OCN/ATM/ESS 587
Problems
(Due 11/12/09)

1. Consider the following statement: "There is as much heat contained in the upper 2 meters of the ocean as is contained in the entire atmosphere above." Show whether or not this statement is even approximately true. You may assume the atmosphere to be 15 km thick (95% of the atmosphere is contained in the lower 15 km) [note: consider the typical differences in specific heat, density, and temperature of the atmosphere and ocean].

2. A planet similar to the Earth has an ocean 5 km deep and an overlying atmosphere 5 km thick. The ocean has a constant density of 1027 kg/m^3 and the atmosphere has a constant temperature of 5 °C. Estimate and compare the pressures at the bottom of the atmosphere and the bottom of the ocean, assuming that the pressure at a level of 5 km in the atmosphere is 500 millibars. Be as quantitative as possible in your answer.

3. On Venus, the surface temperature of the day side of the planet has been measured to be the same as on the night side. On Mars, extremely large surface temperature variations have been measured between day and night. What are the important parameters that might be responsible for this difference in the diurnal cycle of heating on these two planets? Be as quantitative as possible in your answer.

4. A hypothetical Planet Z is approximately 60 AU from a star similar to the sun (note: 1 AU = the mean distance from the sun to the Earth, or about 1.5×10^8 km) and has an albedo of 0.3. Planet Z has no known atmosphere, but it is suspected that it has a molten core that accounts for the relatively warm surface of the planet. (a) Suppose that the flux of heat from the interior of the planet to the surface is 0.5 $watts/m^2$. Estimate the surface temperature of Planet Z. (b) It is discovered that Planet Z does indeed have an atmosphere. If this atmosphere absorbs the maximum amount of long-wave radiation possible, what would be the surface temperature on Planet Z?

5. The jet stream in the atmosphere (see Fig. 6.4 and 6.7 in Hartmann) and the Gulf Stream in the Atlantic Ocean (see Fig. 7.7 and 7.9 in Hartmann) are both approximately in geostrophic balance. Typical speeds in the Gulf Stream can be as high as 50 cm/sec near the surface. Based on the horizontal length scales depicted in these figures, estimates of the speeds, and a knowledge of the Earth's rotation rate, determine for which of these two domains the geostrophic approximation is the most valid.

6. The average rainfall (fresh water flux) over the Earth's surface is about 1 meter/year. (a) What is the average upward flux of freshwater at the Earth's surface? (b) What is the energy flux that results from this upward flux of freshwater, and how does this energy flux compare to the incoming solar radiation? (c) If this energy flux was uniformly distributed over the upper 100 m of the world ocean, what would be the resulting rate of warming or cooling of the world ocean?