User's guide

One-dimensional Energy Balance Model

The model can be run using default values by pressing the button "submit" located at the bottom of the page. A Northern Hemisphere map displaying zonal temperatures in colour shades is then generated overlaid by the position of the ice margin. Four other outputs can be chosen to be displayed in their zonal-average values namely: the albedo (%), the clouds (%), the outgoing infrared radiation (W m^{-2}), and the absorbed solar radiation (W m^{-2}). In order to test the model sensitivity to zonal climates, the user is prompted to modify the default values of the following parameters by moving the appropriate cursors or by overwriting default values in the proper boxes:

Parameters	Values		Outcome
	min	max	
α_{clouds}	0	1	clouds absorbs (0) or reflects (1) all the incoming solar radiation
α_{ice}	0	1	surface ice absorbs (0) or reflects (1) all the incident solar radiation
α_i	0	1	latitude *i* absorbs (0) or reflects (1) all the incident solar radiation at the surface
T_{crit} (°C)	-15	+5	snowline appears during cold (-15°C) or warm conditions (5°C)
K (W m^{-2} C^{-1})	0	50	no (0 W m^{-2} C^{-1}) or intense (50 W m^{-2} C^{-1}) heat transport
A (W m^{-2})	150	310	weak (150 W m^{-2}) or strong (310 W m^{-2}) infrared lost
B (W m^{-2} C^{-1})	0	20	no (0 W m^{-2} C^{-1}) or strong (20 W m^{-2} C^{-1}) temperature dependency on infrared lost to space
F_s	0.5	1.5	F_s x solar constant; weaker (0.5) or stronger (1.5) sun
C_i	0	1	latitude *i* having a clear (0) or totally cloudy (1) sky on average

A reset button allows recovering the default values. The user is also asked to choose one among 4 outputs to be displayed. By pushing “submit” a new map appears displaying the selected output on the basis of varying input values.

The zero-dimensional model shown in an earlier application may be expanded latitudinally. Consequently, in addition to the solar and infrared energy fluxes one must consider the energy transported across latitudes by the Atmosphere-Ocean system. This model formulation has the advantage of allowing a plausible dependence of albedo on temperature - the poles can be allowed to be icy and the equator warm. This more complex model is designed to examine the sensitivity of the predicted equilibrium climate to changes in the solar constant.

This simple climate model is governed by the equation devised by both Sellers and Budyko in 1969. The version used in the present context is derived from a code provided in Henderson-Sellers and McGuffie (1987) monograph. It is based on the equilibrium reached between the absorbed solar radiation, the emitted infrared terrestrial radiation and the rate of latitudinal heat transport. Using appropriate parameterisations for the outgoing infrared radiation and for the heat transport the model is represented by the following equation:

$$T_i = \frac{S_i(1-\alpha_i) + K\overline{T} - A}{B + K}$$

Successive applications of this equation will eventually generate an equilibrium solution for the equilibrium temperatures reached at each latitude bands *i*, T_i. The solution is a function of S_i, the mean annual solar radiation at the latitude band *i*, in the units of W m^{-2}, the zonal albedo, α_i, the heat transport coefficient, *K*, set equal to 3.81 W m^{-2} °C^{-1}, the mean global surface temperature, *T*, *A* and *B* governing the infrared radiation loss to space where *A* is initially set to 204 W m^{-2}, and *B* to 2.17 81 W m^{-2} °C^{-1}.

References cited

Budyko, M. I., 1969: The effect of solar radiation variations on the climate of the Earth, *Tellus,* **21,** 611-619.

Henderson-Sellers, A., and K. McGuffie, 1987: *Climate modelling primer*. John Wiley and Sons, 217 pp.

Sellers, W. D., 1969: A global climatic model based on energy balance of the Earth-Atmosphere system. *J. Appl. Meteorol.,* **8,** 392-400.