Mathematical Model Activity

The Excel spreadsheet allows you to changes values of various parameters in the models to see the impact on Earth's temperature. Answer questions 1-12.

Model 1 (top)

Change the values of planetary albedo while keeping solar flux constant. The maximum possible value of albedo is 1.0 and the minimum possible value is 0.0. Click on "graph1a" to see the resulting plot.

1) What is the emission temperature if planetary albedo is 1.0? Why?

2) Note how the variation of emission temperature with albedo is not linear (doesn't follow a line). Why do you think this is?

Model 1 (bottom)

Change the values of solar flux while keeping planetary albedo constant. The minimum possible value of solar flux is 0 W m^{-2}. Click on "graph1b" to see the resulting plot.

3) What is the emission temperature if the solar flux is 0 W m^{-2}? Why?

4) Approximately what value of solar flux is needed to double the emission temperature (e.g., from ~250 K to ~500 K)? Is the value of solar flux for 500 K twice the value of solar flux for 250 K? Why or why not?

Model 2 (top)

Change the values of planetary albedo while keeping solar flux constant. Click on "graph2a" to see the resulting plot.

5) Note that surface temperature is greater than atmospheric temperature. Why is this?

Model 2 (bottom)

Change the values of solar flux while keeping planetary albedo constant. Click on "graph2b" to see the resulting plot.

6) Note that the value of atmospheric temperature is the same as the value of emission temperature from model 1 (if solar flux and albedo are also the same). Why is this?

Model 3

Change the values of emissivity while keeping planetary albedo and solar flux constant. Click on "graph 3" to see the resulting plot.

7) Verify that surface temperature when emissivity is 0 is the same as emission temperature from model 1 when albedo is 0.31 and solar flux is 1367 m^{-2}. Why is this?

8) Verify that atmospheric temperature when emissivity is 1 is the same as emission temperature from model 2 when albedo is 0.31 and solar flux is 1367 m^{-2}. Why is this?

9) What value of emissivity will produce a value of surface temperature equal to current global surface temperature (about 288 K or 15°C)? How close is this to the real fraction of radiation absorbed by the atmosphere?

10) How much does emissivity need to change to produce a 1 K increase in surface temperature (from 288K)? What about 2 K? 5 K? How much does emissivity need to change to produce a 1 K decrease in surface temperature?

Model 4

Look at the values specified for various parameters. Click on "graph 4" to see the resulting plot.

11) Verify that the surface temperature in model 4 eventually reaches the equilibrium surface temperature in model 3 for an emissivity of 0.85.

12) About how long does it take for the model to reach equilibrium? Why do you think it takes this long?