MET 200: Atmospheric Processes and Phenomena Due: 14 November 2013

Fall Semester Name: ____________________

Businger **Homework Assignment #3 (**25 pts each)

1. Why can't we control the track or intensity of a tropical storm to mitigate its devastating impact? In this problem, we are going to estimate the amount of energy released each second (i.e. the power) by a mature hurricane over the ocean. Assume that the vigorous area of the hurricane is circular with a diameter of 100 km (i.e. viewed from the top). The sea surface temperature is 30°C. Cloud base is 0.5 km above the ocean. Cloud top is at -50°C. Assume that at any one time, half of the area of the hurricane is dominated by updrafts, and half by downdrafts.

(a) Estimate the *temperature* at cloud base (Hint: use the DALR). What is the *relative humidity* of air right at cloud base?

(b) What is the *partial pressure* of water vapor in an air parcel at cloud base? Using this value, calculate the *absolute humidity* (water content in kilograms of water vapor per cubic meter) of the air entering cloud base. [Hint: Use ideal gas law in the form P = cRT, where P is partial pressure of water vapor, and c is concentration of water vapor in mol/m^2.]

(c) Let's assume that the SVP of water vapor at -50°C is very close to 0 kPa. Explain in words what happens to the water vapor between cloud base and cloud top.

(d) Now assume that the average updraft is 10 m/s. What is the volume of air (in cubic meters) that enters the hurricane through cloud base *each second*? What then is the volume of air that exits the hurricane at cloud top each second?

(e) Based on (a) through (d), estimate the amount of energy released per second within the hurricane due to latent heat from cloud formation.

(f) The annual energy consumption of the United States is approximately 10^{20} J. Using the numbers calculated here, estimate how many hours it would take for the hurricane to release this much energy in the form of latent heat.

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2. In 1975, industrial tycoon Henry Kremer offered $350,000 in 2012 dollars to the first pilot who would complete a figure-eight pattern between two posts half a mile apart. Paul McCready, an aeronautical engineer and president of the California firm Aerovironment, decided to give the challenge a shot. He started by considering available muscle power; a well-trained athlete can attain a power output of 250 watts. McCready realized that the weight of the aircraft must be kept low and decided the takeoff weight could not exceed 100 kg. With a 65 kg bicycle rider, that left 35 kg for the aircraft, with pedals, gears, and propeller. Such a light aircraft made of piano wire and corrugated cardboard will induce some drag. Let's estimate the drag as 5 kg (50 Newtons). Given this

information and the class notes from the lecture on flight, answer the following questions. Show your work in arriving at the answers.

a) What is the cruising speed of the aircraft that the athlete can maintain given his power output?

b) What is the area of the wings needed the keep the aircraft in the air at that speed?

c) Estimate the wing span of the aircraft, and briefly discuss the aerodynamic considerations used to arrive at the estimate.

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3. a) Sketch a vector representation of the balance of forces and the resulting *surface* wind (V) for the surface pressure gradient over the open ocean and over forested Virginia, given below (isobars are labeled in millibars). Assume that the forces are in balance at 10 m above the surface. The absolute length of the vectors is not important, but the relative length and angles between them are; *please label them*. Note that there will be a different magnitude of friction over the open ocean than over forested Virginia.

Ocean		Virginia	
____________________________	1000	____________________________	1000
____________________________	1004	____________________________	1004
Ocean •		Virginia •	
____________________________	1008	____________________________	1008
____________________________	1012	____________________________	1012

b) Draw the same diagram for a mid-latitude location in the southern hemisphere, say for Hobart Tasmania. Note that the pressure will decrease towards the south and the Coriolis force will act to the left of the motion, instead on towards the right as it does in in the northern hemisphere.

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4. a) Analyze the sea-level pressure map below for a mature Kona low, drawing isobars every 4-mb. Note that the standard convention is used in plotting pressure, which is given in tenths of mb, with 1000 subtracted from the observed value; e.g., 220 on the map equals 1022.0 mb, 043 equals 1004.3 mb, etc. Analyze in pencil out to the edge of the map. Analyze first in light pencil just to get the sense of the distribution, allowing for easy erasure to get the final smooth gradients. Standard practice dictates that the value of the isopleth (contour) be divisible by the contour interval (e.g., 996, 1000, 1004 mb, etc, are divisible by 4). The final analysis should depict the pressure pattern with smooth contours and smooth gradients. Label the pressure centers and each isobar. Finalize your contours in thin but bold pencil.

b) Where are the strongest winds relative to the low center in this case? In this case the winds over the Hawaiian Islands are from the north. Where would the low center have to be located relative to the islands, to get kona winds?

c) What hazards do kona lows present to Hawaii?

d) What potential benefits do kona lows present?