EAS270, "The Atmosphere" Quiz 2 13 Oct., 2006

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

Instructions: For all 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.

Optional anonymous feedback on course/instructor effectiveness (see back page).

1. The northern hemisphere summer solstice occurs around ____ when the subsolar point travels along a latitude line at ____ ^{o}N

   (a) March 21; 0
   (b) March 21; 23.5
   (c) June 21; 23.5 ✓✓(p45, Fig. 2-13)
   (d) September 21; 0
   (e) September 21; 23.5

2. On a climatological, globally averaged basis, the majority of the solar radiation scattered from planet earth back into space originates from ____

   (a) reflection off the ground
   (b) reflection off clouds ✓✓(p60, Fig. 3-7)
   (c) scattering by the atmospheric gases
   (d) scattering by aerosols
   (e) reflection off the ocean

3. To emphasize the climatic importance of the atmosphere, a hypothetical "radiative equilibrium temperature" T_{eq} (255 K) can be calculated as the mean temperature of an isothermal earth lacking an atmosphere. That temperature is defined by balancing ____ (%) absorption of the solar beam against longwave loss calculated using ____ Law.

   (a) 70, the Stefan-Boltzmann ✓✓(p73, Sec 3-2; also slides 11,12 Lec. 7-8)
   (b) 30, the Stefan-Boltzmann
   (c) 70, Wien's
   (d) 4, Wien's
   (e) 100, the Ideal Gas

4. The three most important latitude-controlled factors that determine total daily shortwave radiation energy incident on an area of $1\,m^2$ of flat surface at sea-level are ____

   (a) land/sea distribution, day length, noon-time solar elevation

   (b) land/sea distribution, day length, topographic elevation

   (c) land/sea distribution, sun-earth distance, topographic elevation

   (d) day length, noon-time solar elevation, slant-thickness (along beam) of atmosphere ✓✓(p49)

   (e) day length, sun-earth distance, topographic elevation

5. Which of the following statements is incorrect? Normally the depth of the turbulent friction layer (ie. atmospheric boundary layer)

   (a) is greater in winter than in summer ✓✓(slides 6,7 of Lec.7)

   (b) is minimal near dawn and increases with time during the day, until late afternoon

   (c) increases with increasingly positive sensible heat flux Q_H from surface to atmosphere

   (d) increases with increasing windiness and increasing surface roughness

   (e) can be as shallow as about 100 m or less, but seldom exceeds about 2 kilometers

6. Due to friction, the near-surface winds typically have a cross-isobar component. The angle of the near-surface airflow *measured relative to the isobars* tends to be greater over ____ surfaces and at ____ latitudes

   (a) evaporating; middle

   (b) rougher; higher

   (c) rougher; lower ✓✓(p111)

   (d) smoother; higher

   (e) smoother; lower

7. Suppose a certain bare, dry soil has emissivity $\epsilon = 0.92$ and its surface temperature is 30° C. It emits longwave radiation energy at a rate $L\uparrow =$ ____ $W\,m^{-2}$ and the spectrum of that emitted radiation peaks at $\lambda_{max} =$ ____ μm

   (a) Given information is insufficient to permit calculation of these numbers

   (b) 0.04; 97

   (c) 0.04; 9.6

   (d) 441; 97

   (e) 441; 9.6 ✓✓(p37 + p39)

8. The "diurnal" (daily) range in near-ground temperature (height 1.5 m) tends to be larger during ____ conditions

   (a) cloudy, windy
   (b) cloudy, calm
   (c) clear, calm ✓✓(p77)
   (d) clear, windy
   (e) winter-time

9. The "sensible" heat content of an air parcel is proportional to its ____ while the "latent" heat content is proportional to its ____

   (a) pressure; density
   (b) sensible heat flux; latent heat flux
   (c) humidity; temperature
   (d) temperature; absolute humidity ✓✓(p66 + slides 8,9 Lec1)
   (e) altitude; pressure

10. In the free atmosphere at mid latitudes in the northern hemisphere, the orientation of the winds about a circular low pressure system is ____ and the speed is ____

    (a) anticlockwise; sub-geostrophic ✓✓(p111)
    (b) anticlockwise; super-geostrophic
    (c) anticlockwise; geostrophic
    (d) clockwise; geostrophic
    (e) clockwise; super-geostrophic

11. If a sample of air is saturated at 20°C, its absolute humidity is ____ kg m^{-3}

    (a) 1.7
    (b) 1.7 x 10^{-2} ✓✓(use equation and Table given as data)
    (c) 1.7 x 10^{-4}
    (d) 2.5 x 10^{-3}
    (e) 2.5 x 10^{-1}

12. A parcel of air has temperature $T = 10$°C and vapor pressure $e = 7.05$ mb. Its dewpoint is about ____ °C and its relative humidity is about ____ %.

    (a) 10; 100
    (b) 10.01; 70
    (c) 12.27; 50
    (d) 2; 20
    (e) 2; 57 ✓✓(inter-relationship of T_d, e covered Lec.11, + use of Table given as data)

13. Radiation fog is caused by the ground's cooling by net loss of ____ . It is most probable under ____ skies and ____ winds

    (a) shortwave radiation; cloudy; cold
    (b) longwave radiation; clear; very light ✓✓(p148)
    (c) latent heat; clear; very light
    (d) water vapour; cloudy; warm
    (e) water vapour; clear; very light

14. Local conditions associated with a radiation frost are a/an ____ with a convective flow of heat ____ the atmosphere ____ the ground surface

    (a) northerly wind; to; from
    (b) easterly wind; from; to
    (c) drizzle; through; at
    (d) ground-based inversion; to; from
    (e) ground-based inversion; from; to ✓✓(slide 10 Lec. 12 + slide 11 Lec. 6)

15. Even on a "no weather" day (i.e. no synoptic scale weather features such as fronts or storms influencing developments) the relative humidity typically has a diurnal cycle such that it is at its daily maximum ____

    (a) near the end of the afternoon, at time of peak temperature
    (b) near noon, at time of peak solar insolation
    (c) near midnight, due to presence of dew or frost
    (d) near dawn, at the time of minimum temperature ✓✓(p129)
    (e) shortly after nocturnal cooling has commenced

16. Which of these humidity variables is unchanged during adiabatic vertical motion of an unsaturated parcel?

    (a) relative humidity (RH)
    (b) dewpoint (T_d)
    (c) vapour pressure (e)
    (d) absolute humidity (ρ_v)
    (e) specific humidity (q) ✓✓(p127; instruction slide 8 Lec. 12)

For the remaining questions, please refer to the attached 12Z analyses.

17. Referring to the 500 mb analysis (Fig. 1), the computed Geostrophic windspeed for the location marked "**a**" (at 52 °N in the stippled region at the top left corner of the map) is an ____ of approximate speed ____ $\mathrm{m\,s^{-1}}$

    (a) easterly; 3
    (b) westerly; 3
    (c) easterly; 30
    (d) westerly; 30 ✓✓
    (e) westerly; 15

18. Referring to the 850 mb analysis (Fig. 2), at the location marked "**a**" ____ advection is occurring while at "**b**" ____ advection is occurring

    (a) cold; warm ✓✓
    (b) warm; cold
    (c) cold; cold
    (d) warm; warm
    (e) no; no

19. Referring to the surface analysis (Fig. 3), the relative humidity at the station in the NW corner of Alberta was about ____ % (note: you will need to use Table 1 in the Data section at the end of the exam)

    (a) 0
    (b) 20
    (c) 40
    (d) 60 ✓✓
    (e) 100

20. At the station on the northern border of Alberta, the past weather symbol (a single comma) denotes ____ and the sea-level corrected pressure was ____ mb

    (a) drizzle; 1097.0
    (b) drizzle; 970
    (c) drizzle; 997.0 ✓✓
    (d) rain; 970
    (e) rain; 997.0

Equations and Data.

- $L\uparrow = \epsilon\,\sigma\,T^4$

  Stefan-Boltzmann law. $L\uparrow$ [W m^{-2}], the emitted longwave energy flux density; ϵ, the emissivity of the surface (dimensionless); $\sigma = 5.67$ x 10^{-8} [W m^{-2} K^{-4}], the Stefan-Boltzmann constant; T [K], the surface temperature.

- $\lambda_{max} = \frac{2900}{T}$

  Wien's displacement law. λ_{max} [μm], the wavelength at which the peak in the emission spectrum occurs; T [K], the temperature of the emitting surface.

- $Q^* = K^* + L^* = K\downarrow - K\uparrow + L\downarrow - L\uparrow$

  The surface radiation balance. 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, $L^* = L\downarrow - L\uparrow$).

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

  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.

- $e = \rho_v\,R_v\,T$

  Ideal gas law for water vapor. e [Pascals], vapour pressure; ρ_v, [kg m^{-3}] absolute humidity; T [K], temperature; $R_v = 462$ [J kg^{-1} K^{-1}], specific gas constant for water vapor).

- RH$= e/e_s(T)$, $q = m_v/(m_v + m_d) = \rho_v/\rho$

  Relative humidity (RH) and specific humidity (q), where m_v, m_d are respectively the mass of vapour and the mass of all else but vapour (ie. of the "dry air") in a sample

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

  The Geostrophic wind equation. Δh [m], the change in height of a constant pressure surface over distance Δx [m] normal to the height contours; $f = 2\Omega\,\sin\phi$ [s^{-1}] the Coriolis parameter (where $\Omega = 2\pi/(24\text{x}60\text{x}60) = 7.27\text{x}10^{-5}$ s^{-1} is the angular velocity of the earth, and ϕ is latitude); $g = 9.81$ [m s^{-2}] acceleration due to gravity.

Table 1: Equilibrium vapour pressure $e_s(T)$ [mb] versus temperature T [C].

T	$e_s(T)$	T	$e_s(T)$	T	$e_s(T)$	T	$e_s(T)$	T	$e_s(T)$	T	$e_s(T)$
0	6.11	5	8.72	10	12.27	15	17.04	20	23.37	25	31.67
1	6.57	6	9.35	11	13.12	16	18.17	21	24.86	26	33.61
2	7.05	7	10.01	12	14.02	17	19.37	22	26.43	27	35.65
3	7.58	8	10.72	13	14.97	18	20.63	23	28.09	28	37.80
4	8.13	9	11.47	14	15.98	19	21.96	24	29.83	29	40.06

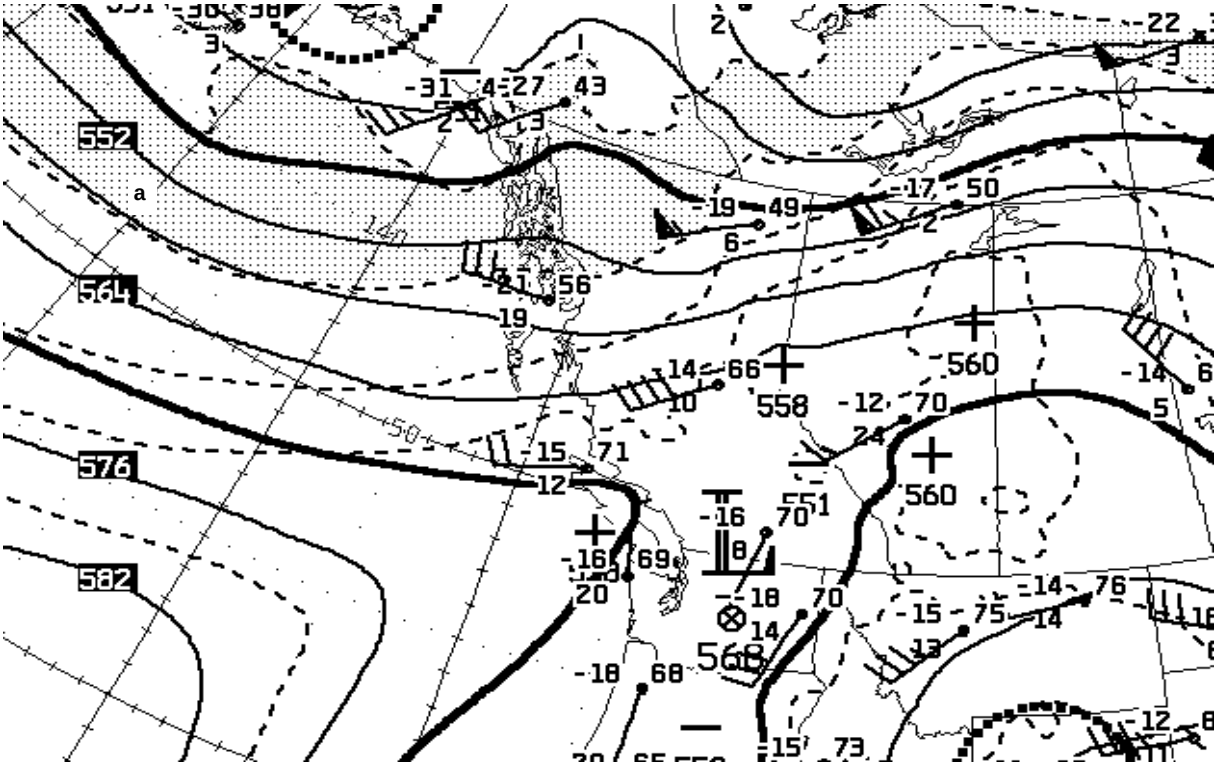

Figure 1: CMC 500 mb analysis, 12Z Thurs 5 Oct 2006.

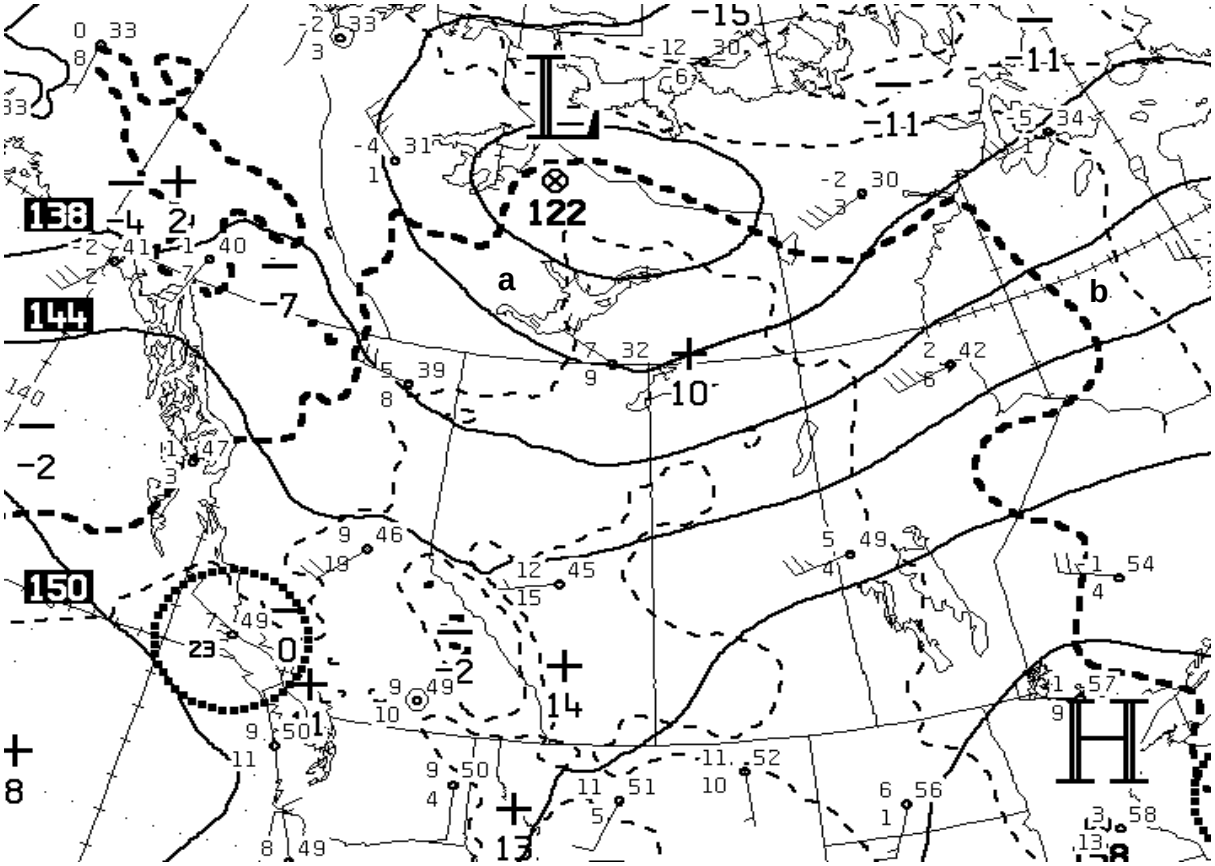

Figure 2: CMC 850 mb analysis, 12Z Thurs 5 Oct 2006.

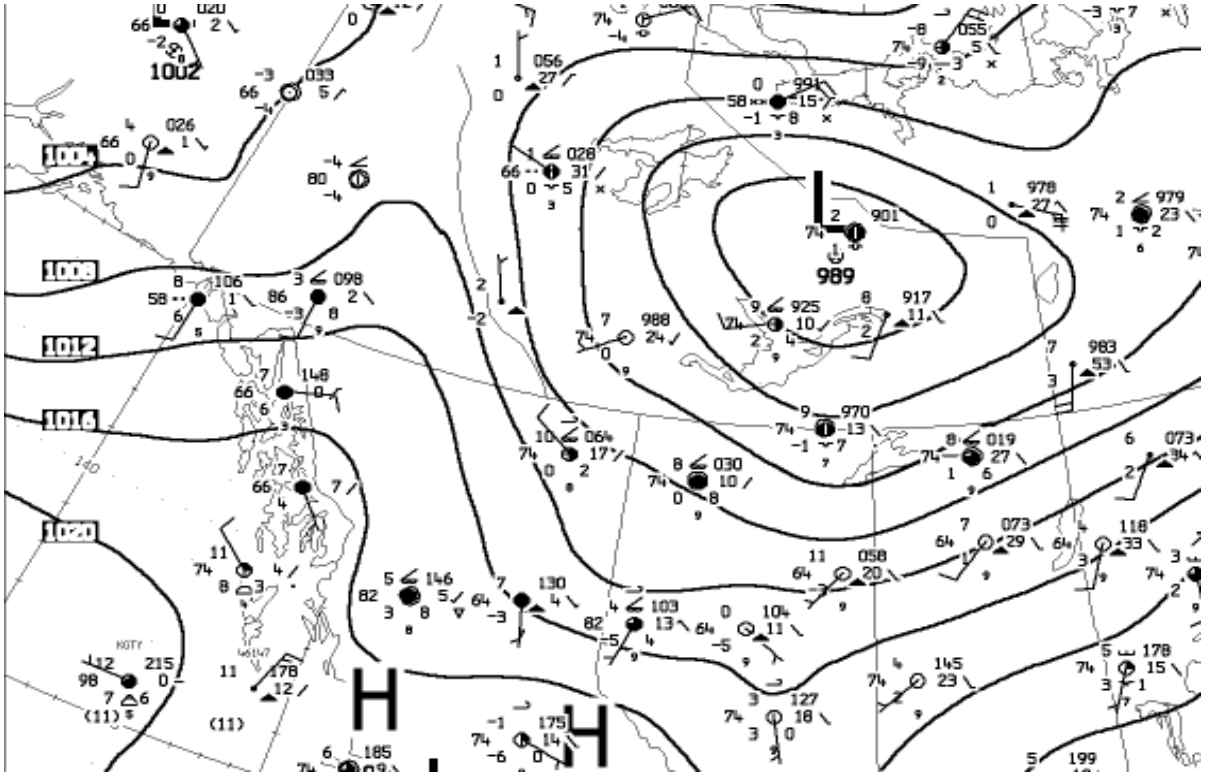

Figure 3: CMC surface mb analysis, 12Z Thurs 5 Oct 2006.

Optional Anonymous Feedback to the Instructor

If you wish, please comment on the effectiveness of the course organization and the teaching style, identifying any problems and making suggestions for improvements. (Please place your feedback in the box provided at the end of class)