Environment Canada Imaging Cover Page

Report N.: *TEC-865*

SKP Box Number: 672572429

Environment Canada / Environnement Canada

Atmospheric Environment / Environnement atmosphérique

Technical Memoranda

A CASE OF SIGNIFICANT FREEZING RAIN AT CANADIAN FORCES BASE COLD LAKE, ALBERTA ON FEBRUARY 9, 1977

by

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Published under the authority of the Assistant Deputy Minister

Publication autorisée par le sous-ministre adjoint

UDC: 551.578.4
ISSN: 0068-7804

TEC 865
21 FEBRUARY 1979

ENVIRONMENT CANADA - ATMOSPHERIC ENVIRONMENT SERVICE
4905 Dufferin Street
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ABSTRACT

A case study of a potentially hazardous weather situation, which had not been forecast, is presented. The freezing rain of February 9, 1977, occurred when many aircraft from CFB Cold Lake were airborne, with some having insufficient fuel to reach an alternate aerodrome.

The situation is analysed in terms of dynamic features at the surface and at the 850-, 700-, 500- and 300-mb levels.

It was found that the initial surface analysis by the Canadian Forces Weather Office, Cold Lake was in error and that a small, but significant, warm frontal wave produced the freezing precipitation.

CAS DE PLUIE SE CONGELANT, SIGNIFICATIVE À LA BASE DES FORCES CANADIENNES DE COLD LAKE (ALBERTA), LE 9 FÉVRIER 1977

par

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RÉSUMÉ

L'auteur étudie le cas d'une situation météorologique potentiellement dangereuse que l'on n'avait pas prévue. De la pluie se congelant est tombée le 9 février 1977 alors que de nombreux avions de la BFC de Cold Lake étaient en vol, certains n'ayant pas assez de carburant pour atteindre un aérodrome de dégagement.

On analyse la situation en termes d'éléments dynamiques en surface et aux niveaux de 850, 700, 500 et 300 mb.

On constate que l'analyse initiale en surface qu'avait effectuée le bureau météorologique des Forces canadiennes à Cold Lake était erronée et qu'une onde frontale chaude, petite mais significative, a provoqué les précipitations se congelant.

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(Manuscript received April 19, 1978)

1. Introduction

On the morning of February 9, 1977, a maritime trowal was analysed by the Canadian Meteorological Centre, by the Prairie Weather Centre and by the Canadian Forces Weather Office (CFWO) Cold Lake as being oriented in a north-south line through central British Columbia. Since the trowal was expected to move eastward at nearly 30 kt, showery precipitation was forecast to begin at Cold Lake at about 1800Z. By that time, the surface temperature would be nearly zero so that there was a risk of spotty freezing rain.

However, at 1524Z freezing rain commenced at Cold Lake and fell continuously until 1740Z, with a brief period of moderate intensity between 1705 and 1728Z.

Later examination of the available charts indicated that a frontal wave could be analysed instead of the trowal. A small, stable wave developed on the warm front and passed just south of Cold Lake during the freezing rain period.

2. Synoptic Situation

On February 9 the 1500Z surface analysis (Figure 1) showed a broad lee trough extending from the Yukon to southern Alberta. The Arctic front, at that time, extended from Fort Chipewyan to Cree Lake then to The Pas. It was drifting slowly but was not expected in the Cold Lake area that day.

The significant feature at analysis time was a maritime wave located near Fort Nelson (YYE) with a cold front to Jasper (YJA) and a warm front to the east of Slave Lake (YZH). A weak warm frontal wave was located southwest of Cold Lake (YOD). Based on history, both waves were apparently moving eastward at 30 kt; the minor wave passed south of Cold Lake at 1600Z.

The 500-mb chart for 1200Z on February 9 (Figure 2), showed a short-wave trough and a vorticity maximum just east of Port Hardy. Historically, this trough was moving into the east-northeast at 40 kt. The downstream short-wave ridge, which was just west of Cold Lake at 1300Z, moved east at 30-35 kt. The PVA associated with the trough had a moderate intensity which had been maintained across British Columbia during the previous 12 h. By 0000Z on February 10 it had lost its strength while moving into the long-wave ridge position. The weakening trough maintained its 40-kt speed and at 0000Z February 10 was just east of Edmonton in a

NW-SE line. A 500-mb temperature analysis showed that weak cold advection covered Alberta from 1200Z February 9 to 0000Z February 10.

At the 700-mb level (Figure 3) weak cold advection was also occurring and the heights were falling slowly (40 m between 1200Z February 9 and 0000Z February 10) as a weak trough near Jasper, at analysis time, moved eastward, lying by 0000Z in a N-S line 30 n. mi east of Cold Lake. This trough and the short-wave ridge at 500-mb delineated the moisture field at 700-mb. The vorticity advection aloft provided the lifting mechanism and a solid band of middle cloud formed in this area.

At 850 mb (Figure 4) a small trough was analysed to be just east of Edmonton at 1200Z February 9, based on a northerly wind reported at that level by the morning radiosonde from Edmonton. Warm air advection was occurring in the low levels to the east of the trough forecast to pass over Cold Lake by about 1800Z; therefore cold advection could not be expected to begin until then. Most of the 850-mb moisture at 1200Z was located to the west of the Rocky Mountains in the upslope flow. Only patchy low-level moisture was present in the subsidence flow to the east. However, as the wave developed, another source of convergence, and hence moisture, was created.

At 300 mb (Figure 5) an anticyclonically curved jet maximum of 90 kt was located over Lac la Ronge at 1200Z, but had been over Fort Chipewyan twelve hours previously, representing a 15-kt southeastward motion. This put Cold Lake into the right entrance portion of the jet stream. Since both the shear term and the curvature were negative, strong PVA would occur in this region causing divergence that would accentuate the lift produced by the trough at 500 mb.

Considering the air mass itself, the morning tephigram from Edmonton (Figure 6) showed that the air was stable even for forced lifts because it was too dry. However, once the wave had formed in the lee of the Rockies, moisture in the low levels would be increasing and along with it the potential instability. The air mass slowly became unstable for forced lifts; if an 850-mb dew-point depression of 5°C is assumed then convective cells to 600 m are possible.

In addition, with warm advection at 850 mb and cold advection at 500 mb the conditional instability of the air mass was increasing. After 1800Z, this destabilisation stopped when the low-level warm advection was cut off. By 0000Z February 10, the Edmonton tephigram showed cooling at all levels.

3. Statistical Predictors of Freezing Rain

The precipitation associated with the wave developed from convective type at 0900Z into a small area of continuous freezing rain. The standard synoptic pattern of snow, freezing rain and then rain did not occur. Therefore the extrapolation of a 1000-500 mb thickness line was of no use in this case, since there were no boundaries between precipitation types.

However, statistical predictors could identify a "risk" area for freezing precipitation based on purely thermodynamic considerations.

On the 1500Z surface analysis (Figure 1) the 0°C isotherms for the surface and the 850-mb level have been drawn to outline the approximate area where freezing rain could occur. The 850-mb isotherm is plotted from 1200Z data; little change in its position would have occurred by 1500Z since there was weak insolation and advection.

Other statistical predictors that can help to outline such an area are given by the following thickness relationships:

$$(Z850 - Z1000) < 1300 \text{ m}$$

$$(Z700 - Z850) > 1560 \text{ m}$$

where Zp is the contour height Z at the pressure level indicated by p (see Koolwine, 1975). The 700-850 mb thickness was found by graphical subtraction, and the 850-1000 mb thickness was found from the 500-1000 mb thickness and the 850-mb chart. The risk area is plotted in Figure 7, and contains Cold Lake.

4. Discussion

The situation described above held the potential for freezing rain as indicated by the thicknesses and the 850-mb surface temperatures. However, the dynamic features were contradictory and very localized in their effect, so that the amount and intensity of the precipitation from the system were missed.

At 0600Z on February 9 the short-wave ridge had just moved into Alberta and PVA was appearing over the mountains. With a good southwesterly flow aloft a lee trough was already present and while a wave formed on the associated warm front, the low-level convergence and moisture increased. Convective activity was triggered and was first reported by the radar at Edmonton at 0845Z.

With the good upper divergence provided by the PVA and the jet core the cells would be expected to develop rapidly both in intensity and extent. This was confirmed by the following radar reports which showed a growing area of echoes. Maximum tops were 6400 m.

The first cells made their appearance about 30 n. mi southeast of Whitecourt (YZU: see Figure 1) where the wave was analysed to be at 0900Z, arriving 40 n. mi east-northeast of Edmonton by 1200Z. The motion was based on the 700- and the 500-mb wind speeds (approximately 25 kt), the observed speeds of the convective cells and the weather sequences from Edmonton International Airport (YEG).

At that station, with little change in cloud cover and no insolation, the temperature rose from -2°C at 0900Z to 0°C at 1100Z then fell to -2°C by 1200Z, holding steady for the succeeding two hours. A similar pattern was observed at Namao (YED), but with a southerly flow the urban effects might have disturbed the temperatures. The warm air had invaded Edmonton briefly as the wave passed north of the city.

The cold air advection aloft prevented any development of the surface wave. The surface winds remained light and no circulation about the wave could be found. Thus the wind field was of little use in locating the wave. However, the advection would help induce the formation of stronger updraughts and enchance precipitation forming processes.

The satellite picture taken between 1526 - 1548Z on February 9 revealed an area of convective cells over and to the south of Cold Lake. This confirmed the 30-kt east-northeast velocity that was estimated from other sources.

The precipitation associated with the wave was not extensive but was confined to the north and close to the wave. Radar classified it as mixed rain and snow but the temperature structure indicated that it was freezing rain. No upstream stations reported precipitation of any form so no warning of the onset of freezing rain at Cold Lake was issued. Lac la Biche which is the nearest station (approximately 60 n. mi west-northwest) is a MARS I station which does not report precipitation. As the wave continued to track east, surface temperatures rose above the freezing mark so that only rain was reported by stations in Saskatchewan.

The wave continued to move eastward at nearly 30 kt, but by 2100Z it had dissipated as the upper trough lost its identity.

5. Conclusions

In the critical weather situation of February 9, 1977, only the most careful analysis of all the available data could have revealed a minor wave which produced moderate freezing rain at CFB Cold Lake. The effects of such small stable waves cannot be underestimated during any season when freezing precipitation can be a hazard.

Because of the incorrect forecast of precipitation for Cold Lake, the briefings to the squadrons in the morning were too optimistic and as a result many aircraft from CFB Cold Lake were airborne when the freezing rain began. Since these aircraft have a very limited endurance many were unable to make an alternate aerodrome and had to land on the ice-coated runways at Cold Lake.

Reference

1. Koolwine, T., 1975: Freezing Rain, M.Sc. Thesis, University of Toronto, 92 pp.

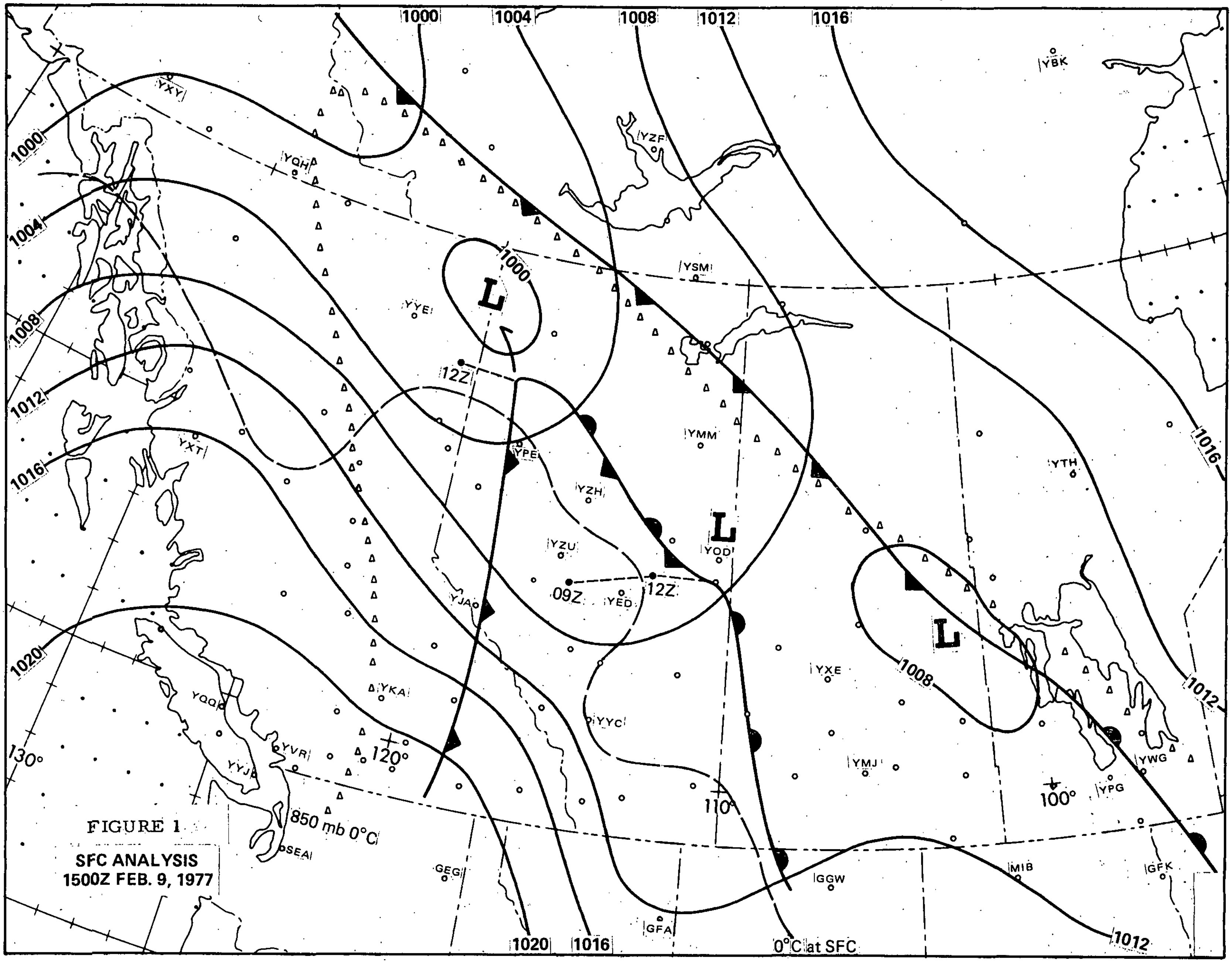

FIGURE 1

SFC ANALYSIS
1500Z FEB. 9, 1977

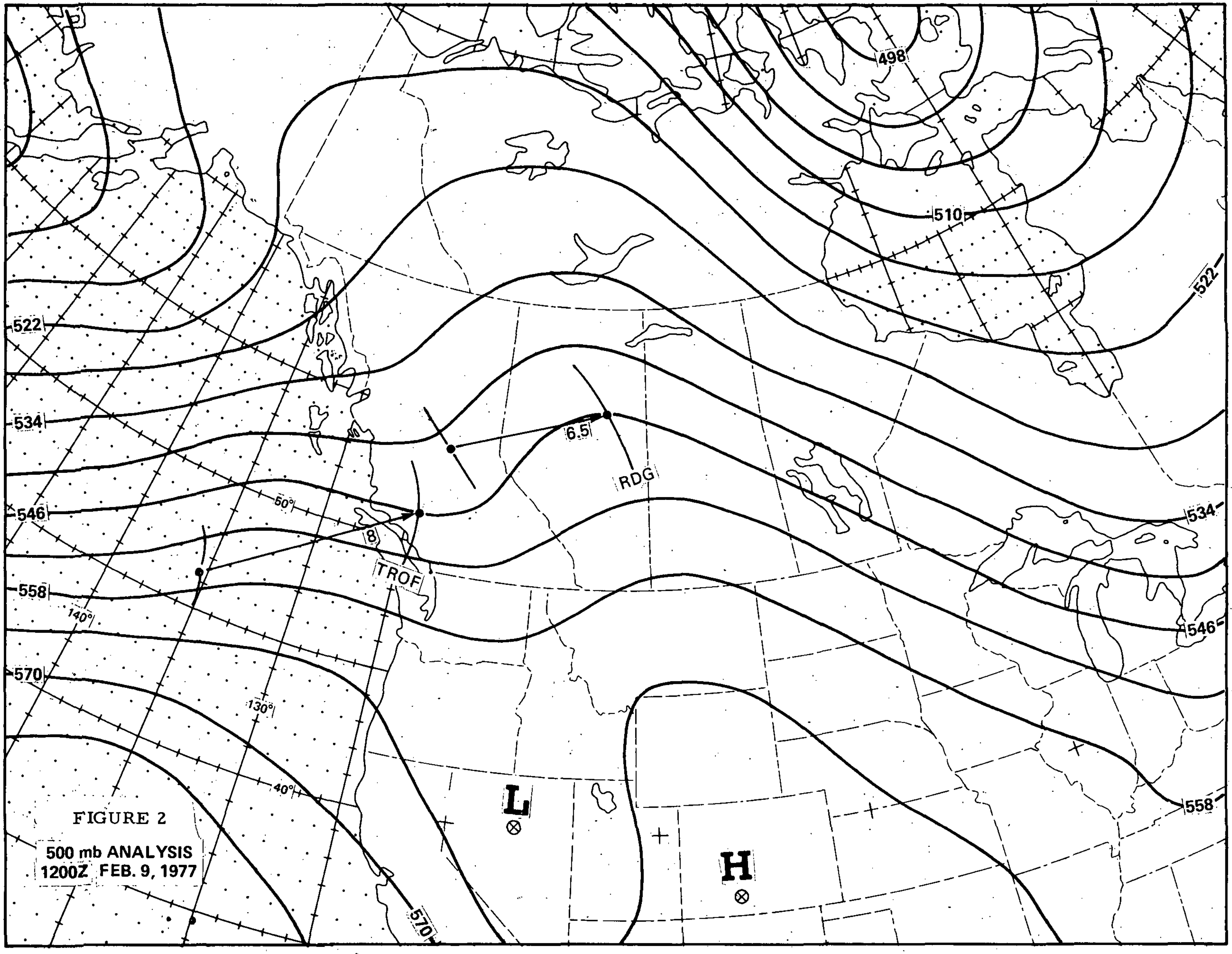

FIGURE 2

500 mb ANALYSIS
1200Z FEB. 9, 1977

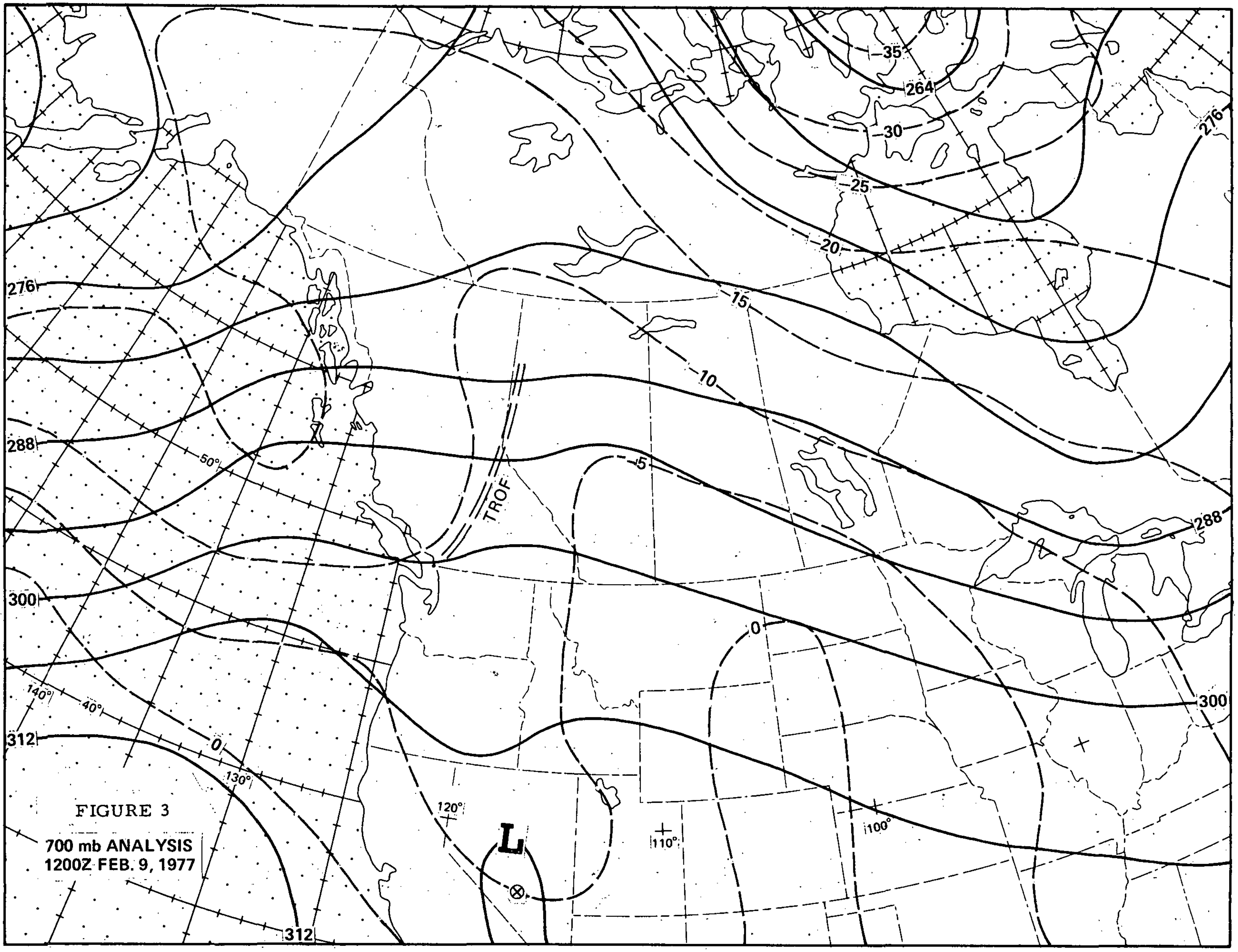

FIGURE 3

700 mb ANALYSIS
1200Z FEB. 9, 1977

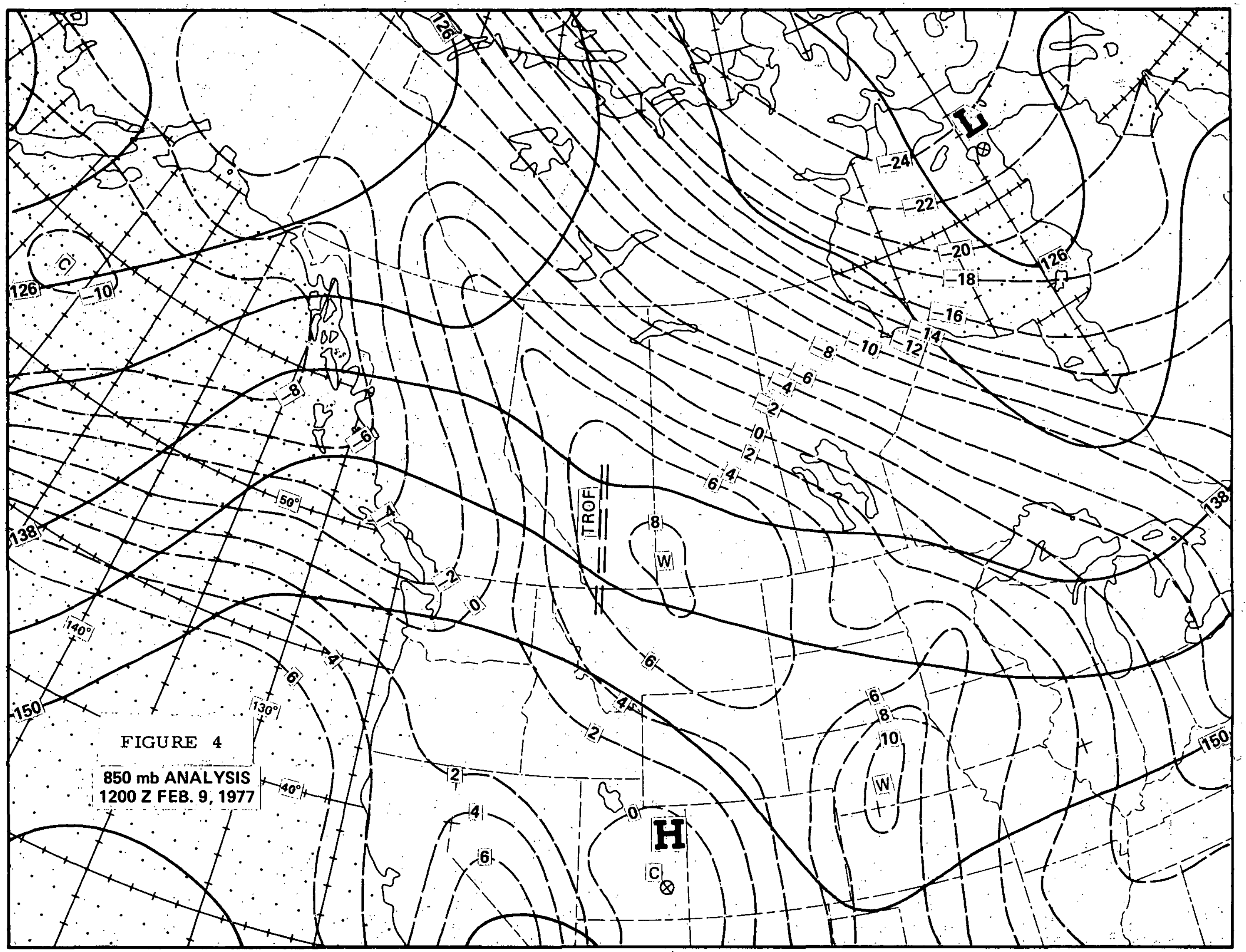

FIGURE 4

850 mb ANALYSIS
1200 Z FEB. 9, 1977

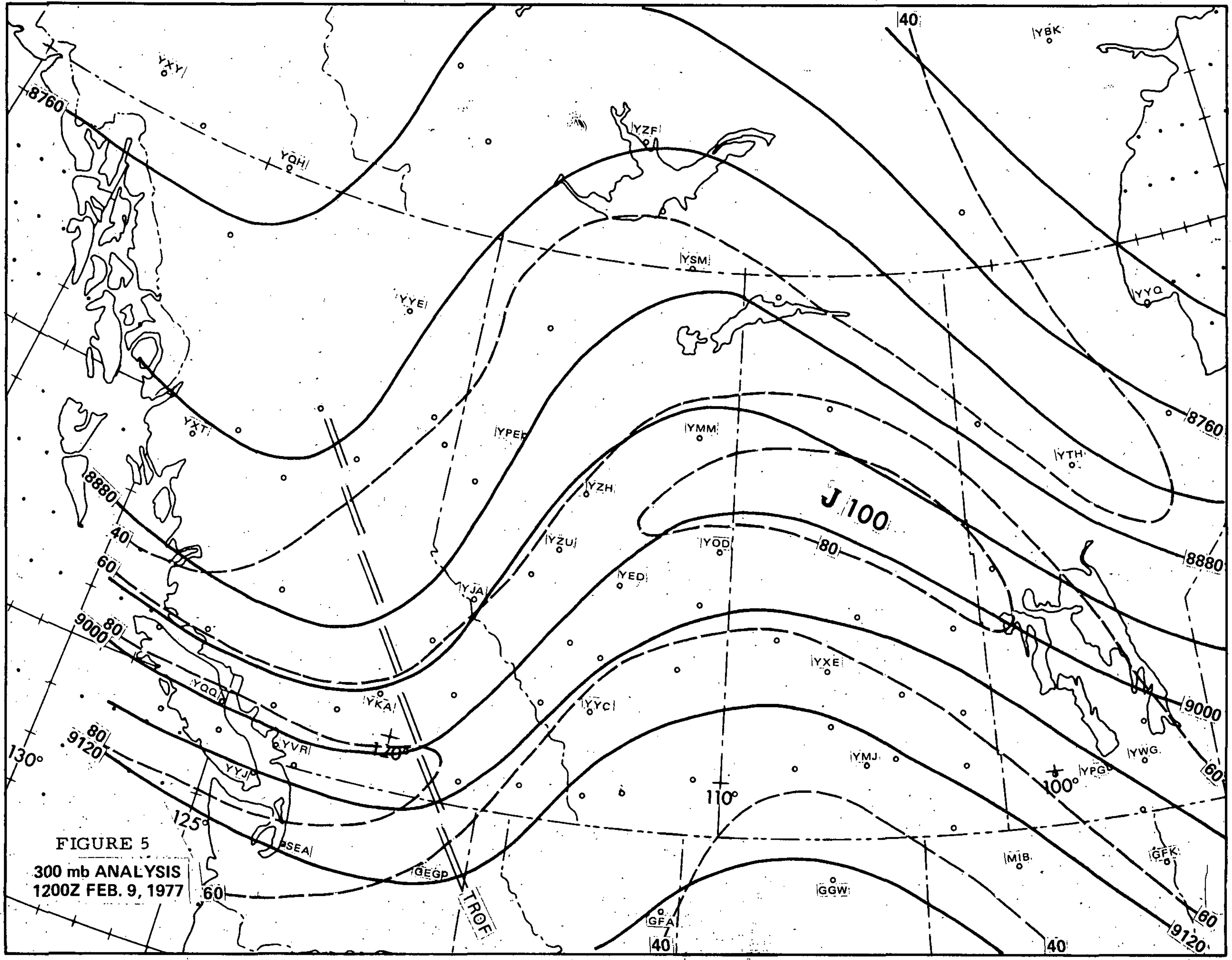

FIGURE 5

300 mb ANALYSIS
1200Z FEB. 9, 1977

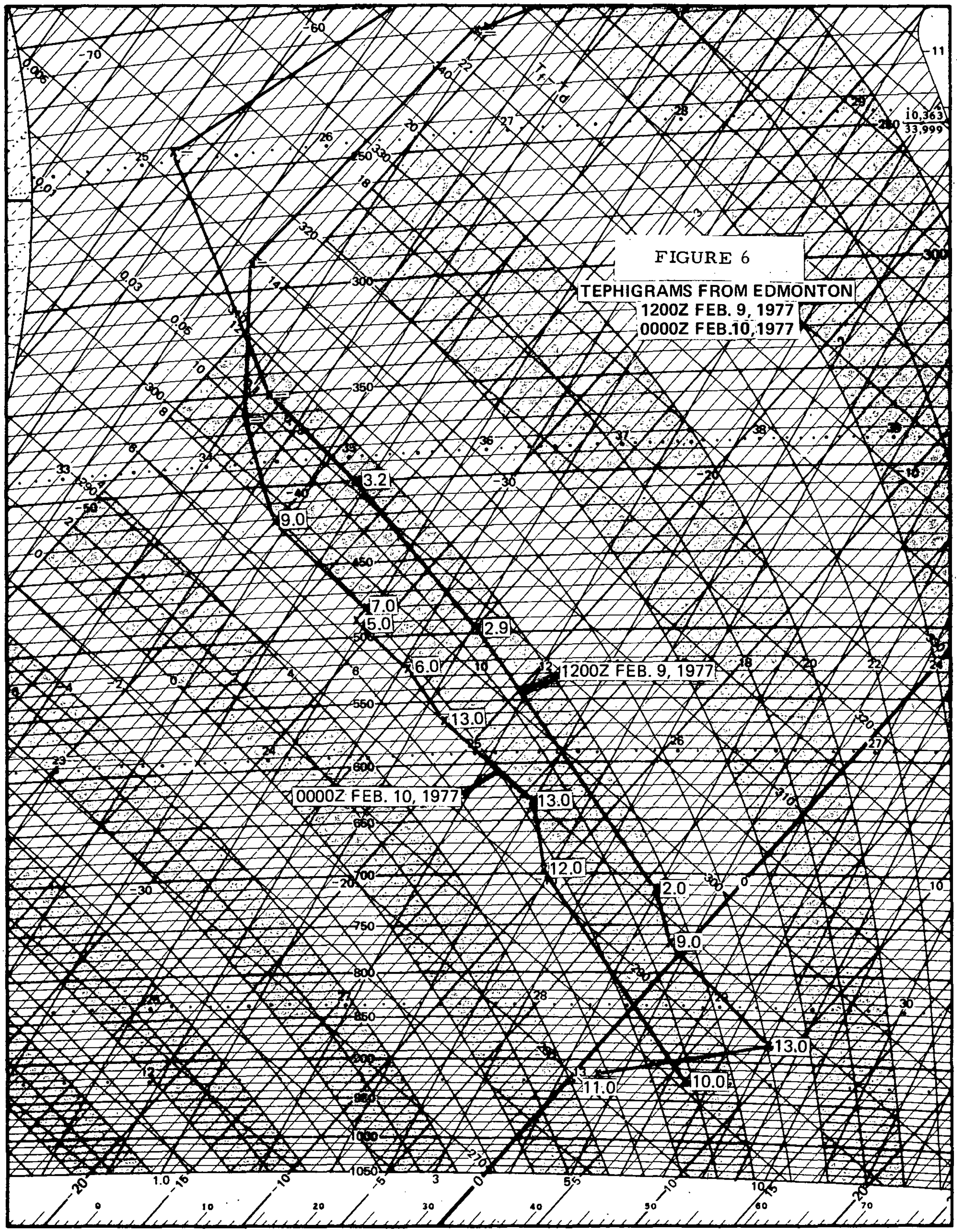
FIGURE 6
TEPHIGRAMS FROM EDMONTON
1200Z FEB. 9, 1977
0000Z FEB.10,1977
1200Z FEB. 9, 1977
0000Z FEB. 10, 1977
3.2
9.0
7.0
5.0
2.9
6.0
13.0
13.0
12.0
2.0
9.0
13.0
10.0
11.0
10,363
33,999

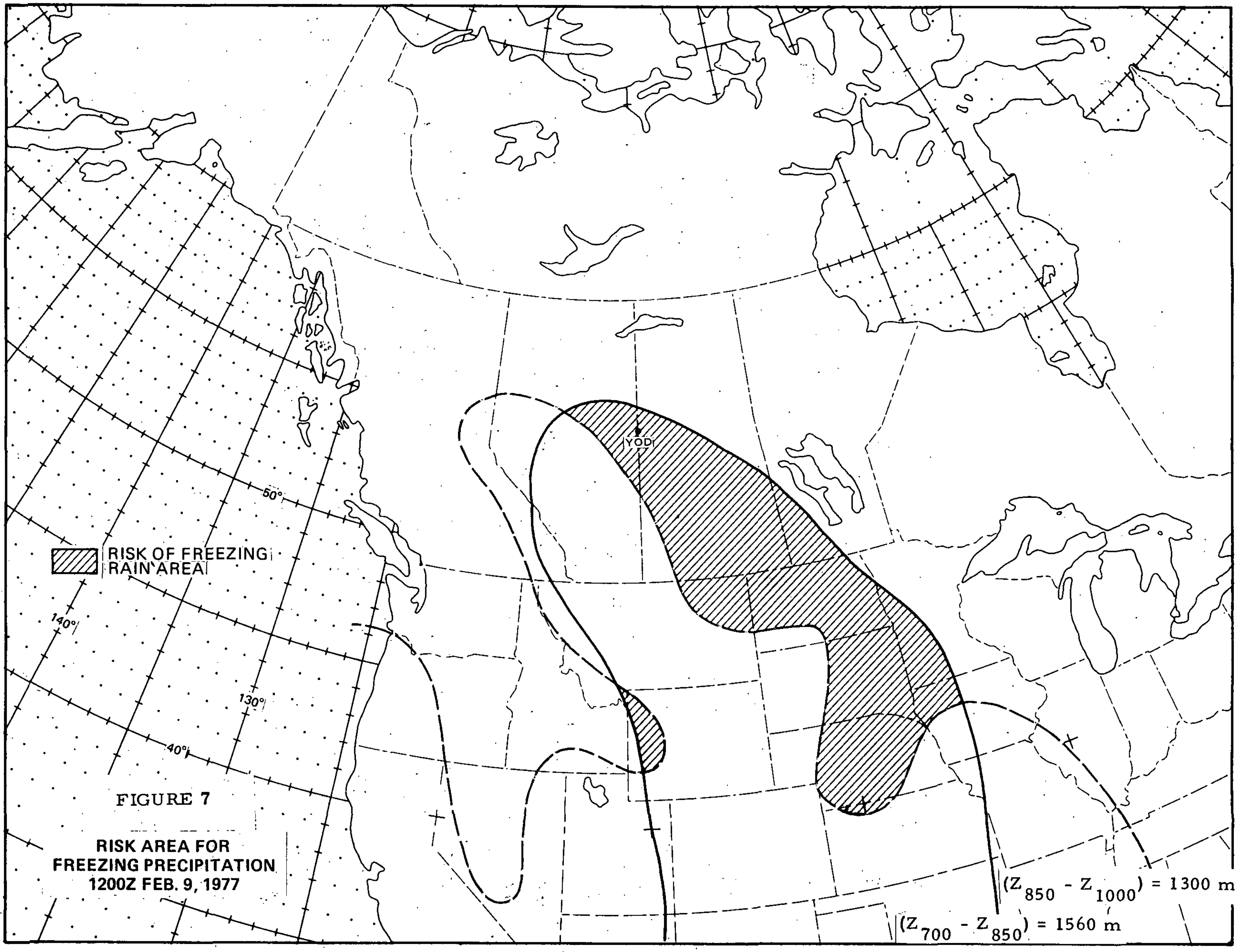

FIGURE 7

RISK AREA FOR FREEZING PRECIPITATION 1200Z FEB. 9, 1977

TEC 865 UDC: 551.578.4
21 February 1979 ISSN: 0068-7804

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Subject Reference: 1. Freezing Rain
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