EAS270, "The Atmosphere" Quiz 1 23 Sept., 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 have been indicated. Page references – 5th edition, Aguado & Burt**.

1. The *troposphere* extends from the base of the atmosphere to about what height? Does the climatological mean temperature increase or decrease with increasing height in the troposphere?
   (a) 80 kilometers; increase
   (b) 50 kilometers; increase
   (c) 10 kilometers; increase
   (d) 50 kilometers; decrease
   (e) 10 kilometers; decrease ✓✓(p15)

2. What total mass of air lies over one square metre of area on the 100 hPa surface?
   (a) 100 hPa
   (b) 10000 Pa
   (c) 100 N m^{-2}
   (d) 1000 kg ✓✓(in MKS units $P = 10^4$, $A = 1$, $g \approx 10$; and $M = P/(Ag)$)
   (e) 100 Pa

3. Which of the following gases is the most abundant variable gas in today's atmosphere?
   (a) O_2 (oxygen)
   (b) CO_2 (carbon dioxide)
   (c) CH_4 (methane)
   (d) N_2 (nitrogen)
   (e) H_2O (water vapour) ✓✓(p7)

4. Nitrogen gas N_2 makes up what percentage by volume of the atmosphere? Why does N_2 have "relatively little effect on most meteorological processes"?
   (a) 21; it is not a greenhouse gas
   (b) 21; it is a "permanent" gas with a very long residence time
   (c) 78; it is a "variable" gas with a very short residence time
   (d) 78; it is a "permanent" gas with a very long residence time, and does not interact with terrestrial radiation ✓✓(p6-7)
   (e) 98; it is not a greenhouse gas

5. Which explains the diurnal (daily) cycle in CO_2 concentration just above a growing crop?
   (a) nighttime photosynthesis and daytime respiration
   (b) daytime photosynthesis and nighttime respiration ✓✓(p8 & lecture slides)
   (c) reflected solar radiation
   (d) aerosols interacting with the ozone layer
   (e) the greenhouse effect

6. In an "inversion" layer of the atmosphere, does the temperature increase or decrease with increasing height? What is the impact of this on vertical motion?

   (a) increase; inhibits vertical motion ✓✓(p15)
   (b) increase; promotes vertical motion
   (c) decrease; inhibits vertical motion
   (d) decrease; promotes vertical motion
   (e) neither increase nor decrease; no influence

7. What is the wavelength $\lambda_{\max}$ of the peak in the spectrum of radiation emitted by a water surface with a temperature of 90°C? In which wavelength band does this fall?

   (a) 32.2 μm; longwave
   (b) 8.0 μm; longwave ✓✓(computation, Wien's Law)
   (c) 32.2 μm; shortwave
   (d) 8.0 μm; shortwave
   (e) 90 m; longwave

8. Which phrase correctly describes the interaction of radiation with a gas?

   (a) A gas is impenetrable to radiation
   (b) A gas is impenetrable to ultraviolent radiation
   (c) A gas is impenetrable to thermal radiation
   (d) A gas is a selective absorber and emitter of radiation ✓✓(p40)
   (e) A gas with temperature T absorbs and emits thermal radiation in proportion to T^4

9. If solar elevation angle is $\theta = 45^{\circ}$, what is the flux of solar energy to a horizontal surface (neglecting absorption or scattering by the atmosphere)?

   (a) 386 ppm
   (b) 1367 W m^{-2}
   (c) 2900 μm
   (d) 683.5 W m^{-2}
   (e) 967 W m^{-2} ✓✓($1367 \sin 45$; example on lecture slide)

10. The mean radii of the orbits of Mars and Earth about the sun are $R_M = 2.25 \times 10^{11}$ m and $R_E = 1.5 \times 10^{11}$ m. Given that the solar constant for Earth is $S_{0E} = 1367$ W m^{-2}, what is the solar constant S_{0M} for Mars?

    (a) $S_{0M} = S_{0E} \times (R_M/R_E)^2$
    (b) $S_{0M} = S_{0E} \times (R_E/R_M)^2$ ✓✓(p44)
    (c) $S_{0M} = S_{0E} \times R_M/R_E$
    (d) $S_{0M} = S_{0E} \times R_E/R_M$
    (e) $S_{0M} = 1/S_{0E} \times R_E \times R_M$

11. What is the flux of energy emitted by a black body whose temperature is 15°C?

    (a) 5.67×10^{-8} W m^{-2}
    (b) 1.3×10^{-5} W m^{-2}
    (c) 2.9×10^{-3} W m^{-2}
    (d) 4.7×10^{-3} W m^{-2}
    (e) 391 W m^{-2} ✓✓(calculation, Stefan-Boltzmann law)

12. At what latitude does the subsolar point lie at the times of the equinox?

    (a) on the equator ✓✓(p49)
    (b) on the tropic of Capricorn
    (c) on the tropic of Cancer
    (d) on the latitude line 23.5°N
    (e) on the latitude line 23.5°S

    For the remaining questions, please refer to the attached surface analysis. The low pressure system is Hurricane Irene, situated near the east coast of the United States.

13. What label would you assign to the inner-most isobar around the low pressure centre?

    (a) 976 hPa
    (b) 977 hPa
    (c) 980 hPa ✓✓(count in from the labelled isobars, the interval being 4 hPa)
    (d) 984 hPa
    (e) 988 hPa

14. What was the sea-level corrected pressure reported at the station closest to the low pressure centre?

    (a) 771 hPa
    (b) 1077.1 hPa
    (c) 977.1 hPa ✓✓(code is 771; place a 10 in front, and a decimal point to left of the final digit)
    (d) 9771 hPa
    (e) 10771 hPa

15. Reported surface wind speeds around the hurricane are larger over the sea. A station to the southeast of the storm reported cumulus clous (whose symbol is given in the Data section below), and temperature and dewpoint $28, 24$°C respectively. What were the wind speed and wind direction at that station?

    (a) 6 $\mathrm{m\,s^{-1}}$; S
    (b) 6 $\mathrm{m\,s^{-1}}$; N
    (c) 15 $\mathrm{m\,s^{-1}}$; NW
    (d) 15 $\mathrm{m\,s^{-1}}$; SE
    (e) 15 $\mathrm{m\,s^{-1}}$; S ✓✓

Equations and Data.

- one full barb on the wind vector corresponds to about 5 $\mathrm{m\ s^{-1}}$
- 1 hPa = 100 Pa
- $p = \frac{M\,g}{A}$

  The pressure (p, Pa) that results when mass M [kg] overlies area A [$\mathrm{m^2}$], where $g \approx 10\,[\mathrm{m\,s^{-2}}]$

- T [K] $= T$ [°C] $+ 273.15$ (Note that a *change* of one degree Kelvin is the same as a *change* of one degree Celcius).

- $L_{\uparrow} = \epsilon\, \sigma\, T^4$

  Stefan-Boltzmann law. $L_{\uparrow}$ [W m^{-2}], the emitted longwave energy flux density (for which our textbook uses the symbol "I"); ϵ, the emissivity of the surface (dimensionless); $\sigma = 5.67 \times 10^{-8}$ [W m^{-2} K^{-4}], the Stefan-Boltzmann constant; T [K], the surface temperature.

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

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

- $I = S_0 \sin\theta$

  Intensity (I) of solar beam radiation on a horizontal surface, neglecting scattering or absorption, as function of solar elevation angle θ above the horizontal. $S_0 = 1367$ W m^{-2} is the solar constant, i.e. strength of the solar beam at the top of the atmosphere. I is the energy per unit time incident on a unit of area of horizontal surface.

Low Clouds : type CL

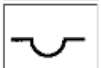
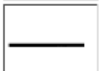
	Cu (Cumulus) with little vertical extent and seemingly flattened
	Cu of moderate or strong vertical extent, generally with protuberances in the form of domes or towers, either accompanied or not by other cumulus or by stratocumulus, all having their base at the same level.
	Cb (CumuloNimbus) the summits of which, at least partially, lack sharp outlines but are neither clearly fibrous (cirriform) nor in the form of an anvil; cumulus, stratocumulus, or stratus may also be present
	Sc (StratoCumulus) formed by the spreading out of cumulus; cumulus may also be present
	Sc not resulting from the spreading out of cumulus
	St (Stratus) or Sf (Stratus Fractus) in a more or less continuous sheet or layer, or in ragged shreds, or both, but no stratus fractus of bad weather
	Sf (stratus Fractus) of bad weather or cumulus fractus of bad weather, or both (pannus), usually below altostratus or nimbostratus
	Cu and Sc other than that formed from the spreading out of cumulus; the base of the cumulus is at a different level from that of the stratocumulus
	Cb cumulonimbus, the upper part of which is clearly fibrous (cirriform), often in the form of an anvil; either accompanied or not by cumulonimbus without anvil or fibrous upper part, by cumulus, stratocumulus, stratus, or pannus

Figure 1: Symbols for some common low cloud types (plotted immediately below the station circle).

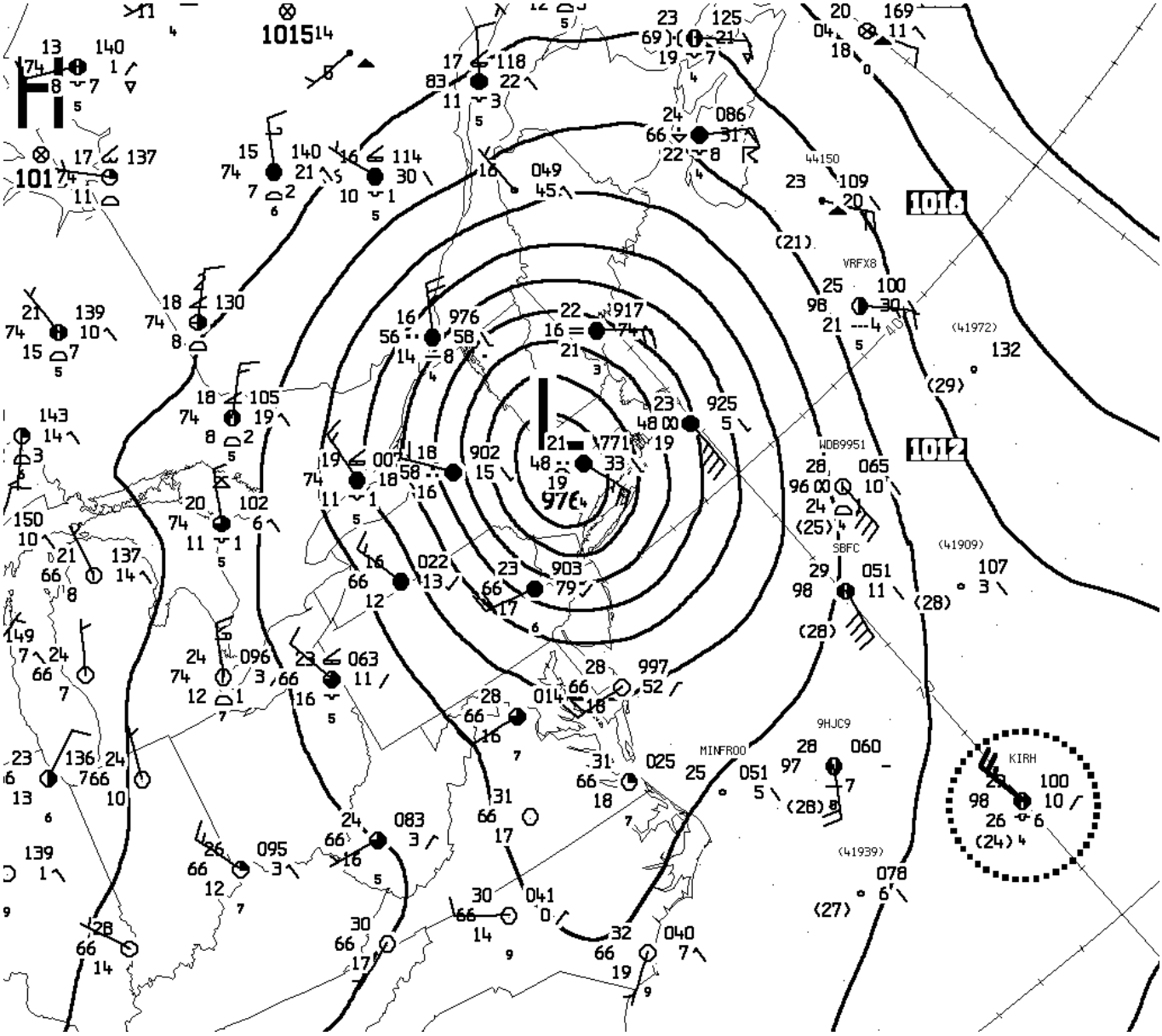


Figure 2: CMC surface analysis, 18Z August 28, 2011. Hurricane Irene is situated near the east coast of the United States. Note the orientation of the latitude lines (e.g. 40°) and longitude lines (e.g. 70°).