** Denotes required for 513 students.*

1. Assume that the decrease in Arctic sea ice extent has the net effect of reducing global albedo from 0.3 to 0.29.

   a. Estimate the direct radiative forcing this has by considering a solar constant of 1367 W/m2. The direct effect can be estimated *at the top of the atmosphere*, excluding the influence of the greenhouse effect. Report your answer in W/m2.

   b. * Assuming that feedback processes have a 3-fold influence on the change in surface energy budget (i.e., multiply your radiative forcing in (1a) by 3), estimate the change in global mean surface temperature resulting from retreat of Arctic sea ice. Assume that global mean surface temperature prior to melt is 288K.

   c. Retreating Arctic sea ice results in an increase in cloud cover over the Arctic. Let's assume that there is an increase in low-level stratus clouds primary in the summer months. How would this feedback alter the energy balance and change global temperature? Is this a positive or negative feedback?

   d. Retreating Arctic sea ice results in an increase in water vapor over the Arctic from summer through early winter. How would this feedback alter the energy balance and change global temperature? Is this a positive or negative feedback?

2. Studies estimate that aerosols concentrations from industrial activities have resulted in a 5 W/m2 reduction in the surface energy budget across the eastern United States via direct and indirect effects. Coinciding with these changes in aerosols are increased concentrations of long-lived greenhouse gases that have added +2W/m2 to the surface energy budget. Given these diametrically opposed changes describe potential changes in surface temperature for

   a) Daytime temperatures in summer
   b) Nighttime temperatures in winter

3. Wildfires can influence climate in several ways. Describe one process through which fire produces a net negative radiative forcing and one processes that produce a net positive radiative forcing.