

ASSIGNMENT 3: Energy balance model using Excel

(10% of total mark)

Objective:

Create an EXCEL model to predict the Earth's radiative equilibrium temperature.

Theory:

The simplest way to consider the climate of the earth is in terms of its global energy balance. The climate can be simulated by observing that the radiation received (and retained) by the earth must be balanced by the radiation lost (in the long term). Equating the shortwave radiation receipt with the longwave radiation loss results in an expression for the radiative equilibrium temperature at the surface.

Questions:

- 1) Answer the following questions on the implementation of the EBM model:
 - a) Arrange Eq. 3.19 to show how the spreadsheet model calculates the temperature
 - b) How many iterations are included in the model distributed?
 - c) What are some major limitations of the model?
 - d) What is the physical meaning of longwave emission constants A and B (what do they represent).\?
- 2) Use the EBM model to determine the required decrease in the solar constant to glaciare the Earth completely (ice edge at 0 °N; note that T_{crit} is -10°C).
- 3) Make a plot of the latitude of the ice boundary versus the fraction of the solar constant (vary Frac.SC between 0.7 and 1.1 at intervals of 0.01). In your model set K and B to their default values and assume the ice-free albedo = 0.3, ice-albedo = 0.6.
- 4) Test the sensitivity of the model to the important model parameters listed below. In each case run a sensitivity test by comparing the altered input condition to the base (default) case. Assume a fixed solar constant of 1370 W m^{-2} . Report the range of values for which you have tested the model sensitivity. Report your results in graphical form and comment on your findings.
 - a) transport coefficient K
 - b) critical temperature T_{crit}
 - c) longwave emission constant B
- 5) Submit a report which should include your answers, figures (probably taken from the Excel file) and any comments plus the EBM Excel version to the GE4212 workbin (Due date: Oct. 1, 12 pm).

References/Sources:

McGuffie, K. and Henderson-Sellers, A., 1996: A Climate Modelling Primer (2nd ed.). Chapter 3.

McGuffie, K. and Henderson-Sellers, A., 1996: Building an EBM with Excel (pdf-file)

McGuffie, K. and Henderson-Sellers, A., 1996: Excel EBM model (xls-file)