EAS372 **Open book Mid-term Exam** 8 Feb., 2011

Professor: J.D. Wilson   Time available: 80 mins   Value: 15%

Please answer in the booklet provided. Equations and data given at back.

A. "Live" web weather data (8 x 1/2 $\rightarrow$ 4%)

To answer the following questions, please use whatever web resources best suit (e.g. CMC analyses, text data for Stony Plain sounding, etc).

1. Red Deer Regional Airport reported [minus 30 Celcius] for the 0600 MST temperature this morning
2. 1000-500 hPa thickness at Edmonton at 12Z this morning was [5143 m]
3. Use Vizaweb to access the 0h panel of the GEM Regional Run initialized at 12Z today; choose N_America as Domain. The strongest updraft at the 850 hPa level has a magnitude in the range [-4 to -8] Pa s^{-1}
4. According to the GEM Regional Model run initialized at 12Z today, the 1000-500 hPa thickness over Edmonton at 12Z Thurs 10 Feb. will be [about 526 - 528 dam, depending on which specific prog you used]
5. According to this morning's Edmonton sounding, true surface pressure was [943 hPa]
6. According to this morning's Edmonton sounding, height (AGL) of the 500 hPa surface over Edmonton was [5450-766=4684 m]
7. According to this morning's sounding from Fort Smith (YSM), temperature-dewpoint spread at 700 hPa was [34^{o}C]
8. What WATCHES, WARNINGS, OR STATEMENTS are listed by the most recent SIGNIFICANT WEATHER DISCUSSION ISSUED BY THE PRAIRIE AND ARCTIC STORM PREDICTION CENTRE OF ENVIRONMENT CANADA? [BLIZZARD WARNINGS FOR CAMBRIDGE BAY, GJOA HAVEN. BLIZZARD WARNING FOR MOST OF THE KIVALLIQ DISTRICT AND CLYDE RIVER. WIND CHILL WARNINGS FOR RESOLUTE AND TALOYOAK. WIND CHILL WARNING FOR REGINA AND ESTEVAN.]

B. Interpretation of weather charts. (6 x 1/2 → 3%)

In Edmonton on January 15 the minimum and maximum temperatures were $(-26.1, -22.0)^{o}$C, while on Jan 20 they were $(-14.9, +2.6)^{o}$C. The weather situation on these two days is depicted by Figures (1, 2). Edmonton experienced snowfall on both days: 4.4 cm on the 15th, and 0.9 cm on the 20th.

1. Temperatures at the 850 hPa level over east-central Alberta were more uniform on ____ while low-level winds over SW Alberta would have been stronger on ____
   - (a) 15 Jan; 15 Jan
   - (b) 20 Jan; 20 Jan
   - (c) 15 Jan; 20 Jan ✓✓
   - (d) 20 Jan; 15 Jan

2. The system far north of Manitoba (and visible on both days) is often termed the/an ____ . The Alberta lee trough features on ____
   - (a) Arctic vortex; 15 Jan
   - (b) Alberta clipper; 15 Jan
   - (c) Arctic vortex; 20 Jan ✓✓
   - (d) Alberta clipper; 20 Jan

3. Lloydminister (east of Edmonton, on the Saskatchewan border) should have seen ____ on ____
   - (a) steady warming; 20 Jan ✓✓
   - (b) steady cooling; 20 Jan
   - (c) strong low level winds; 15 Jan
   - (d) mild surface temperatures; 15 Jan

4. On neither day was wind data submitted from the sounding at Fort Smith[1] (YSM, 71934; just north of the N. border of Alberta). In the framework of the Geostrophic model, a reasonable categorical guess for the Fort Smith 700 hPa winds on 15th and 20th Jan. (respectively) would be
   - (a) calm; moderate WNW
   - (b) calm; moderate ESE
   - (c) weak to moderate from sector $135 - 225^{o}$; moderate WNW ✓✓
   - (d) weak to moderate from sector $315 - 360^{o}$; moderate WNW

[1] or at The Pass (YQD, 71867; near the Saskatchewan-Manitoba border).

5. Comparing Edmonton's 850 and 700 hPa winds on 20 Jan., we note "veering," which is associated warm advection. The atmosphere over Central Alberta at this time was ____ and the thermal wind $\vec{U}_{700|850}$ was probably

   (a) baroclinic; oriented roughly parallel to the 850 hPa height contours

   (b) baroclinic; oriented roughly parallel to the 850 hPa isotherms ✓✓

   (c) barotropic; oriented roughly perpendicular to the 850 hPa isotherms

   (d) barotropic; oriented roughly parallel to the 850 hPa isotherms

6. On both occasions there was strong, moist WNW 700 hPa flow over central Alberta, and overall the 700 hPa flow patterns on these two days appear qualitatively similar; *surface* conditions, however, were very different. Which of the following statements makes most sense?

   (a) the flow at the 700 hPa level *exerts no influence*, direct or indirect, on surface temperature

   (b) sometimes — indeed, frequently — present conditions cannot be explained in terms of (or attributed to) the *present* configuration of the circulation pattern, for present conditions depend (also) on the *recent history* of the circulation, at all levels ✓✓

   (c) the observed very different surface conditions have to be explainable in terms of *more subtle* elements of the upper flow, such as diffluence (Jan 15) or a weak shortwave (Jan 20) over north-central Alberta

   (d) the greater snowfall amount on 15 Jan is a direct consequence of the much lower surface temperature, which resulted in a reduced upward longwave radiative energy flux density, cooling the clouds

C. Calculations & use of thermodynamic chart (4 x 2 → 8 %)

Morning temperatures at Edmonton City Centre Airport hit -30^{o}C on Monday 31 Jan 2011. Figure (3) is the sounding and Fig. (4) the 850 hPa analysis for 12Z on Tues 1 Feb.

1. Referring to Figure (3), if a parcel "P" of air from 700 hPa were lowered adiabatically to 925 hPa, what would be the resulting values of its temperature and dewpoint? If the parcel were instead *lifted* adiabatically, its temperature-dewpoint spread would converge to zero at what pressure level and at what temperature? *Answers: by tracing a dry adiabat down to 925 hPa one finds $T \approx +11^{o}$, and by tracing a mixing-ratio line (same as dewpoint lapse rate line) down one has $T_d \approx -28^{o}$. Conversely, moving upward from 700 hPa the dry adiabat and the mixing-rtio line intersect at about 500 hPa with $T = T_d \approx -36^{o}$.*

2. What would the parcel P's density, vapour pressure, absolute humidity and specific humidity be, when lowered to 925 hPa? *Answers*: $\rho \approx 1.13\ \mathrm{kg\,m^{-3}}$; and with $e = e_*(-28) \approx 47$ Pa we get $\rho_v \approx 3.6 \times 10^{-4}\ \mathrm{kg\,m^{-3}}$; thus $q \approx 3.2 \times 10^{-4}\ \mathrm{kg\,kg^{-1}}$

3. Referring to Fig. (4), compute an approximate value for the Geostrophic 850 hPa windspeed at the point marked "X" in NW Saskatchewan. *Answer*: Latitude is about 58^{o}. The distance between neightbouring height contours is $\Delta n \approx (10.5\,\mathrm{mm})/46\,\mathrm{mm}) \times 11 \times 111,000$ m (about 280 km). $V \approx 17\ \mathrm{m\,s^{-1}}$.

4. Again referring to Fig. (4) and using the wind speed computed above, calculate an approximate value for the rate of temperature advection A_T at the point marked "X." Please give your answer in $^{\circ}\mathrm{C\,hr^{-1}}$, and state whether your result corresponds to warming or cooling. *Answer*: Roughly $+1^{\circ}$C/hr, warming.

Equations and Data.

- one full barb on the wind vector corresponds to 5 m s^{-1}, and 1 degree of latitude corresponds to a distance of 111 km

- $p = \rho\ R\ T$, the ideal gas law. p [Pascals], pressure; ρ, [kg m^{-3}] the density; T [Kelvin], the temperature; and $R = 287$ [J kg^{-1} K^{-1}], the specific gas constant for air.

- $e = \rho_v\ R_v\ T$, the ideal gas law for water vapour. e [Pascals], vapour pressure; ρ_v, [kg m^{-3}] the absolute density; T [Kelvin], the temperature; and $R_v = 462$ [J kg^{-1} K^{-1}], the specific gas constant for water vapour.

- $\theta = T\ \left(\frac{p_0}{p}\right)^{R/c_p}$, the potential temperature θ [K] of air whose actual pressure and temperature are (p, T), ie. the temperature that air would have if compressed adiabatically to pressure p_0. The exponent involves the gas constant for air ($R = 287$ J kg^{-1} K^{-1}) and the specific heat of air at constant pressure ($c_p \approx 1000$ J kg^{-1} K^{-1}). Temperatures must be expressed in the Kelvin unit.

- the saturation vapour pressure at temperature T is given by

$$\begin{aligned} e_*(T) &\approx 610.78\ \exp\ \frac{19.8\ T}{273+T}\ \text{(over water)}\ , \\ &\approx 610.78\ \exp\ \frac{22.5\ T}{273+T}\ \text{(over ice)}\ , \end{aligned}$$

  where T is to be entered in degrees Celcius and e is in [Pa].

- $A_T \equiv \left(\frac{\partial T}{\partial t}\right)_{adv} = -\ V\ \frac{\partial T}{\partial s}$

  Advective contribution to the rate of change of temperature, expressed in natural coordinates. The unit vector $\hat{s}$ for the s axis points downstream and parallel to the flow contours (eg. height contours), and V is the wind *speed*.

- $V = \frac{g}{f}\ \frac{\Delta h}{\Delta n}$

  The Geostrophic wind equation. Δh [m], the change in height of a constant pressure surface over distance Δn [m] normal to the height contours; $f = 2\Omega\ \sin\phi$ [s^{-1}] the Coriolis parameter (where $\Omega \approx 2\pi/(24 \times 3600)$ s^{-1} is the angular velocity of the earth, and ϕ is latitude); g acceleration due to gravity.

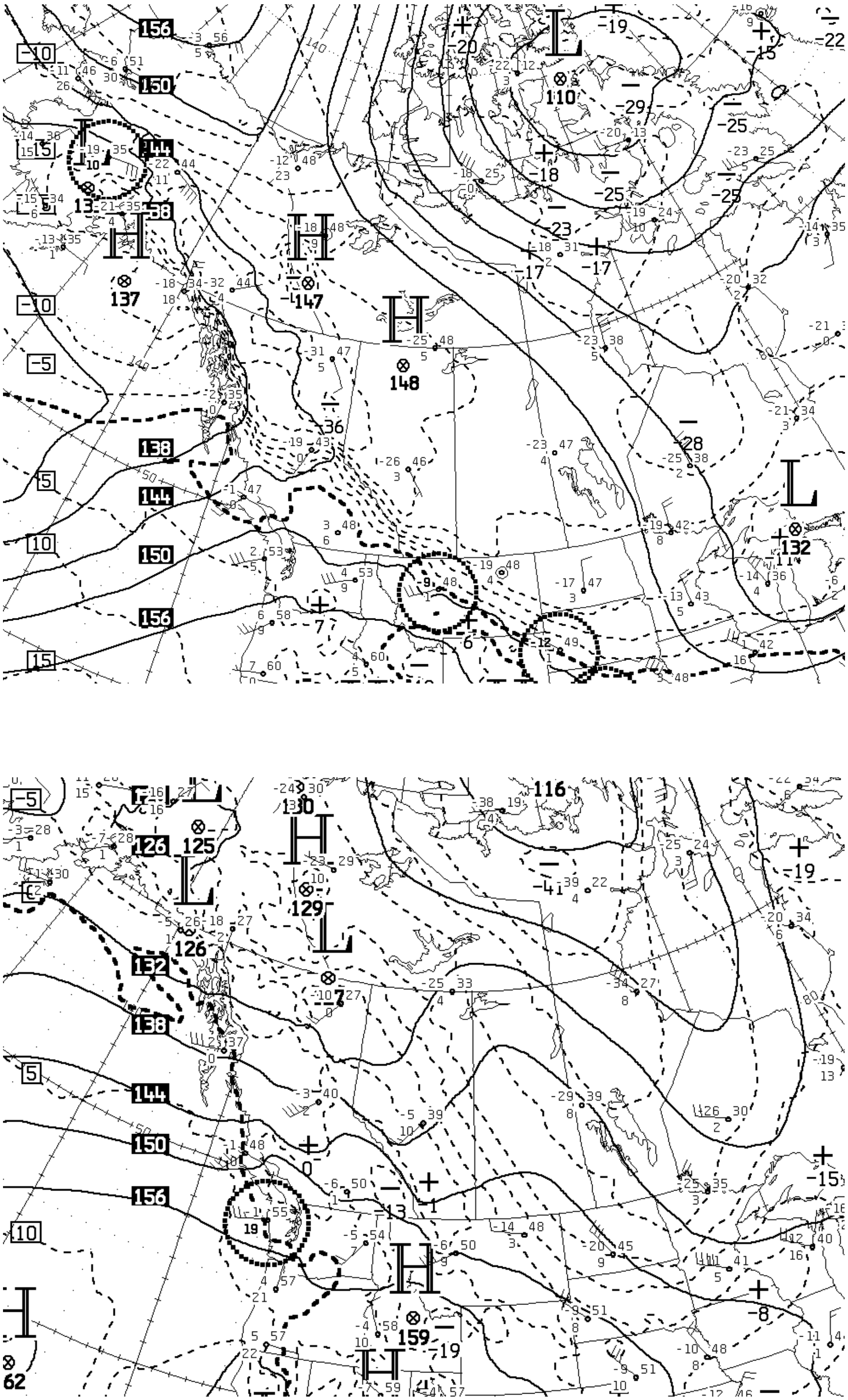

Figure 1: CMC 850 hPa analyses for 12Z on January 15th (upper) and 20th (lower), 2011.

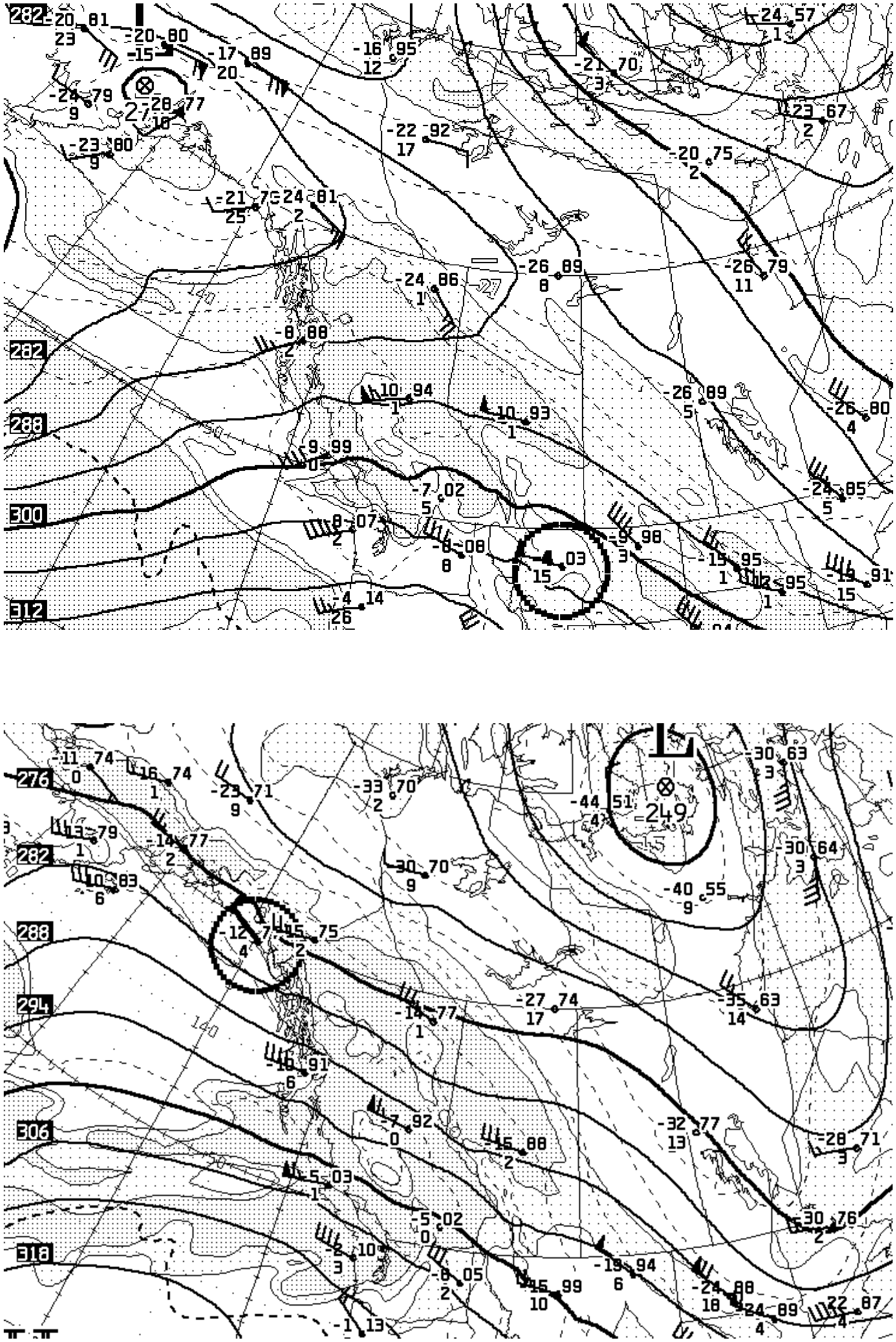

Figure 2: CMC 700 hPa analyses for 12Z on January 15th (upper) and 20th (lower), 2011.

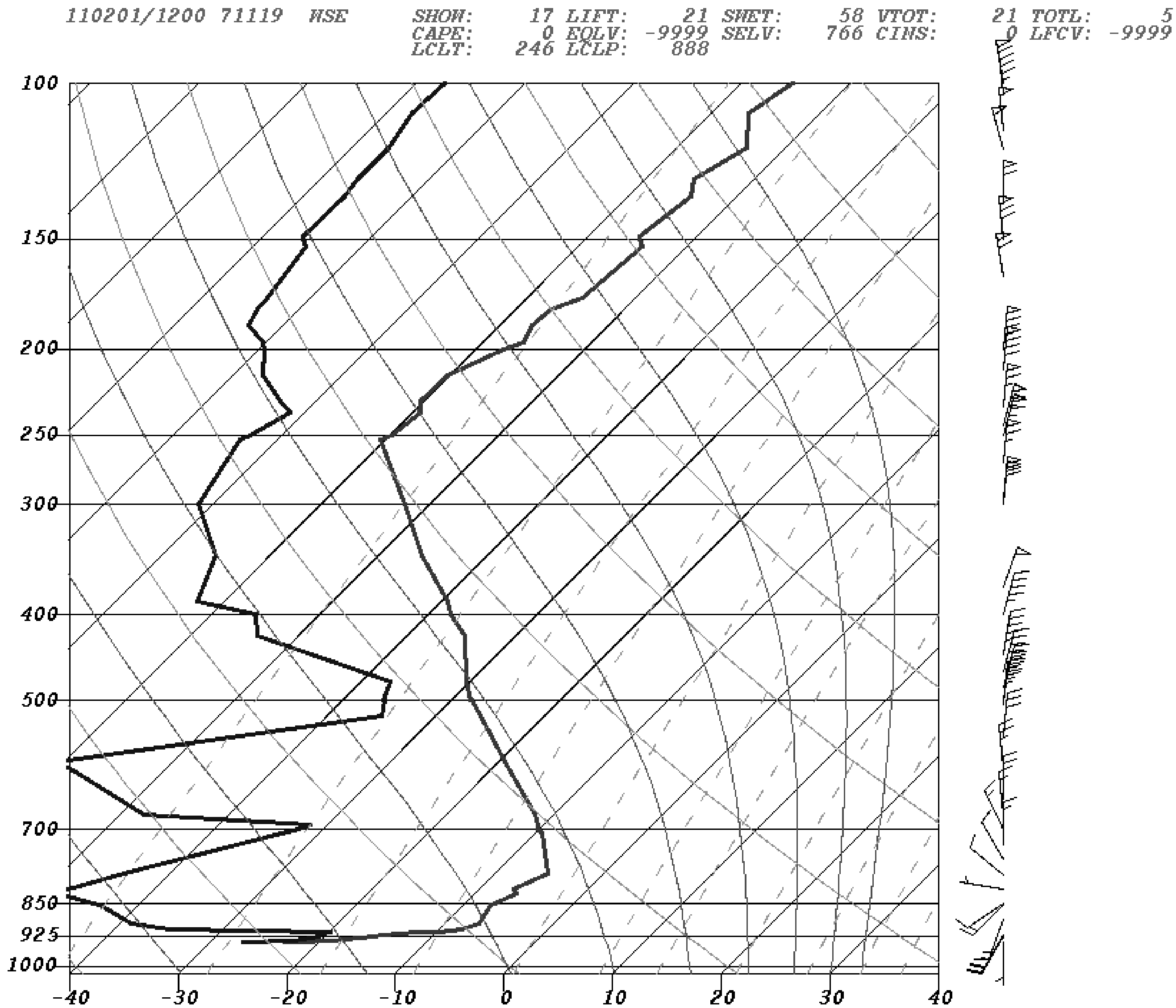

Figure 3: Edmonton (Stony Plain) sounding at 12Z on 1 Feb., 2011.

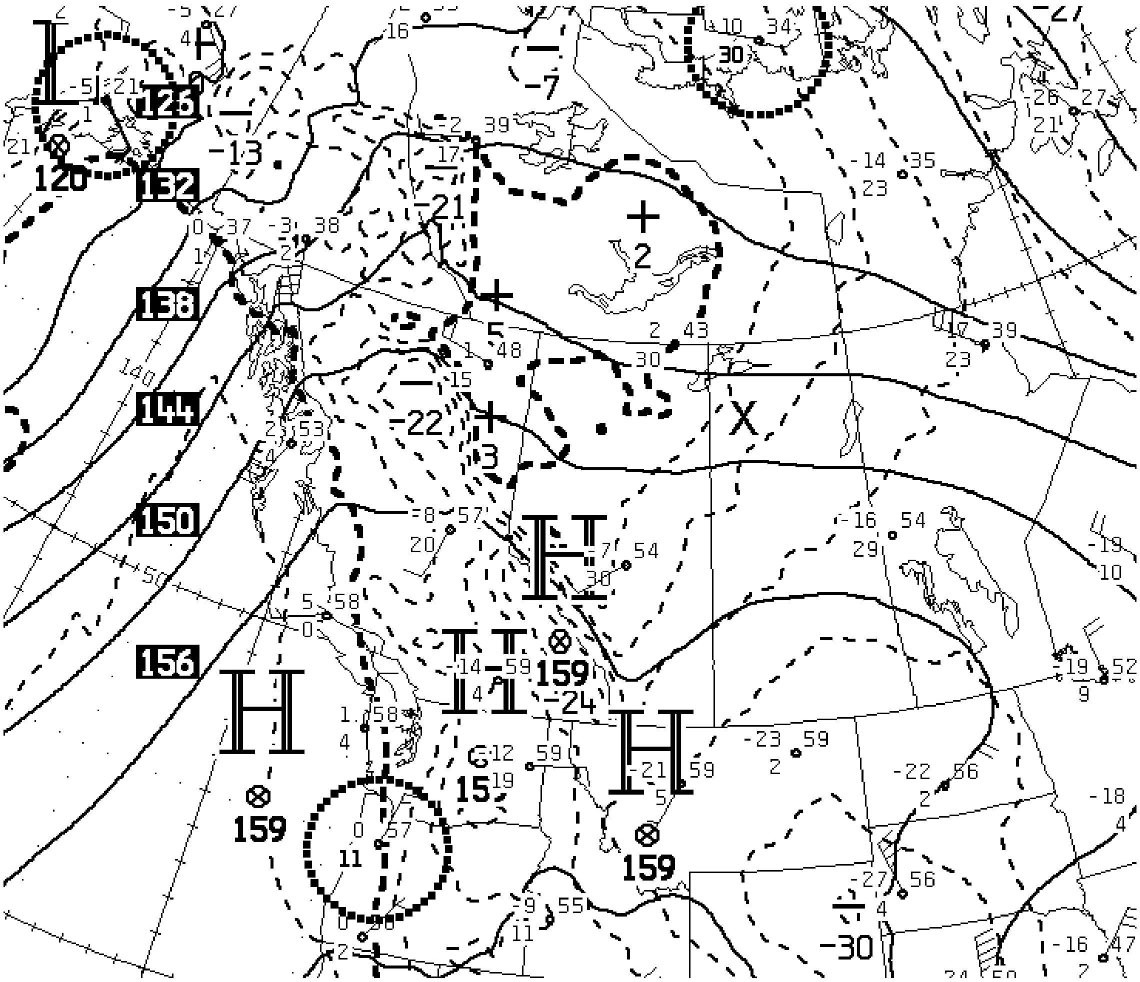

Figure 4: CMC 850 hPa analysis, 12Z on 1 Feb., 2011.

Class structure, environment, delivery

— your (anonymous) feedback will be appreciated