EAS270, "The Atmosphere" Quiz 2 12 Oct., 2011

Professor: J.D. Wilson Time available: 25 mins Potential Value: 10%

Instructions: For all 15 questions, choose what you consider to be the best (or most logical) option, and use a pencil to mark that choice on the answer form. **Eqns/data given at back**. You may keep this quiz. *Correct answers added.*

1. Which process explains daytime sky colour in a pristine (ie. clean) atmosphere?
   (a) Mie scattering by air molecules
   (b) Rayleigh absorption of red wavelengths by air molecules
   (c) preferential atmospheric absorption of blue wavelengths
   (d) preferential atmospheric scattering of red wavelengths
   (e) preferential atmospheric scattering of blue wavelengths ✓✓(p62 of textbook)

2. On a global, climatological basis, which process is responsible for the bulk of the solar radiation scattered from planet earth back into space?
   (a) reflection off the surface (ground, lake, ocean)
   (b) reflection off clouds ✓✓(p62)
   (c) scattering by the atmospheric gases
   (d) scattering by aerosols
   (e) black body emission

3. What is the wavelength range (in μm) covered by the "atmospheric window"? At wavelengths within this "window," is the absorptivity of H_2O and CO_2 high or low?
   (a) 0.4 - 4 low
   (b) 0.4 - 4 high
   (c) 8 - 11 low ✓✓(p66)
   (d) 8 - 11 high
   (e) 4 - 100 low

4. Which of the following statements is **incorrect**? Normally the depth of the turbulent friction layer (ie. atmospheric boundary layer)
   (a) is minimal near dawn and increases with time during the day, until late afternoon
   (b) increases with increasingly positive sensible heat flux Q_H from surface to atmosphere
   (c) increases with increasing windiness and increasing surface roughness
   (d) is greater in winter than in summer ✓✓(lecture 8)
   (e) can be as shallow as about 100 m or less, but seldom exceeds about 2 kilometers

5. Which statement about the instantaneous (as opposed to climatological average) value of the net radiation Q^* on a horizontal surface at sea- or ground-level is **correct**?
   (a) Q^* is of smaller magnitude than the solar constant ✓✓(lecture 6)
   (b) Q^* is equal to the solar constant
   (c) Q^* is greater than the solar constant
   (d) Q^* is always positive
   (e) Q^* is always negative

6. Suppose the incoming solar radiation flux on a snowpack is $K\downarrow = 100$ W m^{-2}. If the albedo of the snowpack is 80%, what is the magnitude of the reflected solar radiation flux?
   (a) -20 W m^{-2}
   (b) 20 W m^{-2}
   (c) 80 W m^{-2} ✓✓(p64)
   (d) 180 W m^{-2}
   (e) 120 W m^{-2}

7. At what time on a clear, sunny day does maximum surface temperature normally occur?
   (a) At local solar noon, when $K\downarrow$ is maximum
   (b) When $L\downarrow$ is maximum
   (c) When $L\uparrow$ is minimum
   (d) At the afternoon transition (through zero) of the net radiation $Q^* = K^* + L^*$ ✓✓(p81)
   (e) When net radiation Q^* crosses zero in the upward direction

8. Which weather conditions tend to increase the "diurnal" (daily) range in near-ground temperature (at height 1.5 m)?
   (a) cloudy, windy
   (b) cloudy, calm
   (c) clear, calm ✓✓(p81)
   (d) clear, windy
   (e) winter season

9. Which of the following combinations produces the strongest Coriolis force?
   (a) fast winds and low latitude
   (b) fast winds and high latitude ✓✓(p115)
   (c) slow winds and low latitude
   (d) slow winds and high latitude
   (e) complete calm on the equator

10. The "Geostrophic wind" results from a balance of which forces? If you stand with your arms raised outward and your back to the Geostrophic wind, in the northern hemisphere which arm points to lower pressure?
   (a) friction & pressure-gradient; right
   (b) friction & pressure-gradient; left
   (c) Gravity & pressure-gradient; left
   (d) Coriolis & pressure-gradient; right
   (e) Coriolis & pressure-gradient; left ✓✓(p118, lecture 11)

11. Due to friction near-surface winds have a cross-isobar component. Which surface type and which latitude is associated with a greater angle of the near-surface airflow relative to the isobars?
   (a) oceanic; stratospheric
   (b) rougher; higher
   (c) rougher; lower ✓✓(p120)
   (d) smoother; higher
   (e) smoother; lower

12. A parcel of air at the 700 hPa level which is moving at constant speed parallel to circular isobars ____
    (a) Accelerates towards the centre of low pressure ✓✓(pp118-122)
    (b) Accelerates along the local tangent to the isobars
    (c) Experiences no centripetal acceleration
    (d) Is not subject to the Coriolis force
    (e) Is not subject to the pressure-gradient force

For the remaining questions, please refer to the attached weather analyses/charts.

Context: On 25 September 2011 the temperature at Edmonton International Airport (YEG) reached a maximum of over 31°C at 14:00 MDT, whereas the 1971-2000 thirty-year normal daily maximum for September is 16.9°C.

13. Which statement regarding the morning's Stony Plain sounding (i.e. 12Z on 25 September 2011) is **untrue**?
    (a) the Stuve diagram gives the 700 hPa height as 3061 m, which is consistent with the station report on the 700 hPa analysis
    (b) there was a nocturnal surface inversion, whose top was at about 900 hPa
    (c) the tropopause, defined as "the level at which temperature cases to decrease with height," had to be higher than 12 km above sea-level
    (d) true surface pressure, i.e. not corrected to sea-level, was lower than 900 hPa ✓✓
    (e) the atmosphere over Edmonton was unsaturated ($T > T_d$) at all levels

14. Which of the statements below concerning Edmonton's weather on 25 September is **true**?
    (a) The weather was controlled by a closed upper low centered south of the Great Lakes
    (b) The low-level (850 hPa) air further north in Alberta was much cooler ✓✓
    (c) The weather was exceptionally humid, with dewpoints at the 850 hPa level of 28°C
    (d) Height of the 850 hPa surface over Edmonton was 941.0 dam
    (e) The wind at the 700 hPa level was blowing *parallel* to the isotherms at that level

15. The Stony Plain radiosonde had reported $T_{850} = 24^\circ$C, and a southerly wind with a speed[1] of $20\,\mathrm{m\,s^{-1}}$. Based on the configuration of the 850 hPa temperature field over central and northern Alberta, what is the most reasonable of the conjectures below as to the probable short term (6-12 hour) consequence of a (hypothetical) switch in 850 hPa wind direction over Edmonton, a switch resulting in a wind from the north or northwest?
    (a) Warming
    (b) Development of an overcast sky due to clouds at the 850 hPa level
    (c) Cooling ✓✓
    (d) Progession onto the continent of the 850 hPa trough (presently just offshore)
    (e) No change in temperature

[1] The four barbs are partially obscured by a stamped + and beneath it a **24**, i.e. $\overset{+}{24}$.

Equations and Data.

- one full barb on the wind vector corresponds to about 5 m s^{-1}
- 1 hPa $=$ 100 Pa
- $Q^* = \ K^* \ + L^* \ = K\downarrow - K\uparrow + L\downarrow - L\uparrow$

  The radiation balance on a horizontal reference plane surface. All fluxes are in [W m^{-2}]. $K\downarrow, K\uparrow$, the incoming and outgoing solar fluxes (net solar, $K^* = K\downarrow - K\uparrow$); and $L\downarrow, L\uparrow$, the incoming and outgoing longwave fluxes (net longwave, $L^* = L\downarrow - L\uparrow$). Any quantity carrying the arrow ($\downarrow$ or $\uparrow$) is non-negative by definition.

- $Q^* \ = \ Q_H \ + Q_E \ + Q_G$

  Surface energy balance on a reference plane at the base of the atmosphere, all fluxes in [W m^{-2}]. Q^* the net radiation, positive if directed towards the surface; Q_H, Q_E the sensible and the latent heat fluxes, positive if directed from the surface towards the atmosphere; Q_G the 'soil' heat flux, positive if directed from the surface into ground/lake/ocean. The latent heat flux is related to the vertical flux of water vapour E by the relationship $Q_E = L_v E$, where L_v [J kg^{-1}] is the latent heat of vapourization.

Figures

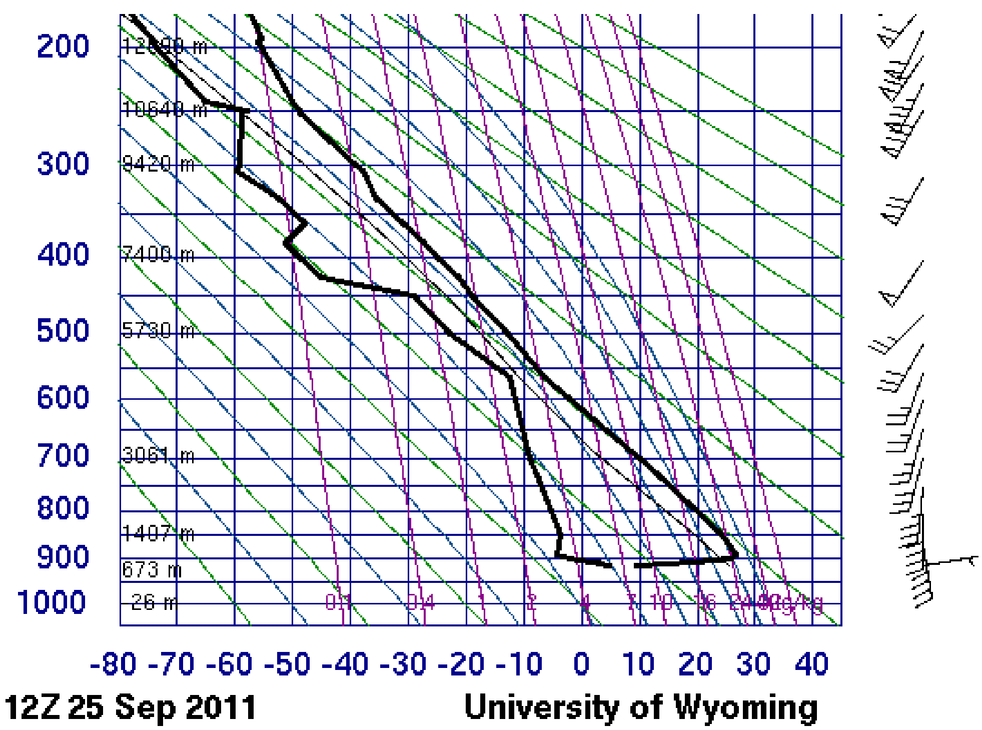

Figure 1: Stuve diagram displaying the Stony Plain sounding for 12Z Sept. 25, 2011. The heavy black lines give T and T_d in Celcius, where necessarily $T_d \leq T$. Temperatures are plotted on the "x" axis, and heights (or actually, pressures – increasing downwards) on the "y" axis. The lighter lines on the diagram are irrelevant to the quiz, and may be ignored.

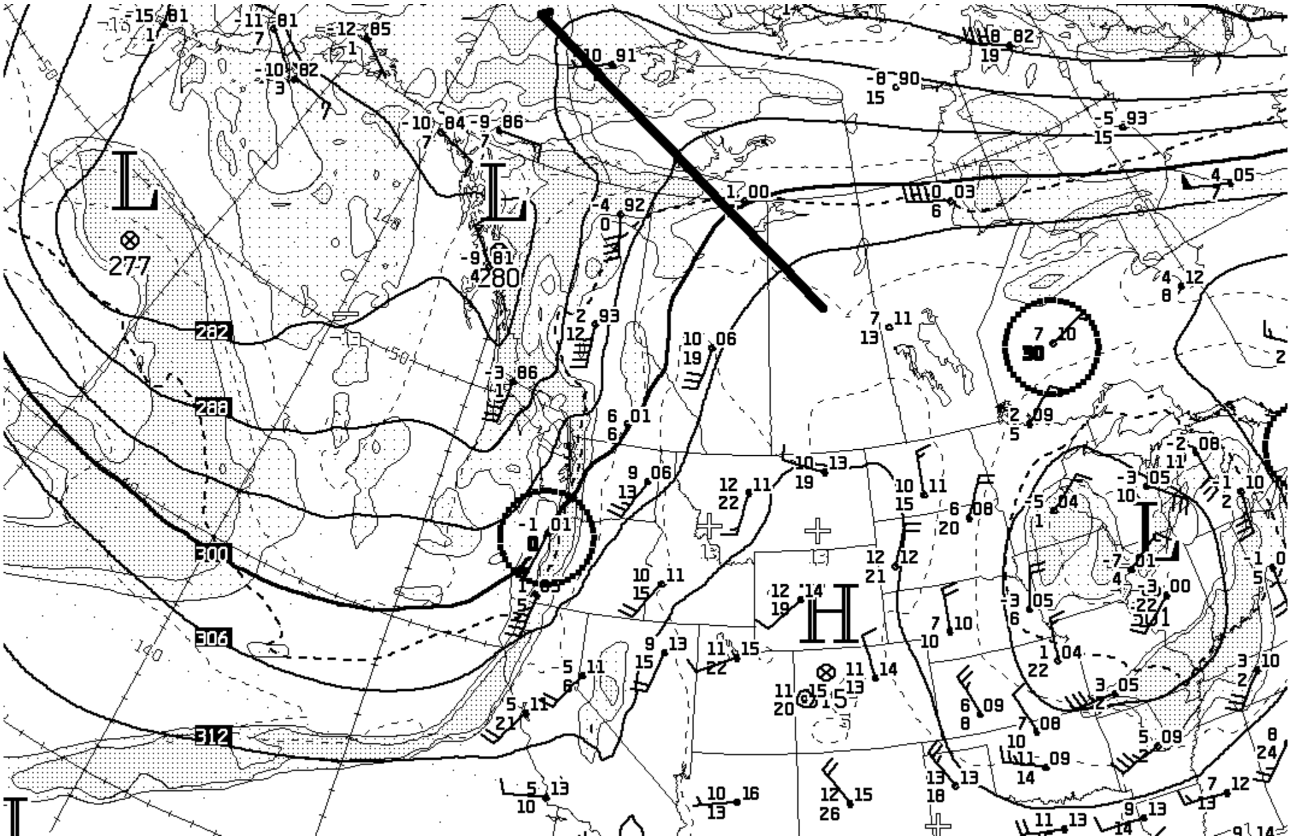

Figure 2: CMC 700 hPa analysis, 12Z Sept. 25, 2011. Solid contours, 700 hPa height. Dashed contours, isotherms. Dense stippling, $T - T_d \leq 2^{\circ}$C. Heavy line, an upper ridge (lines demarcating other troughs and ridges not added).

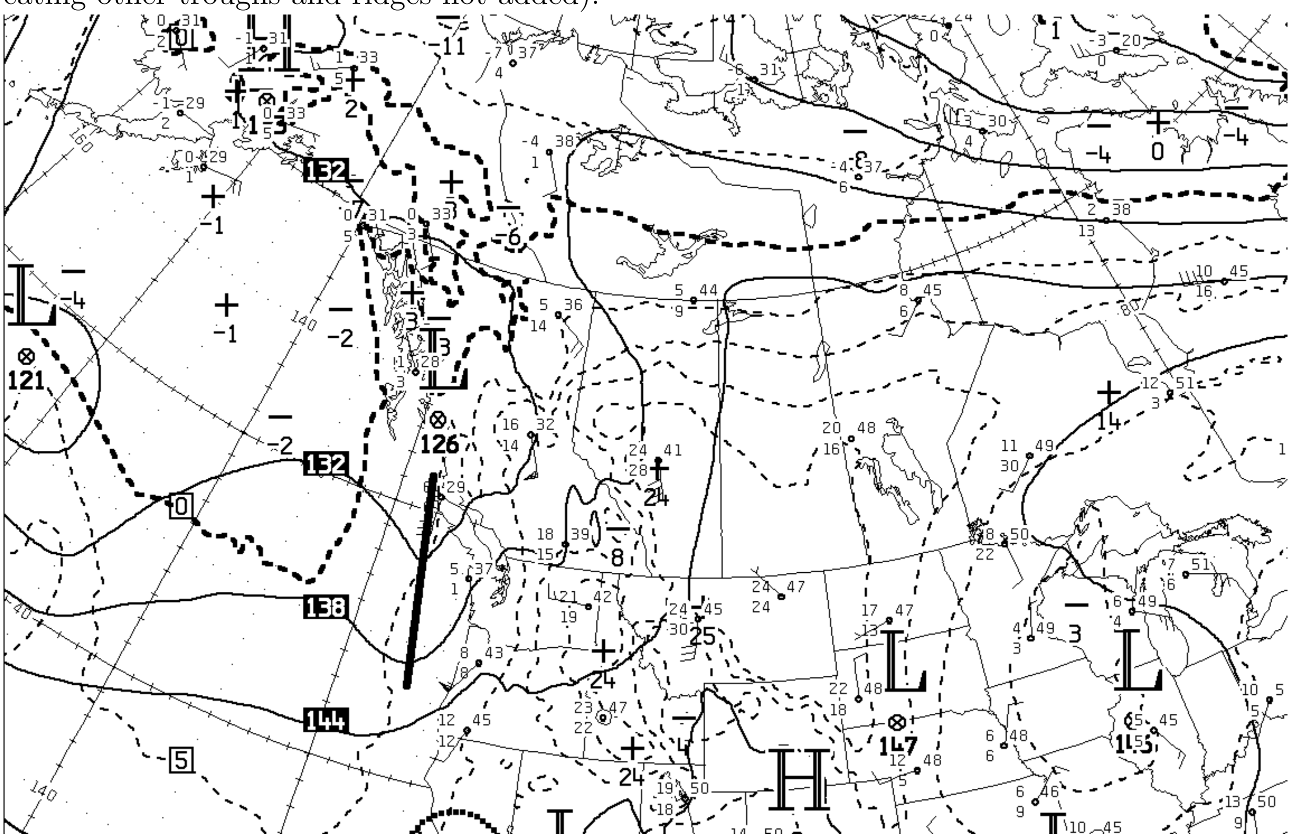

Figure 3: CMC 850 hPa analysis, 12Z Sept. 25, 2011. Solid contours, 850 hPa height. Dashed contours, isotherms. Heavy line, an 850 hPa trough.