

### Homework Assignment #3

#### ECE 597UU/697UU, Fall 2009

(Posted on the course website on Thu, 1 Oct; due in class on Thu, 8 Oct)

#### Problem 1 (12 pts.): *Equilibrium temperatures on the north pole and on the full moon*

(a, 2 pts.) What is the zenith angle  $\vartheta$  of the Sun at the north pole midsummer (20/21 June)?

(b, 4 pts.) Suppose the albedo of north-pole ice is  $a = 0.50$  and neglect absorption of solar light by the atmosphere. What is the equilibrium temperature at the north pole around midsummer? Justify your answer.

(c, 2 pts.) Same as (b), but now suppose that someone would cover the area around the north pole with asphalt, which has an albedo similar to water (0.05).

(d, 2 pts.) Why are these two equilibrium temperatures so high compared to the global equilibrium temperature of 255 K?

(e, 2 pts.) What is the surface equilibrium temperature at the center of the full moon (assume an albedo of  $a = 0.12$ )?

(f, not graded) What do you think is the average thickness of ice around the north pole?

#### Problem 2 (4 pts.) *Mass of the atmosphere*

(3, 2 pts.) Assuming a globally averaged sea level air pressure of 1013 hPa, an Earth radius of  $R = 6371$  km and a mean acceleration due to gravity of  $g = 9.8 \text{ ms}^{-2}$ , what is the total mass of the atmosphere? Justify your answer and your assumptions.

(b, 1 pt.) What is the ratio between the mass of the atmosphere and the mass of the solid Earth?

#### Problem 3 (10 pts.) *Air density change*

Suppose that the minimum (nighttime) temperature on a crisp fall day is 0 deg C and the maximum (daytime) temperature is 20 deg C. Suppose the air is sufficiently dry so you can neglect the water vapor content. Suppose further that the air pressure is 1000 hPa and does not change during that day.

(a, 2 pts.) What is the air density at these two temperatures?

(b, 2 pts.) Same as (a), but now suppose you are in Colorado at an air pressure of 800 hPa.

#### Problem 4 (10 pts.) *Gas constant of humid air*

(a, 2 pts.) Derive the equation for  $R_h$  (the gas constant for humid air) as a function of temperature  $T$ , (total) pressure  $p$  and specific humidity  $q$ .

(b, 2 pts.) Evaluate  $R_h$  for  $p = 1000$  hPa,  $T = 20$  deg C, and  $q = 1 \text{ g kg}^{-1}$ .