EOSC 112: Lab1b – Week of September 17
Greenhouse effect (partially absorbing atmosphere).

Objective: Investigate the impact of absorption, albedo, and solar constant on the surface temperature of the planet. How do changes in albedo and absorption translate into surface temperature changes?

Procedure: *lab1b.xls* is an Excel spreadsheet that takes as input (grey boxes), values for planetary albedo A (A3), atmospheric absorption *absorp* (A7), and solar constant (A11). The output is given in the yellow boxes (fluxes, units: $\mathrm{W\,m^{-2}}$), and temperatures (blue boxes, units: K). Recall that the fluxes are defined in the following figure:

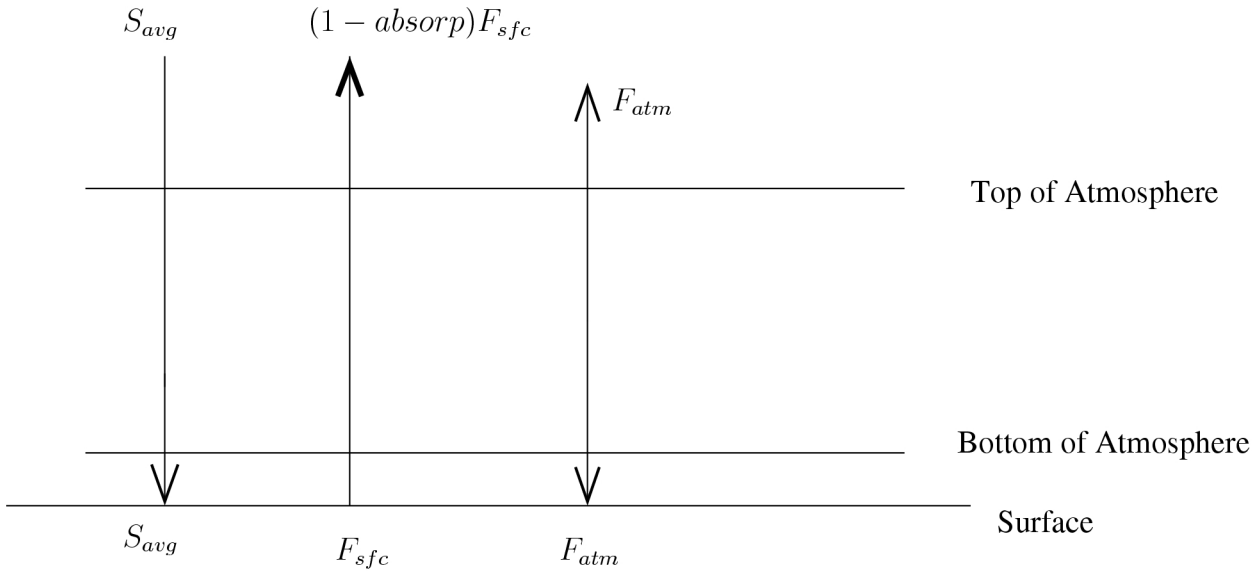

Figure 1: Short (S_{avg}) and longwave (F_{atm}) fluxes for a partially absorbing atmosphere. (Units: $\mathrm{W\,m^{-2}}$). Note that now some of F_{atm} makes it through the top of the atmosphere. (For example, if $absorp = 0.8$, then 20% of F_{sfc} makes it to outer space.)

and these equations:

$$F_{atm} = \frac{absorp}{2 - absorp} S_{avg} \quad (1)$$

$$F_{sfc} = \frac{2}{2 - absorp} S_{avg} \quad (2)$$

From Equation (2) we can solve for T_{sfc}, the surface temperature:

$$T_{sfc} = \left(\frac{2 S_{avg}}{\sigma(2 - absorp)} \right)^{1/4} \quad (3)$$

S_{avg}, F_{sfc}, F_{atm} and T_{sfc} are reported in the boxes (A15), (A19), (A23) and (D24).

Questions: Use the spreadsheet to answer the following:

Q1: Enter an *absorp*=0.8, S=1370, Albedo=0.3, (values close to current climate). Add up the fluxes by hand to show F_{sfc} balances the flux from sun (S_{avg} and atmosphere F_{atm}). Also confirm by hand that $\sigma T_{sfc}^4 = F_{sfc}$.

Q2: Increase the atmospheric absorption until the value of F_{sfc} is 4 ± 0.5 $\mathrm{W\,m^{-2}}$ bigger than the value you found in Q1. Report the new value of the absorption, as well as it's change from the previous value in per cent (i.e. 100.*(new - old)/old)

New value of *absorp*

Change from 0.8 in percent

Q3: For the absorption increase in Q2, what is the change in T_{sfc} (new value and change in previous value in per cent). *Note that by the year 2050, the longwave flux leaving the top of the atmosphere will be reduced by 4* $\mathrm{W\,m^{-2}}$ *due to the human-produced greenhouse effect increasing* F_{sfc} *by about that amount.*

New value of T_{sfc}

Change from original value in percent

Q4: You've been hired to counteract the 4 $\mathrm{W\,m^{-2}}$ greenhouse warming by increasing the planetary albedo using white plastic sheets. Put in the extra absorption you found in Q2, and then increase the albedo until you return F_{sfc} to its original value (value with *absorp=0.8*). Report the new albedo and its change from 0.3:

New value of A

Change from 0.3 in percent