EAS372 Mid-term Exam 16 Feb., 2017

Professor: J.D. Wilson Time available: 75 mins Value: 15%

Open book exam. Please answer in the booklet provided.

A. Theory & calculation (2 x 3 → 6%)

Answer any **two** questions in this section:

1. Imagine a region over which the temperature was uniform in space and time ($T = 20°\text{C}$) while wind was zonal, and independent of latitude, longitude and elevation: $\vec{u} = (u, 0, 0)$, with $u = \text{const.} = 5\,\text{m}\,\text{s}^{-1}$. Suppose however that over the domain of interest there were a constant longitudinal gradient in the relative humidity ($0 \le \text{RH} \le 1$) such that $\partial\text{RH}/\partial x = 0.0005\ \text{km}^{-1}$. Compute the advective tendency

$$\frac{\partial \rho_v}{\partial t} = -u\frac{\partial \rho_v}{\partial x} \tag{1}$$

in the absolute humidity, given that (under the stated restriction of a uniform temperature)

$$\frac{\partial \rho_v}{\partial x} = \frac{\partial}{\partial x}\frac{e}{R_v T} = \frac{1}{R_v T}\frac{\partial e}{\partial x} = \frac{1}{R_v T}\frac{\partial}{\partial x}\left[\, e_*(T)\ \text{RH}(x)\right] = \frac{e_*(T)}{R_v T}\frac{\partial \text{RH}}{\partial x}\,. \tag{2}$$

Express your answer in $\text{kg}\,\text{m}^{-3}\,\text{hr}^{-1}$.

2. It is common in meteorological models to use the "sigma coordinate" $\sigma = p/p_{\text{sfc}}$, which has the advantage of being "flat" (constant) both at the base ($\sigma = 1$) and at the top ($\sigma = 0$) of the atmosphere: for earth's atmosphere, $\sigma = 1/2$ would be close to the 500 hPa level. Suppose that at a certain time and place the horizontal divergence $D_p \equiv \partial u/\partial x + \partial v/\partial y$ were given by the formula

$$D_p(\sigma) = A\,\sin\left[2\pi\,(\sigma - \frac{1}{2})\right]\,. \tag{3}$$

Roughly sketch the pattern of D_p versus σ, with σ as your vertical axis. Identify any level(s) of non-divergence (LND) and use an arrow to indicate the sign of the vertical motion (up or down) at that (those) levels. Does this idealized scenario correspond to a cyclonic or an anticyclonic weather system?

3. Refer to Figure (1), and assume this is a northern hemisphere case.

   (a) Specify the wind vectors $\vec{U}_{\text{L}}$, $\vec{U}_{\text{U}}$ at the lower and upper levels based on the given thermal wind vector. Please give the speed, direction in degrees, and categorical direction (N, NNE, NE, ENE, E, ESE, SE, SSE, S... etc). Recall the convention that a "NE" wind *comes* from the NE and has compass direction in the neighbourhood of 45°, etc.

   (b) What deduction are you able to make regarding thermal advection at the hodograph's location?

B. "Live" web weather data (4 x 1 → 4%)

1. Retrieve and record the CYEG METAR for 12Z Wednesday 15 February 2017 (note: yesterday!). Decode the cloud type(s) and base height(s). Speculate on any relationship with Figures (6, 7).

2. Retrieve the record of past weather data for Calgary International Airport (hourly, January 15th 2017). What were the reported temperature and dewpoint for 12:00 LST (Local Standard Time)?

3. What was the 1000-500 hPa thickness in the NE corner of Alberta at Fort Smith (YSM sounding) at 12Z on 15 January 2017?

4. Based on today's CMC 850 hPa analysis for 12Z, what was the temperature T_{850} at 60°N on the Saskatchewan-Manitoba border (interpolate or give a temperature range, if necessary)? What value (or range) for T_{850} had been *forecast* for that time and place by the GEM GDPS run that was initialized at 12Z on February 11?

C. Interpretation of Weather Charts (5%)

Using "point form", please give your interpretation of the meteorological cause of the mild weather conditions that were observed (Figure 2) in Edmonton on Wednesday 15 February 2017, based on the information provided by Figures (3 – 7).

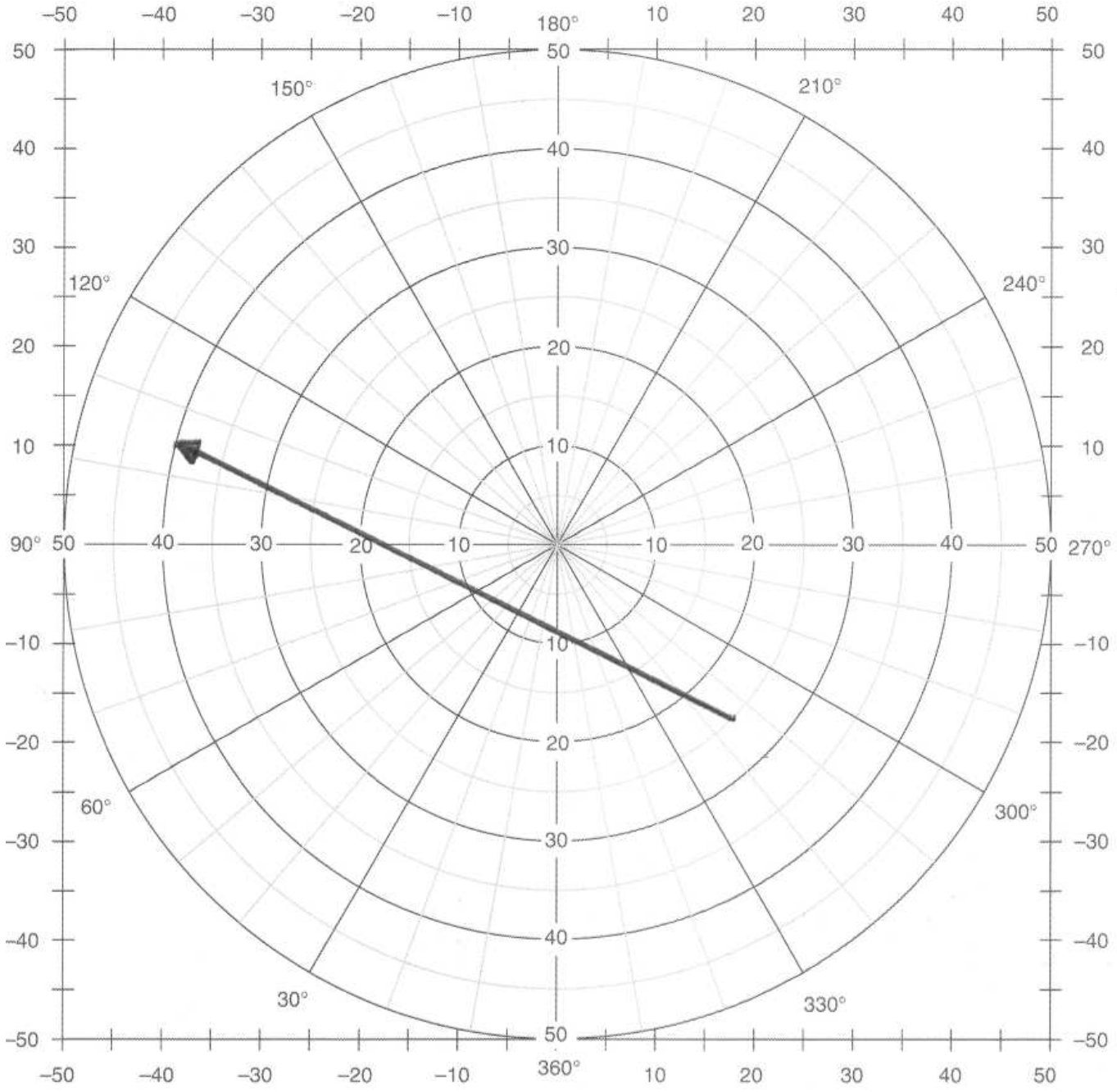

Figure 1: Hodograph. Assume the speed scale is in $\mathrm{m\,s^{-1}}$. The arrow represents a thermal wind vector.

Date / Time (MST)	Conditions	Temperature (°C)	Wind (km/h)	Wind chill	Relative humidity (%)	Dew point (°C)
15 February 2017						
16:00	Mainly Sunny	9 (9.0)	S 11	*	55	1
15:00	Mainly Sunny	11 (11.2) ↑	calm	*	45	0
14:00	Partly Cloudy	11 (10.9)	SSE 3	*	47	0
13:00	Mostly Cloudy	9 (8.9)	ESE 9	*	59	1
12:00	Mostly Cloudy	7 (7.0)	N 5	*	59	-1
11:00	Mostly Cloudy	5 (4.6)	SE 16	*	66	-1
10:00	Mostly Cloudy	6 (5.5)	SSE 3	*	57	-2
09:00	Mostly Cloudy	5 (5.2)	SSE 15	*	59	-2
08:00	Mostly Cloudy	3 (3.4)	S 13	*	68	-2
07:00	Mostly Cloudy	3 (3.1)	S 12	*	67	-2
06:00	Mostly Cloudy	4 (4.3)	SSE 20	*	59	-3
05:00	Mostly Cloudy	3 (3.4)	S 17	*	67	-2
04:00	Mostly Cloudy	2 (2.4)	S 17	*	65	-4
03:00	Mostly Cloudy	2 (1.9)	SE 12	*	68	-3
02:00	Cloudy	1 (1.4)	S 12	*	67	-4
01:00	Mostly Cloudy	0 (0.3)	SSE 13	*	73	-4
00:00	Mostly Cloudy	-1 (-0.9)	S 8	-4	79	-4

Figure 2: Observed conditions at Edmonton International Airport (CYEG), Wednesday 15th February 2017.

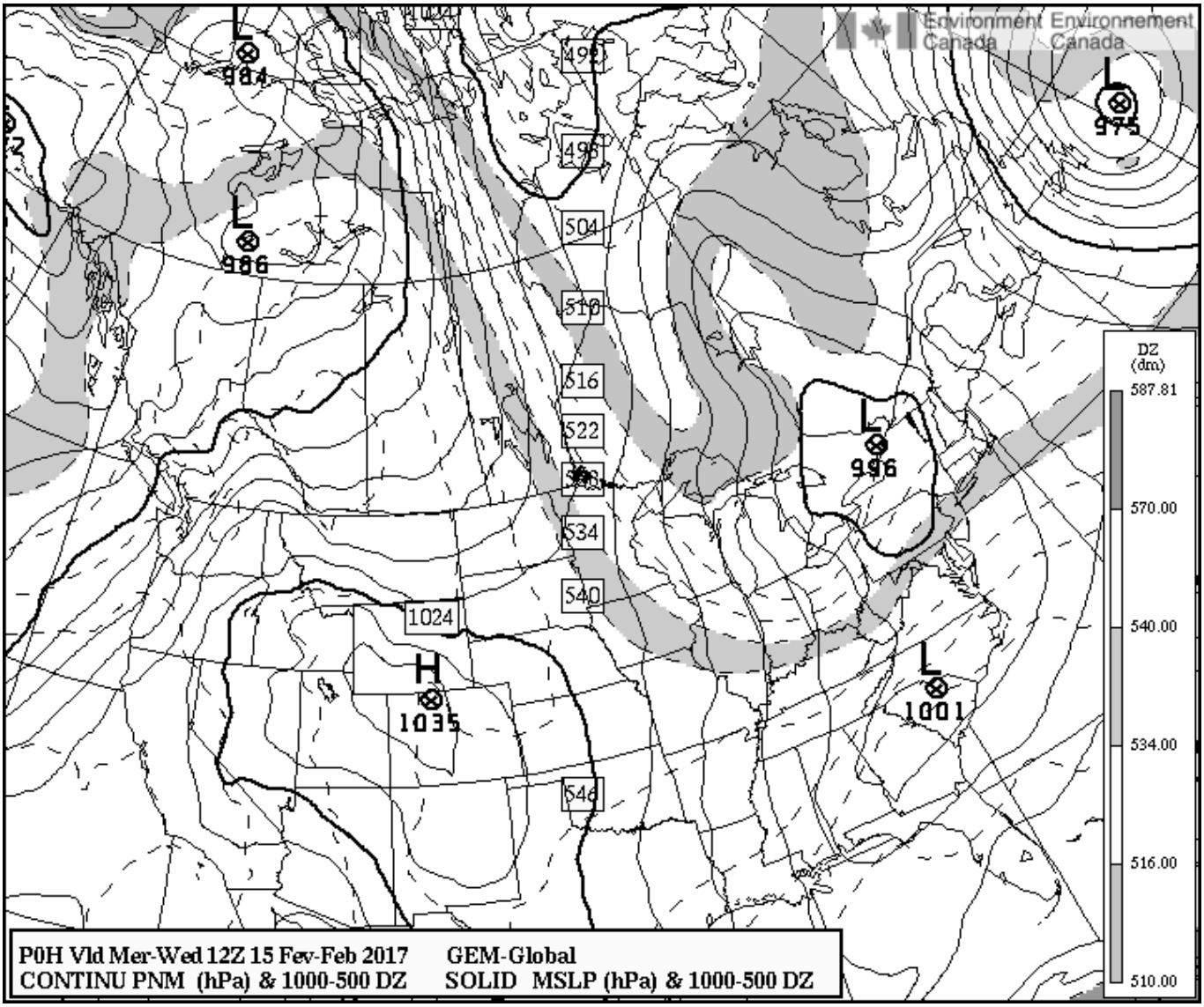

Figure 3: MSLP and thickness, GEM GDPS 0h prog valid 12Z Wednesday 15th February 2017.

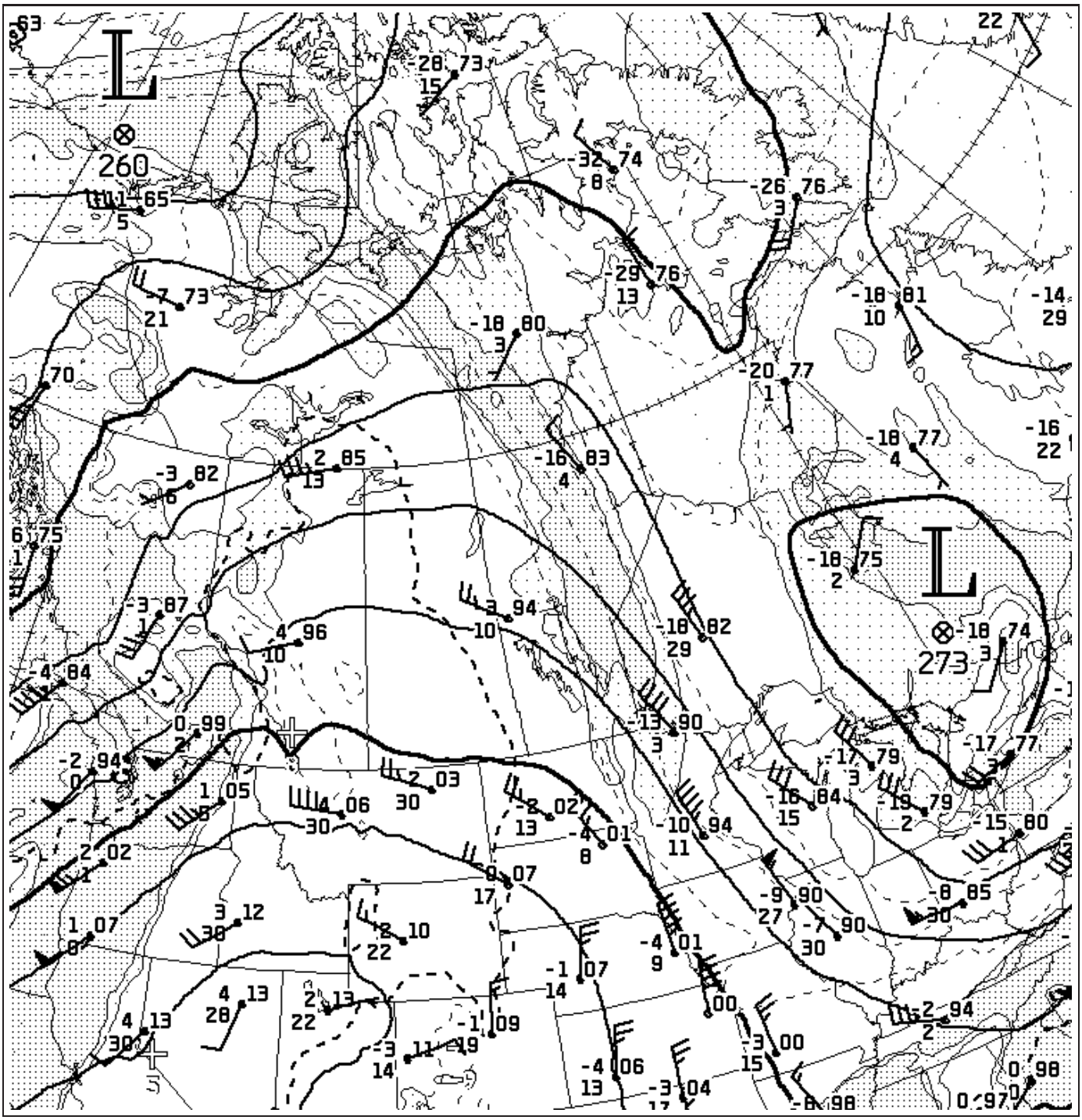

Figure 4: CMC 700 hPa analysis, 12Z Wednesday 15th February 2017.

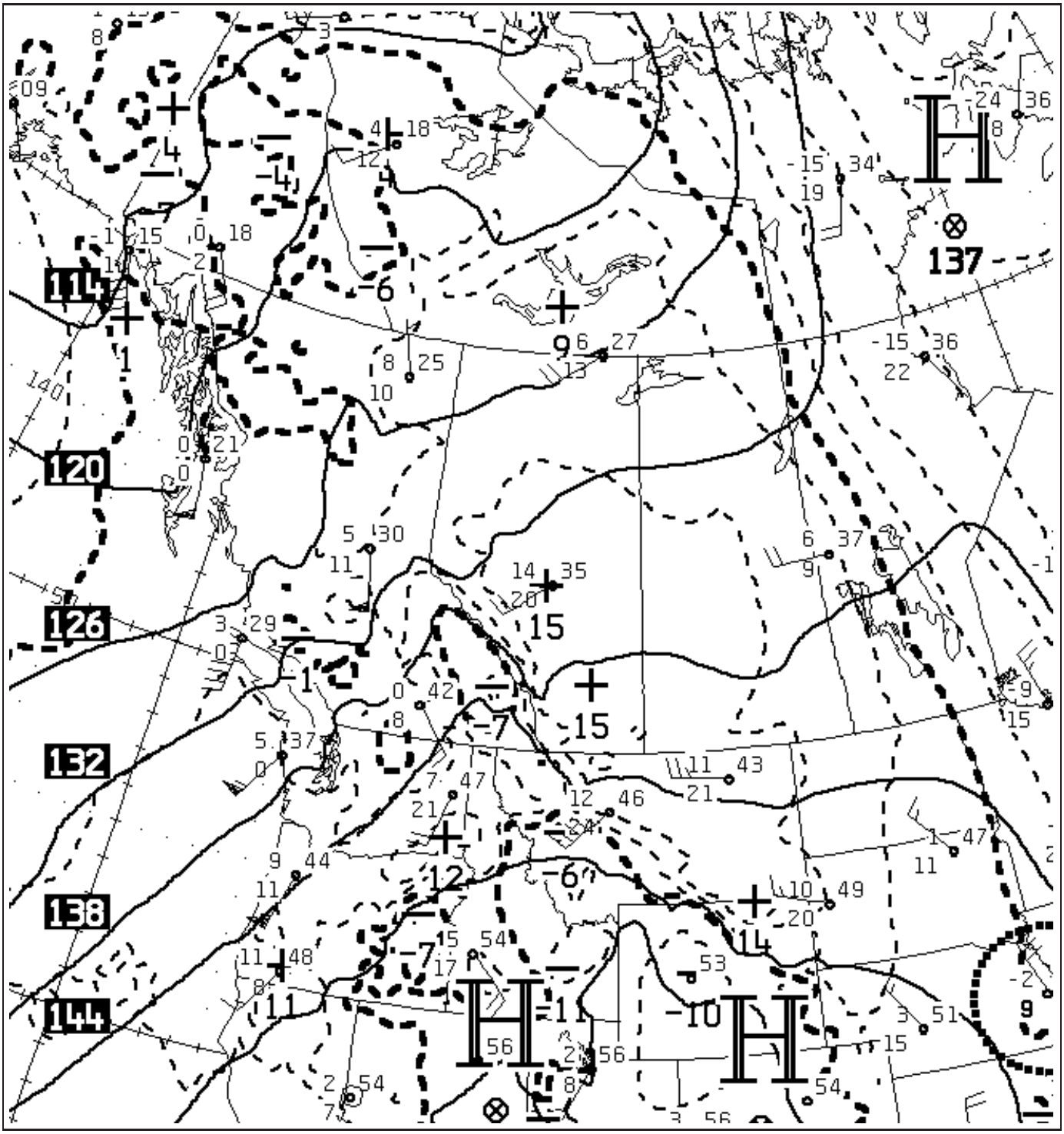

Figure 5: CMC 850 hPa analysis, 12Z Wednesday 15th February 2017.

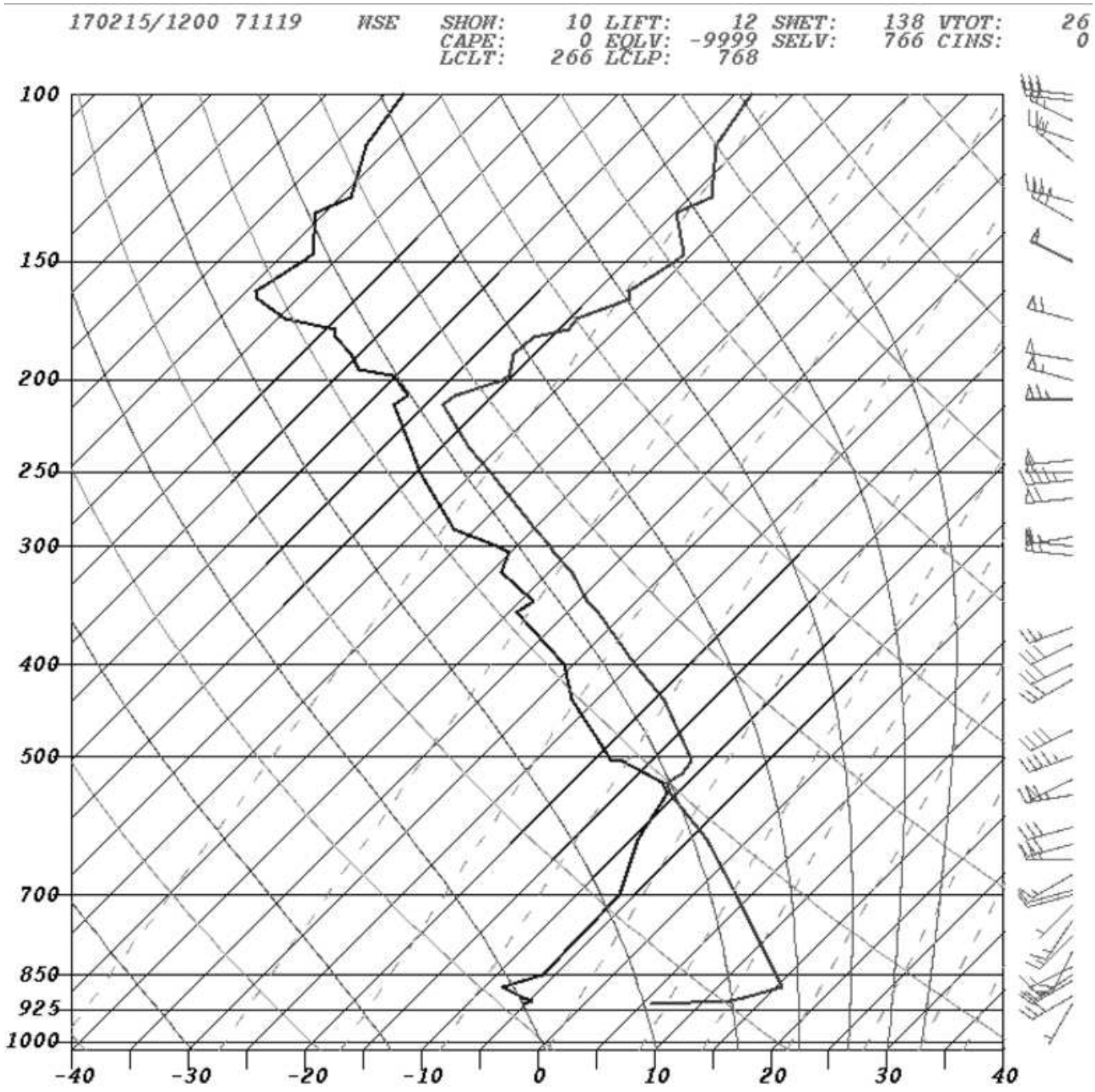

Figure 6: Edmonton (Stony Plain, wse) sounding, 12Z Wednesday 15th February 2017.

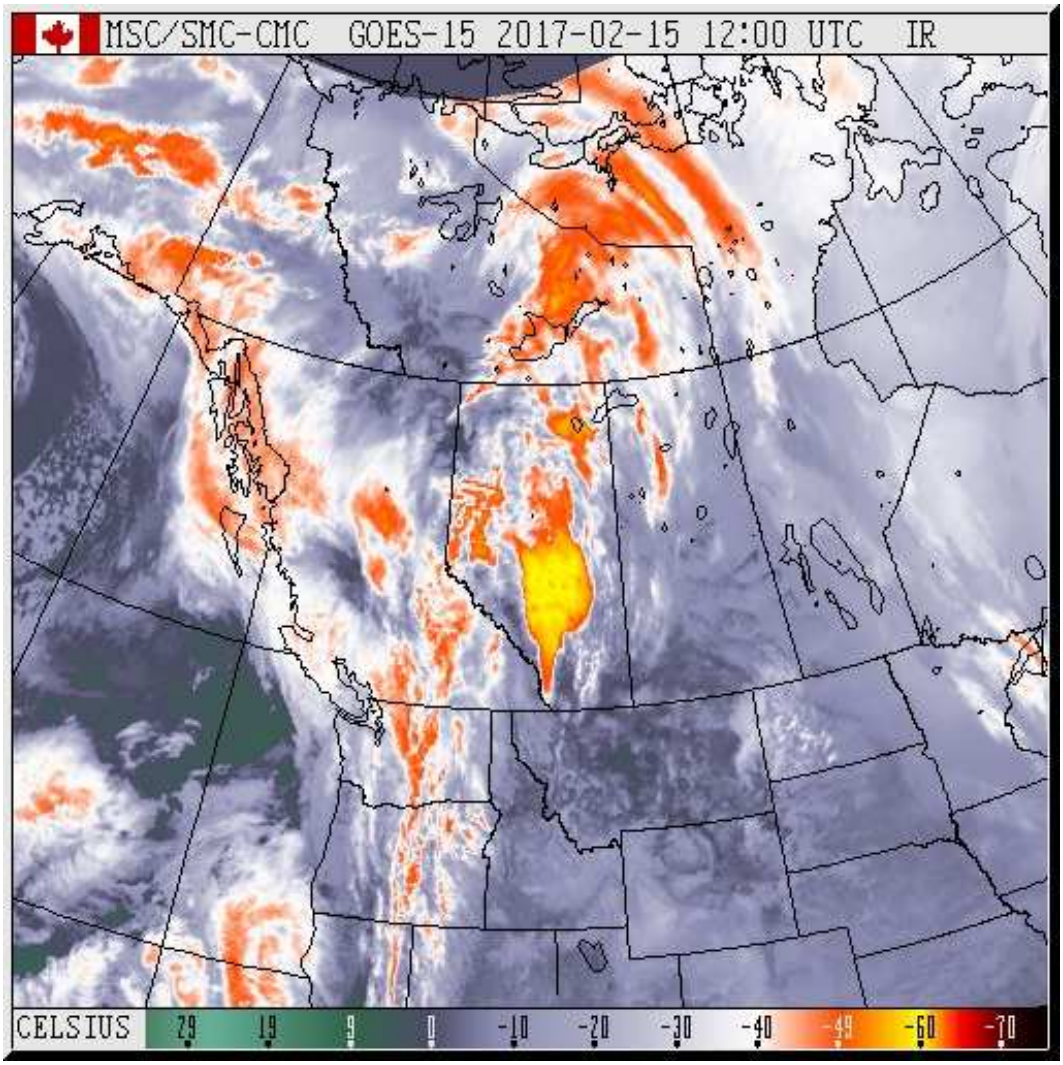

Figure 7: GOES West infra-red image, 12Z Wednesday 15th February 2017.