ASTR/ATOC 3720: Homework Assignment #5

Due: Thur. May 1 in class

1. The obliquity of Uranus is about 98˚ and its orbital period is about 84 years. This means that the planet is essentially on its side and the seasons are many years long. Draw pictures and explain what (and why) you'd expect the general global circulation patterns to look like in the following cases (hint: think Hadley):

    a. During the period when the north pole is pointed almost directly and continuously at the Sun (northern summer).

    b. When the Sun is overhead at the equator (equinox).

2. Pluto's orbit has an eccentricity of 0.244 and a semi-major axis (mean distance from the Sun) of 39.2 AU.

    a. Calculate the the perihelion and aphelion distances for Pluto.

    b. Calculate the effective temperatures for Pluto at both perihelion and aphelion, assuming that the planet's albedo is 0.5.

    c. The temperature change due to the eccentric orbit of Pluto probably causes much of its atmosphere to freeze out on the surface, increasing its albedo to as high as 0.70. Calculate a new aphelion effective temperature based on this new albedo.

3. Titan is a satellite of Saturn. It has an albedo of 0.20. (You'll find most of the numbers you need from your lecture notes and the tables in the back of NSS.)

    a. Calculate the effective temperature of Titan.

    b. The actual surface temperature of Titan is 94 K. Using the "slab" model, determine the optical depth of Titan's atmosphere.

    c. Calculate the acceleration due to gravity at the surface of Titan.

    d. Calculate the adiabatic lapse rate for Titan, assuming that the atmosphere is almost completely made of N_2.

    e. Assuming a surface temperature of 94 K and a "dry" adiabatic lapse rate up to the tropopause at 42 km, what would you expect the temperature to be at the tropopause?

    f. The actual tropopause temperature on Titan is around 71 K. Pressures and temperatures in Titan's atmosphere are high enough that methane can exist as a liquid, solid, or gas. Explain then why the temperature at 42 km is warmer than what a dry adiabatic lapse rate would give.