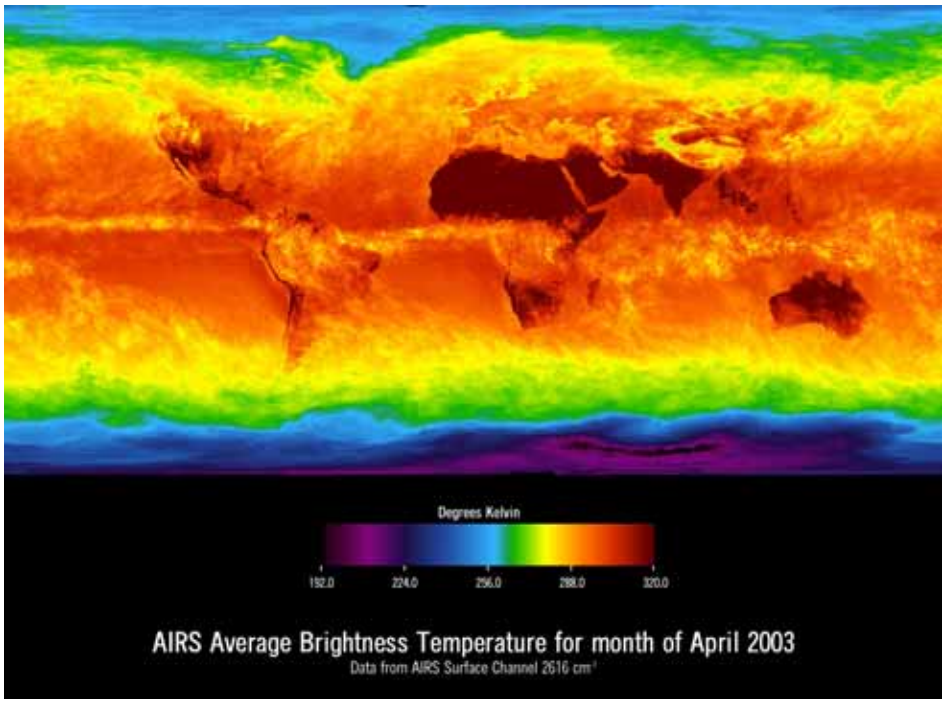
Physical Meteorology
Spring 2008
Homework #1

1. The NASA Atmospheric Infrared Sounder (AIRS) satellite (http://www-airs.jpl.nasa.gov/) measures the radiances coming from Earth in the wavelength range from 3.7 to 15.4 μm. The AIRS radiances are used to retrieve vertical profiles (i.e., soundings) of temperature, water vapor, and other trace gases for meteorological forecasting and climate research. An example of AIRS data is shown below. This mosaic shows the average brightness temperature for a whole month's worth of data (The full image, with description, can be viewed at http://photojournal.jpl.nasa.gov/catalog/PIA00427):



   a. You are an AIRS scientist looking at the raw radiance data from AIRS (at a wavenumber of 2616 cm^{-1}) that went in to the making of the above map. You want to create a map of brightness temperature similar the one above. Assuming the atmosphere is emitting as a blackbody with a temperature T_b, come up with an analytical (i.e., all in terms of the fundamental h, c, λ, k, and $B_\lambda(T_b)$) expression for T_b in terms of the measured radiance.
   b. What is the wavelength, in μm, corresponding to a wavenumber of 2616 cm^{-1}?
   c. One place in your data set has a radiance of 1.18 W m^{-2} μm^{-1}. What is the brightness temperature, using your answers from parts a and b? What part of the Earth does this correspond to in the above image?
   d. Another place in your image has a radiance of 11.5 W m^{-2} μm^{-1}. What is the brightness temperature, and what part of the Earth does this correspond to?

2. You are an interplanetary explorer, looking for signs of life on other planets. You arrive in a solar system to find two new planets. You measure the blackbody spectrum of the two planets. Planet A has its peak emission at 10 μm, and planet B has its peak emission at 1 μm. Which planet will you choose to go looking for life on first, and why?

3. There is evidence of liquid water on the surface of the Earth dating back to around 3 billion years ago, when the Earth was just forming. However, during this time, the sun only put out about 70% of the radiation that it does today. Calculate the effective emission temperature of the Earth with this assumption. How does this temperature compare with the freezing point of water? What would you expect the predominant phase of water to be during this epoch?

4. This time of year, many people would rather be on the beach (not me, by the way -- I'd rather be chest deep in powder).
    a. You've decided to skip class and go to the beach in Cozumel, Mexico. You want to get up early (or perhaps, stay up late) to watch the sunrise. Calculate the time of sunrise on 1 February in Cozumel, Mexico (20°30' N 86°54' W).
    b. Compare this value to the one from the online calculator at http://aa.usno.navy.mil/data/docs/RS_OneDay.php. How can you explain the difference?