MET 200: Atmospheric Processes and Phenomena Due: 12 December 2013
Fall Semester Name: _____
Businger **Homework Assignment #4** 20 points each

1. Let's say that a lightning bolt causes the transfer of 10 C of electrons to a tree on Oahu. This is the same number of electrons that run through a single 60 W light bulb in about half a minute.

a. Why is the amount of energy associated with a lightning strike much greater than the energy required to run a 60 W light bulb for half a minute? [words only]

b. If the electrons transferred during the lightning strike are at 10 million volts, estimate the energy released during the lightning strike.

c. An average of 20 million cloud-to-ground lightning strikes per year has been measured in the continental United States. What is the total amount of energy released as lightning over the United States? Compare this to the annual energy consumption of the U.S. (2×10^{20} J/year).

d. The average duration of a lightning strike is 30 μs. What is the average power released? How many Moss Landing power plants (power production of 2.5 GW) would be needed to produce the same amount of power for this brief duration?

2. a. Write expressions (equations) for the Coriolis force and centrifugal force.

b. For the airflow in a steady state tornado, scale these two terms, and compare the resulting magnitude of the Coriolis force and centrifugal force. Assume $f \sim 10^{-4}\ s^{-1}$, $V_T \sim 100\ m\ s^{-1}$ and $R \sim 1$ km.

c. On the back of this page, make a graph of buoyancy versus wind shear and indicate by letter the location/mix of environmental conditions, most conducive to: Tornadic supercells (T), Large hail producing thunderstorms (H), Microburst producing thunderstorms (M), Air mass thunderstorms (A)

3. a. When glaciation was at a maximum ~18,000 years ago, was global precipitation greater or less than at present? Explain your reasoning.

b. The thickness of the ice over Hudson Bay (latitude 55°N) was about 3000 m 18,000 years ago. If the annual precipitation near Hudson Bay is 15 in, calculate how long it would take snow falling on this region to reach a thickness of 3000 m. Assume that all the precipitation falls as snow, that there is no melting during the summer, and that the annual precipitation remains constant. To account for the compaction of the snow into glacier ice, use a thickness ratio of 5 to 1.

4. a. A large asteroid slams into Jupiter and triggers a thermonuclear reaction at the center of the planet that turns Jupiter into a star of equal surface temperature and size as the sun. If the Solar Constant at Earth is ~1400 W/m^2, what would be the percentage increase in radiant energy received at Earth due to the new star's appearance? Assume that on average Jupiter is ~4x farther from the Earth than the sun is. Show your work.

b. Estimate change in equilibrium global surface temperature of the Earth caused by Jupiter igniting using the simple radiation balance model introduced in Lecture 3, slide 19. Show your work.

c. Explain how global warming can increase the frequency of both floods and droughts over the US?