EAS372 Mid-term Exam 11 Feb., 2016

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

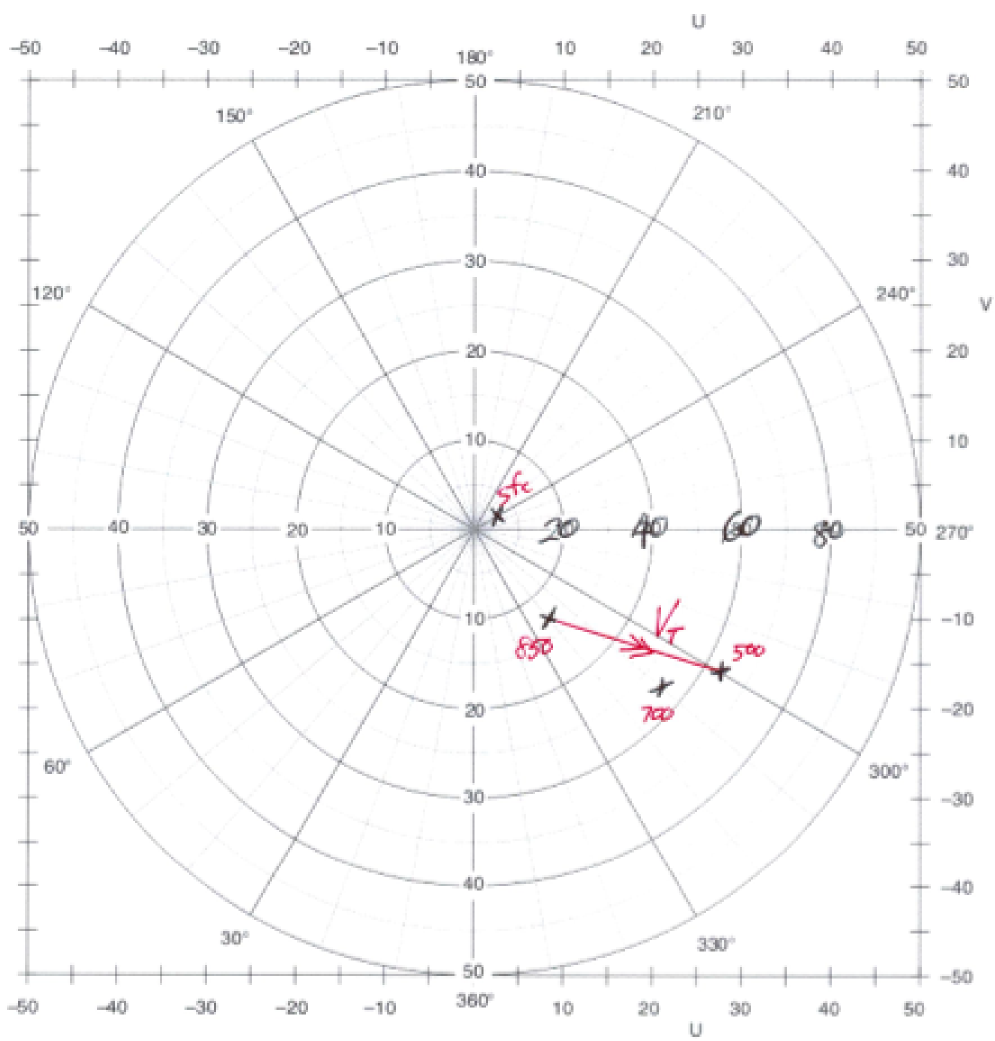
Open book exam. Please answer in the booklet provided.

A. Equations, graphs & calculations (3 x 2 → 6%)

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

1. Plot the wind profile from the sounding of Table 1 on the blank hodograph, and draw on the thermal wind vector for the 850-500 hPa layer.

   Answer:



2. Give the **components** of the thermal wind vector $\vec{V}_T = \vec{V}_2 - \vec{V}_1$, if $\vec{V}_1$ is a south-westerly with speed $|\vec{V}_1| = 7 \text{ m s}^{-1}$ and $\vec{V}_2$ is a north-westerly with speed $|\vec{V}_2| = 17 \text{ m s}^{-1}$. (Hint: Pythagoras rule for right angle triangle with side lengths $\alpha, \alpha, \sqrt{2\alpha^2}$.)

   Answer: Taking the convention that the x-component of a westerly wind is positive and that the y-component of a southerly is positive, then

$$\vec{V}_1 = (\alpha, \alpha)$$

   where $2\alpha^2 = 7^2 = 49$ implies $\alpha = 4.95$. Using the same trigonometry for $\vec{V}_2$ we conclude

$$\begin{aligned} \vec{V}_1 &= (4.95, 4.95) \ , \\ \vec{V}_2 &= (12.02, -12.02) \end{aligned}$$

   (where $2 \times 12.02^2 = 289 = 17^2$). Therefore

$$\vec{V}_T = (7.07, -16.97) \ .$$

   (In terms of magnitude and direction — not what was asked for — the thermal wind speed was $\sqrt{(12.02 - 4.95)^2 + (-12.02 - 4.95)^2 = 18.4}$ m s^{-1}, and the direction was about 337°, i.e. N of NW.)

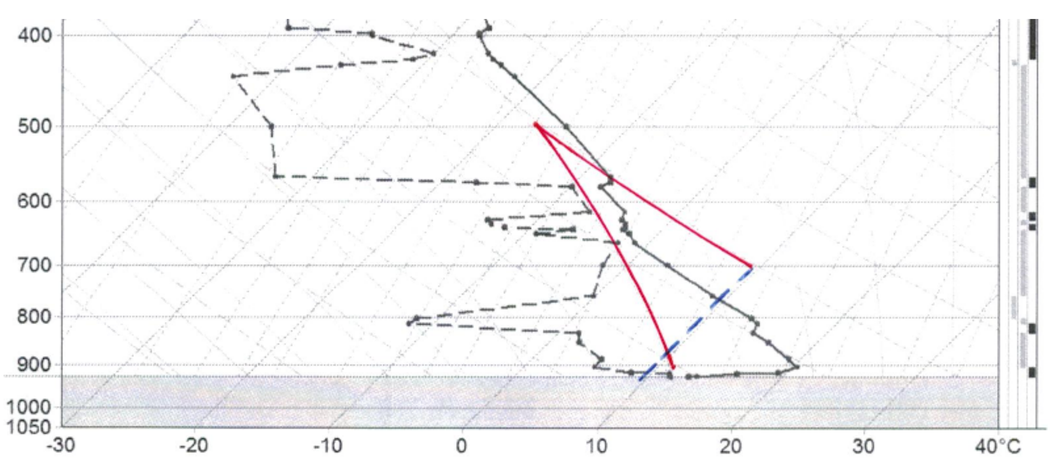
3. Determine the components of $\vec{A} \times \vec{B}$ in the case that $\vec{A} = (1, -1, 0)$ and $\vec{B} = (-1, 1, 0)$

   Answer:

$$\vec{A} \times \vec{B} = \begin{pmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & 0 \\ -1 & 1 & 0 \end{pmatrix} = \hat{i}.0 - \hat{j}.0 + \hat{k}.0 = (0, 0, 0) \ .$$

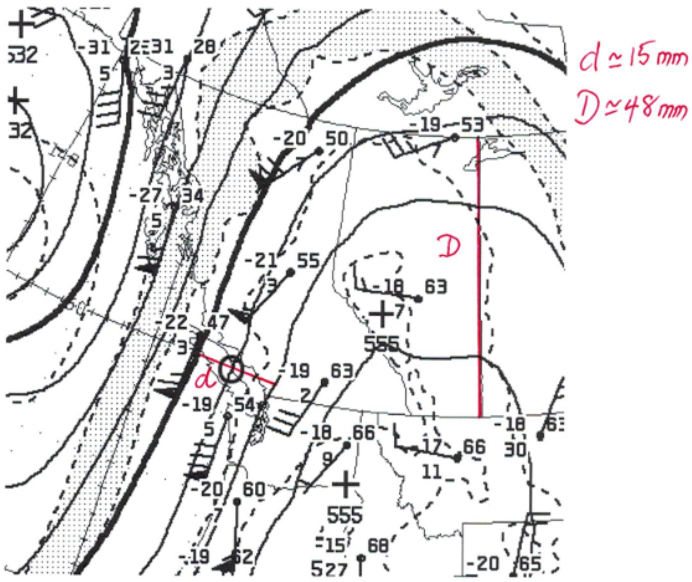
4. Referring to Fig. (1), if a surface parcel were lifted moist adiabatically to the 500 hPa level, then returned dry adiabatically to 700 hPa, what would its final temperature be?

   Answer: about 10°C (see process paths in red on sounding).



5. Referring to Fig. (2), determine the geostrophic wind speed at the point marked by a circle over Vancouver Island (take the latitude as 50°, implying $f = 1.11 \times 10^{-4}\,\mathrm{s}^{-1}$).

   The true distance d is $d = (15/48) \times 11 \times 111^3 = 3.82 \times 10^5$ m. The corresponding difference in the 500 hPa height is 120 m (i.e. twice the 6 dam contour interval). Therefore $V_g = 28\,\mathrm{m\,s^{-1}}$.



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

1. Retrieve and record today's 15Z METAR for CYEG (in standard format). Decode the low cloud type(s) and base height(s).

   Answer:

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   METAR CYEG 111500Z 14002KT 3SM -SN SCT016 OVC025 M05/M07 A3014 RMK
   SC3SC5 SLP247=
   ```

   3/8 cover of scattered stratocumulus at 1600 feet AGL, overcast at 2500 feet AGL with further 5/8 stratocumulus.

2. Give three values for today's 12Z thickness (1000-500 hPa) in the NE corner of Alberta: (i) Fort Smith (YSM) sounding, (ii) RDPS 0h prog and (iii) NAM 0h prog.

   Answer: From the YSM sounding, $Z_{500} = 5370$ m while $Z_{1000} = 259$ m, so, $\Delta Z = 511$ dam; from the RDPS 0h prog (appended at back of exam), $504 \le \Delta Z \le 510$ dam; and from the NAM 0h prog, 510 dam.

3. Compute the vapour pressure and absolute humidity corresponding to the 850 hPa level on today's 12Z Fort Smith (YSM) sounding. (For a sub-zero dewpoint temperature T_d, use the equilibrium vapour pressure over ice.)

   Answer: the YSM sounding specified $T_{850} = -16.1°C$ and $T_{d,850} = -35.1°C$. Thus vapour pressure $e = e_*(T_d) = 0.2209$ hPa or 22 Pa, and the absolute humidity $\rho_v = e/(R_v T) = 22/(462 * (273.15 - 16.1)) = 1.9 \times 10^{-4}\ \mathrm{kg\,m^{-3}}$.

4. Based on the GDPS prog. initialized at 00Z today (Thursday 11 Feb.), give a range for the cumulative precipitation over Edmonton for the 24 hours ending 00Z Friday 12 February.

   Answer: The prog is appended at the back. The green band over the Edmonton region spans 2.5 to 5 mm (liquid water equivalent) over 24 h.

C. Interpretation of Weather Charts (→ 5%)

Referring to Fig. (3), describe and contrast the meteorological regimes over Alberta on the two occasions.

How does one *organiz* one's answer to a question of this type? The wording invites *contrast*, and there is a natural or inherent left/right (day1/day2) organization that is suggested by the question itself. Thus a two-column tabular, point format organization would be suitable.

Essentials of the "big picture":

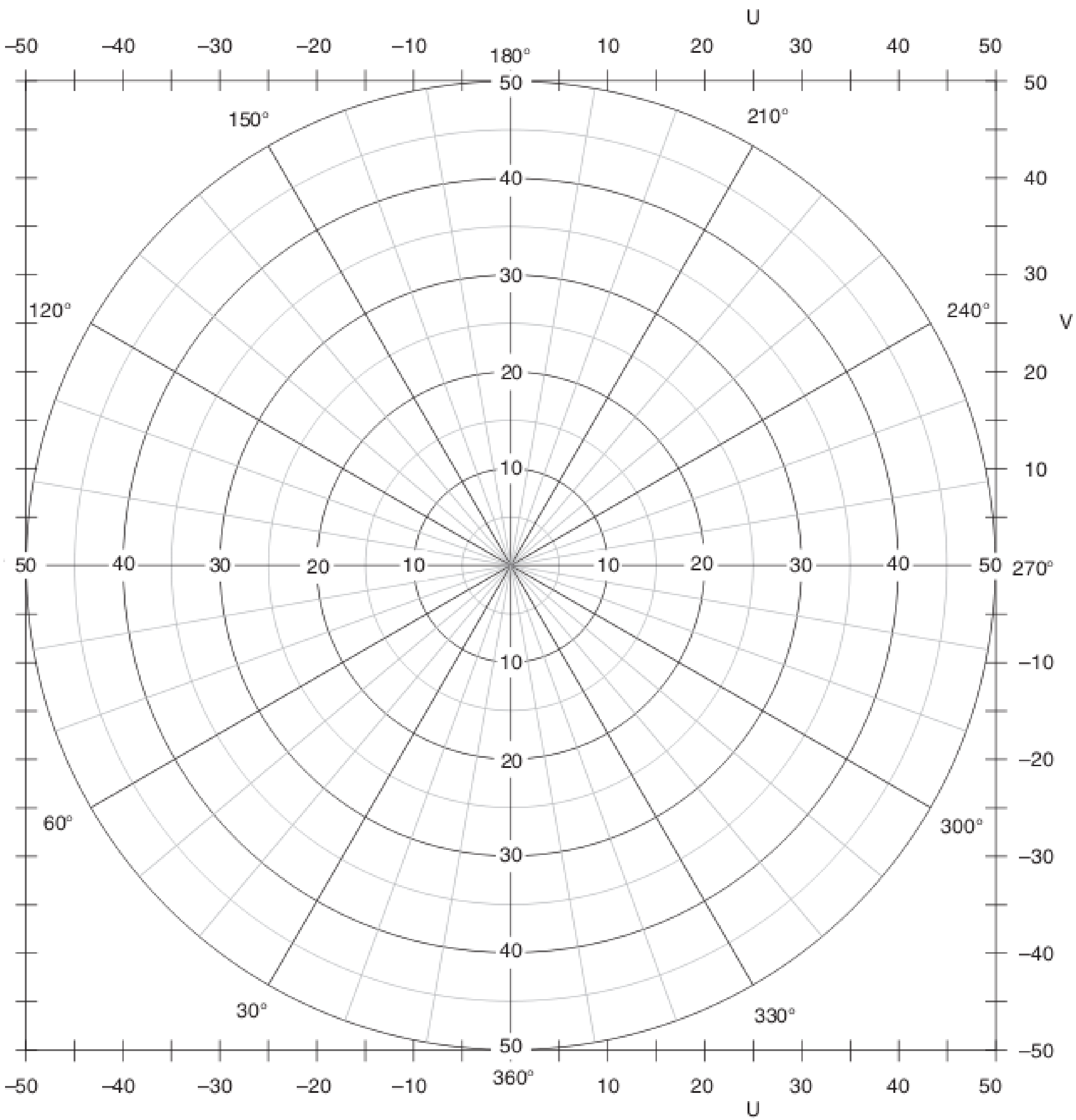
1. recognize 16 Jan as cold scenario, versus 9 Feb as mild (surface temps)
2. surface arctic ridge 16 Jan (easterly outflow persisting across BC to the coast), versus surface lee trough 9 Feb
3. weak northerly upper flow 16 Jan (prairies isolated from Pacific conditions), versus firm westerly upper flow 9 Feb generating lee trough
4. 850 hPa freezing contour far south of Alberta on 16 Jan, versus displaced northward almost to the 60th parallel on 9 Feb, with a lee trowal in the lee of the Rockies

Other points:

1. cross-isobar easterly (upslope) surface winds out of the arctic ridge, 16 Jan
2. configuration of 700 hPa height on 16 Jan (high in NWT, low over Manitoba) channelling air towards Alberta from high latitude
3. strong ridge over western US and B.C. visible all levels on 9 Feb
4. particularly strong 850 hPa temperature gradient (oriented SW-NE) on 9 Feb, sometimes labelled a baroclinic zone though technically not so here as the upper wind is more or less parallel with the isotherms
5. distinct *warm* advection over Sask. & Manitoba 16 Jan
6. possible Chinook conditions in SW Alberta on 9 Feb

Table 1: Stony Plain sounding, 12Z Monday 8 Feb. 2016.

P [hPa]	z [m ASL]	T [°C]	T_d [°C]	DIR	SPD [knots]	θ
935.0	766	-1.5	-10.5	230	5	276.9
850.0	1539	0.2	-0.8	320	26	286.3
700.0	3079	-7.3	-7.6	310	56	294.4
500.0	5650	-20.3	-21.7	300	63	308.2



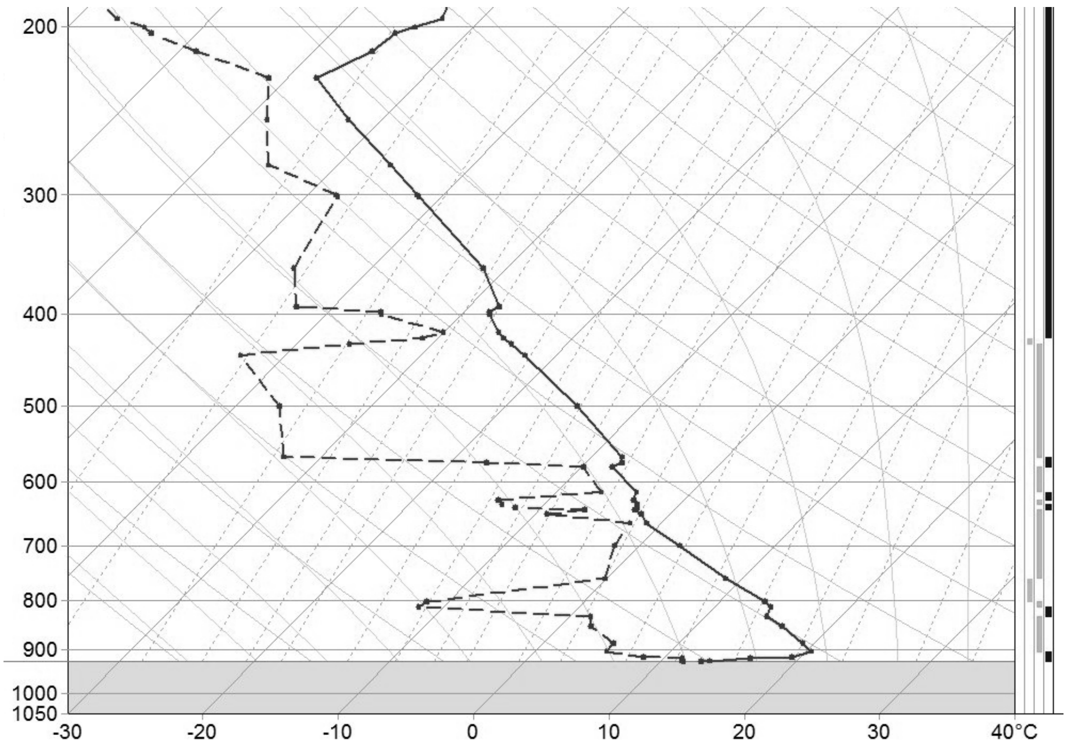


Figure 1: Stony Plain sounding, 12Z August 27, 2011.

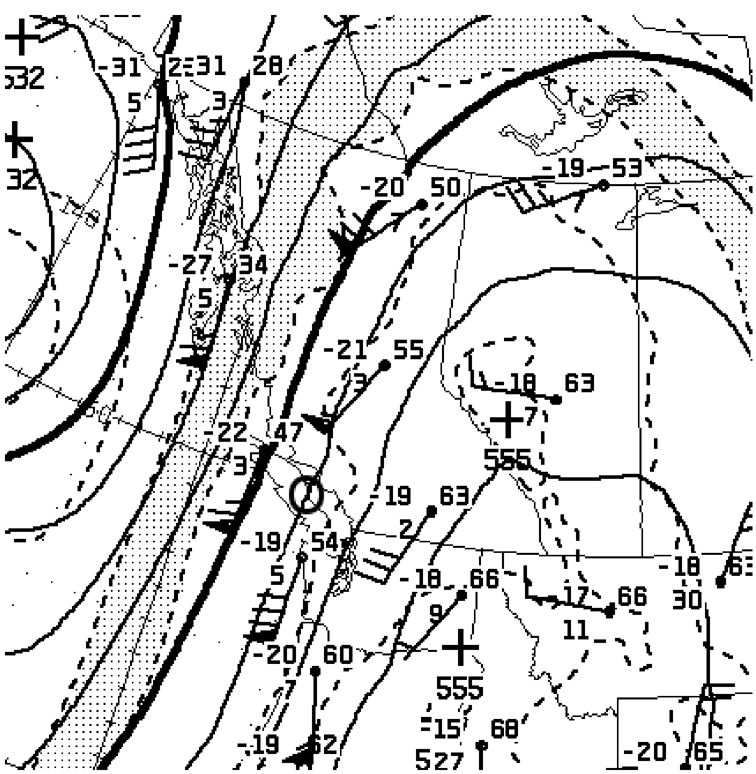


Figure 2: CMC 500 hPa analysis (cropped), 2 March 2010 at 00 GMT.

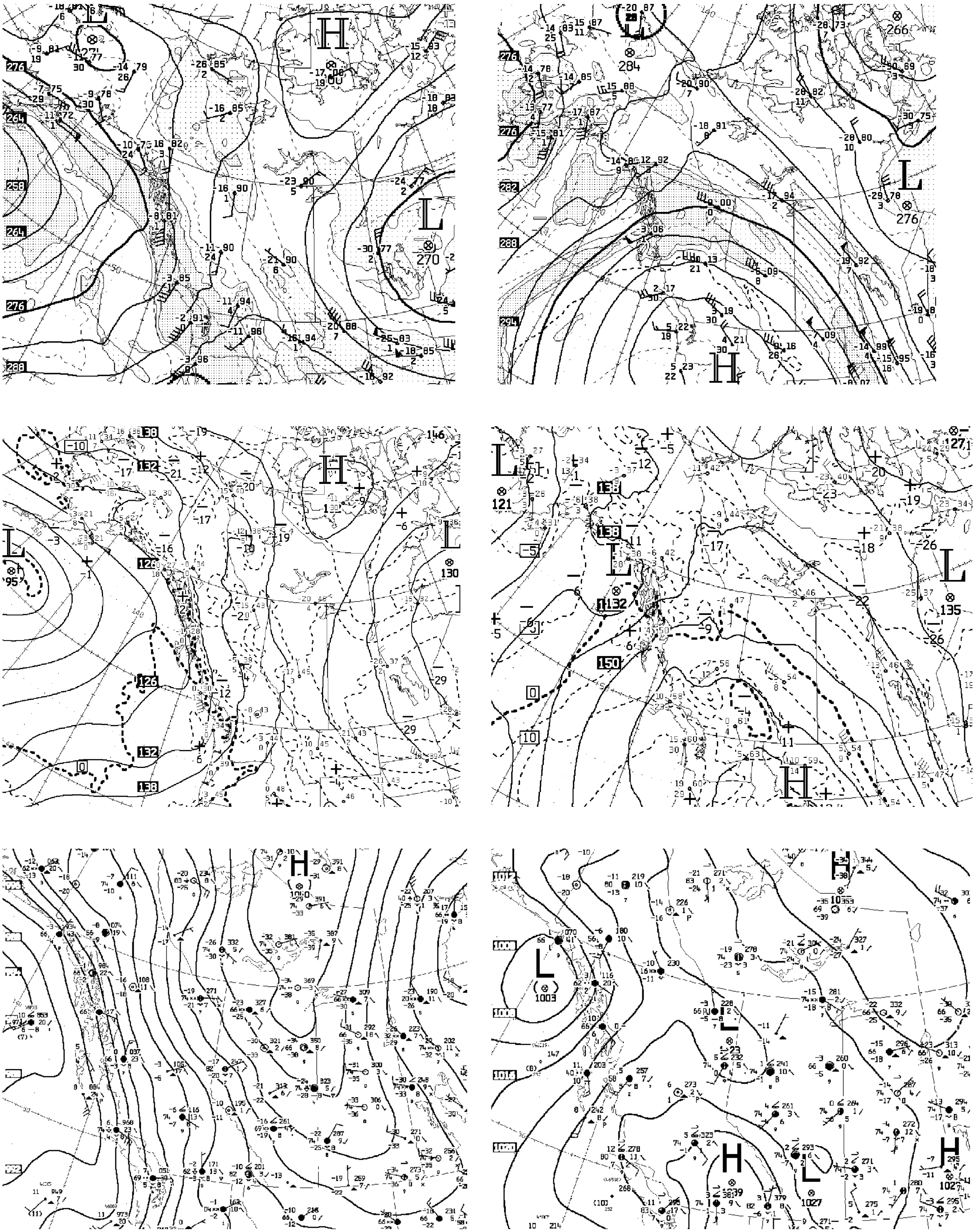
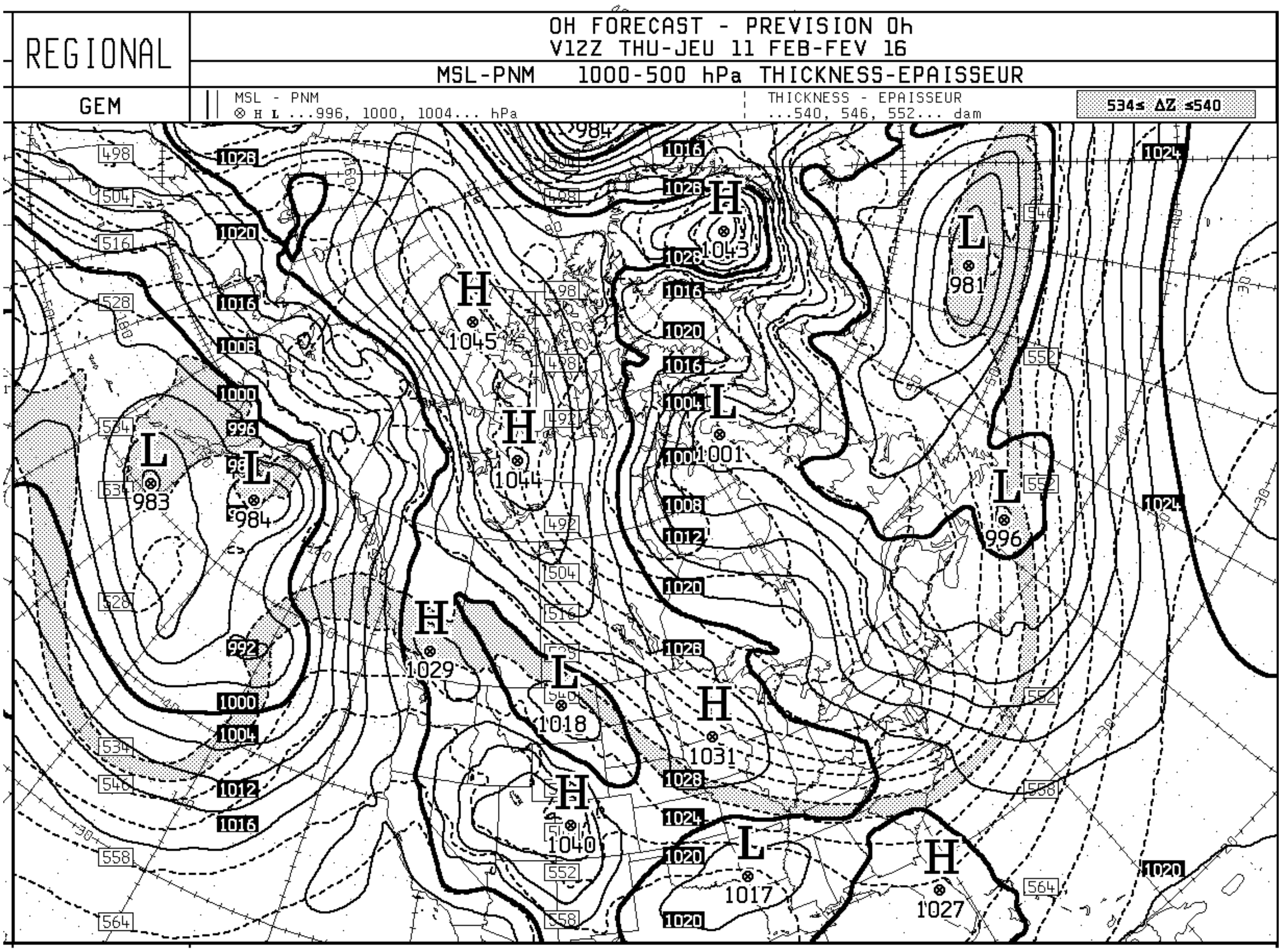
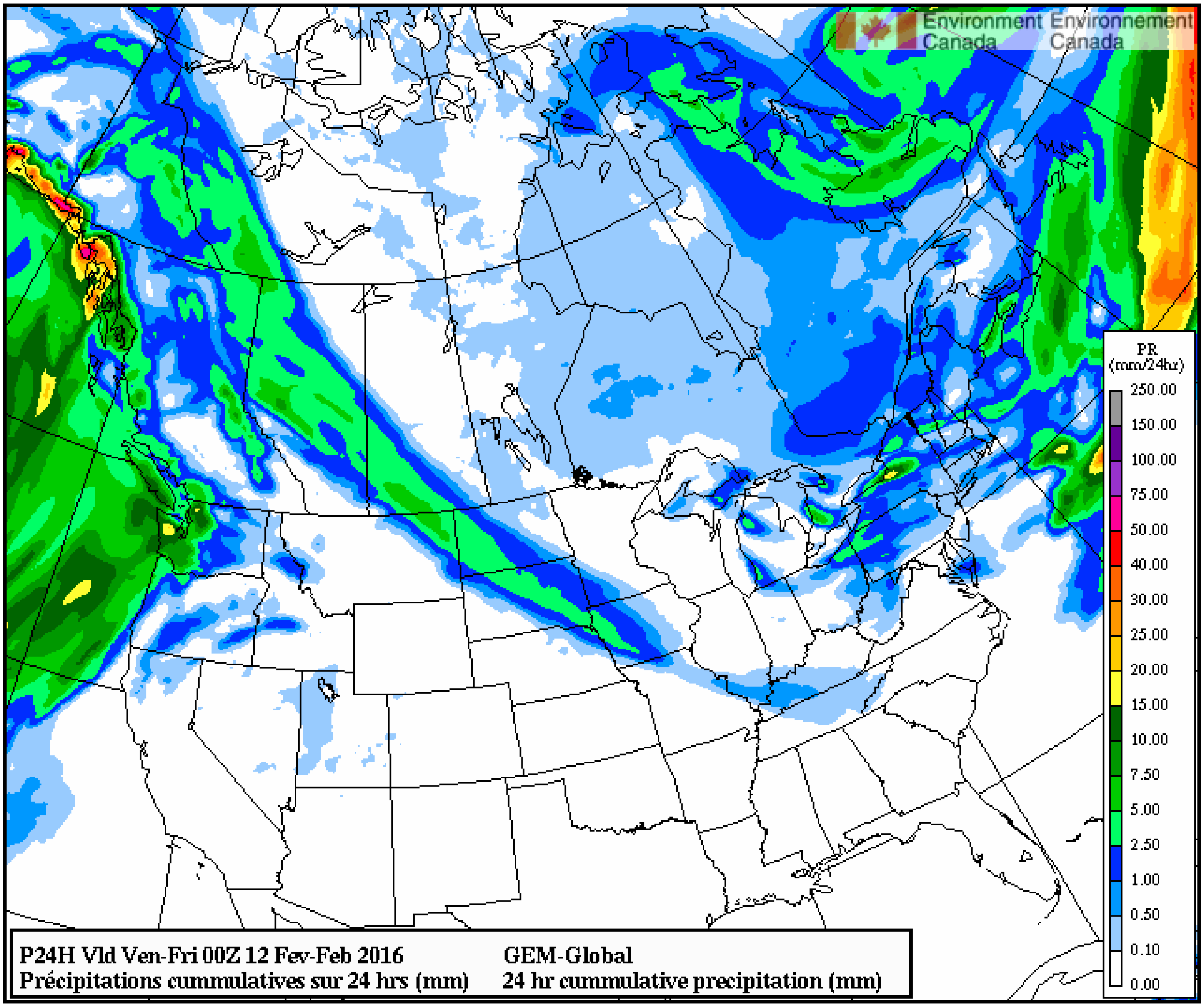


Figure 3: CMC analyses at 12Z on 16 Jan (left) & 00Z on 9 Feb (right), 2016.


REGIONAL
0H FORECAST - PREVISION 0h
V12Z THU-JEU 11 FEB-FEV 16
MSL-PNM 1000-500 hPa THICKNESS-EPAISSEUR
GEM
MSL - PNM
⊗ H L ...996, 1000, 1004... hPa
THICKNESS - EPAISSEUR
...540, 546, 552... dam
534≤ ΔZ ≤540


Environment Canada
Environnement Canada
PR
(mm/24hr)
250.00
150.00
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75.00
50.00
40.00
30.00
25.00
20.00
15.00
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7.50
5.00
2.50
1.00
0.50
0.10
0.00
P24H Vld Ven-Fri 00Z 12 Fev-Feb 2016
Précipitations cummulatives sur 24 hrs (mm)
GEM-Global
24 hr cummulative precipitation (mm)