.	.72 in/6 hr
Feb 24/00Z	Strong	R, W	1.15 in /6 hr	.10 in/6 hr	.22 in/6 hr.	.35 in/6 hr

R, roab; S, satellite; W, surface weather

TABLE 7

Date/Time	Computed ω_6	Computed Maximum Precipitation Rate	Forecast ω_6	Forecast Maximum Precipitation Rate	Observed Maximum Precipitation Rate	Instability
Dec 21/00Z	-3×10^{-3} mb sec^{-1}	.30 in/6 hr	-4×10^{-3} mb sec^{-1}	.35 in/6 hr	1.45 in/6 hr	Strong
Dec 25/00Z	-18×10^{-3} mb sec^{-1}	1.27 in/6 hr	-4×10^{-3} mb sec^{-1}	.53 in/6 hr	.84 in/6 hr	Strong
Dec 29/00Z	-9×10^{-3} mb sec^{-1}	1.63 in/6 hr	-4×10^{-3} mb sec^{-1}	.53 in/6 hr	1.43 in/6 hr	Moderate
Jan 28/12Z	-10×10^{-3} mb sec^{-1}	1.27 in/6 hr	-4×10^{-3} mb sec^{-1}	.53 in/6 hr	.85 in/6 hr	Moderate
Feb 5/12Z	-8×10^{-3} mb sec^{-1}	.99 in/6 hr	-4×10^{-3} mb sec^{-1}	.35 in/6 hr	1.02 in/6 hr	Moderate
Feb 6/00Z	-5×10^{-3} mb sec^{-1}	1.08 in/6 hr	-3×10^{-3} mb sec^{-1}	.35 in/6 hr	1.21 in/6 hr	Moderate
Feb 6/12Z	-10×10^{-3} mb sec^{-1}	.72 in/6 hr	-4×10^{-3} mb sec^{-1}	.35 in/6 hr	.58 in/6 hr	Moderate
Feb 8/00Z	-8×10^{-3} mb sec^{-1}	.72 in/6 hr	-7×10^{-3} mb sec^{-1}	.72 in/6 hr	1.32 in/6 hr	Strong
Feb 24/00Z	-12×10^{-3} mb sec^{-1}	1.00 in/6 hr	-6×10^{-3} mb sec^{-1}	.53 in/6 hr	1.15 in/6 hr	Strong

TABLE 8

	Mean Displacement Error (m)	Standard Deviation of Errors	Mean Deviation $\lvert e \rvert = \frac{\sum \lvert x_i - m \rvert}{N}$	$\frac{\sigma}{\lvert e \rvert}$	Percentage of Errors Within $\lvert \sigma \rvert$ of m.
Thickness Ridge	+ 1.2 degs. lat.	4.2 degs. lat.	3.4 degs. lat.	1.24	70%
Thickness Trough	+ .6 degs. lat.	3.8 degs. lat.	3.1 degs. lat.	1.23	68.8%

TABLE 9

Date/Time		PRECIPITATION AREA (Square degrees latitude) Observed	Computed	PRECIPITATION INTENSITY (inches per 6 hours) OBSERVED	COMPUTED No Instability	Mdt Instability	Stg Instability
01	00Z	50	0	.67	.4	.54	.90
	12Z	Missing					
02	00Z	6.5	20	.27	.14	.27	.42
	12Z	0	22	0	.20	.33	.53
03	00Z	17	0	.32	0	0	0
	12Z	32	12	.35	.15	.28	.42
04	00Z	0	8	0	.17	.30	.48
	12Z	0	0	0	0	0	0
05	00Z	0	0	0	0	0	0
	12Z	0	10	.06	.12	.25	.38
06	00Z	5	3	.23	.10	.22	.35
	12Z	8	1	.52	0	0	0
07	00Z	0	0	0	0	0	0
	12Z	16	12	.25	.15	.28	.42
08	00Z	9	6	.30	.10	.22	.35
	12Z	9	30	.20	.30	.44	.72
09	00Z	4	0	.15	0	0	0
	12Z	13½	6	.25	.14	.27	.42
10	00Z	0	0	0	0	0	0
	12Z	0	0	0	0	0	0
11	00Z	24	4	.49	.10	.22	.35
	12Z	32	28	.48	.22	.35	.57
12	00Z	19	28	.34	.20	.33	.53
	12Z	5	0	.16	0	0	0
13	00Z	0	0	0	0	0	0
	12Z	0	0	0	0	0	0
14	00Z	0	0	0	0	0	0
	12Z	19	23	.38	.22	.35	.57
15	00Z	30	36	.45	.32	.46	.75
	12Z	0	16	0	.15	.28	.42
16	00Z	2	0	.12	0	0	0
	12Z	8	3	.13	.10	.22	.35
17	00Z	3	0	.16	.07	.19	.29
	12Z	5	0	.20	.04	.16	.23
18	00Z	6	0	.18	.08	.20	.31
	12Z	Missing			Missing		
19	00Z	0	1	0	.10	.22	.35
	12Z	16	10	.65	.30	.44	.72
20	00Z	27	54	1.00	.40	.54	.90
	12Z	7	16	.48	.25	.39	.63
21	00Z	13	4	1.45	.10	.22	.35
	12Z	10	1	.72	.12	.25	.38
22	00Z	7	0	.35	.07	.19	.29
	12Z	35	0	.65	.08	.20	.31
23	00Z	28	0	.46	0	0	0
	12Z	50	2	.60	.10	.22	.35
24	00Z	30	0	.26	.05	.17	.25
	12Z	0	0	0	0	0	0
25	00Z	25	0	.84	0	0	0
	12Z	76	44	1.39	.20	.33	.53
26	00Z	40	24	.40	.26	.40	.64
	12Z	10	0	.26	0	0	0
27	00Z	0	0	0	0	0	0
	12Z	0	0	0	0	0	0
28	00Z	0	0	0	.03	.15	.22
	12Z	0	0	0	.05	.17	.25
29	00Z	0	3	0	.25	.39	.63
	12Z	36	34	1.43	.30	.44	.72
30	00Z	56	46	1.40	.35	.49	.81
	12Z	36	42	.54	.22	.35	.57
31	00Z	2	0	.24	0	0	0
	12Z	0	0	0	0	0	0
Totals		827	549	19.78	6.70	11.72	18.66
Average		13.8	9.2				

TABLE 10

PRECIPITATION AREA (Square degrees latitude)			PRECIPITATION INTENSITY (inches per 6 hours)			
Date/ Time	Observed	Computed	Observed	COMPUTED No Instability	COMPUTED Mdt Instability	COMPUTED Stg Instability
02/00Z	6½	20	.27	.14	.27	.42
03/12Z	32	12	.35	.15	.28	.42
06/00Z	5	3	.23	.10	.22	.35
06/12Z	8	1	.52	Nil	Nil	Nil
07/12Z	16	12	.25	.15	.28	.42
08/00Z	9	6	.30	.10	.22	.35
08/12Z	9	30	.20	.30	.44	.72
09/12Z	13½	6	.25	.14	.27	.42
11/00Z	24	4	.49	.10	.22	.35
11/12Z	32	28	.48	.22	.35	.57
12/00Z	19	28	.34	.20	.33	.53
14/12Z	19	23	.38	.22	.35	.57
15/00Z	30	36	.45	.32	.46	.75
16/12Z	8	3	.13	.10	.22	.35
19/12Z	16	10	.65	.30	.44	.72
20/00Z	27	54	1.00	.40	.54	.90
20/12Z	7	16	.48	.25	.39	.63
21/00Z	13	4	1.45	.10	.22	.35
21/12Z	10	1	.72	.12	.25	.38
23/12Z	50	2	.60	.10	.22	.35
25/12Z	76	44	1.39	.20	.33	.53
26/00Z	40	24	.40	.26	.40	.64
29/12Z	36	34	1.43	.30	.44	.72
30/00Z	56	46	1.40	.35	.49	.81
30/12Z	36	42	.54	.22	.35	.57
Totals	598	489	14.70	4.84	7.98	12.82
Averages	23.9	19.6	.59	.19	.32	.51

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