Principles of Planetary Climate
EC2213

Chirayu Gupta

Spring 2021

1 Assignment 2

1.1 Use the logistic albedo function instead of the quadratic albedo function. Change the exponent to 0.5, 1 and 2 to see how the snowball dynamics changes. Why are the dynamics different from the quadratic case? Explain the differences based on how the albedo changes close to 'T_ice_free' and 'T_ice_covered'.

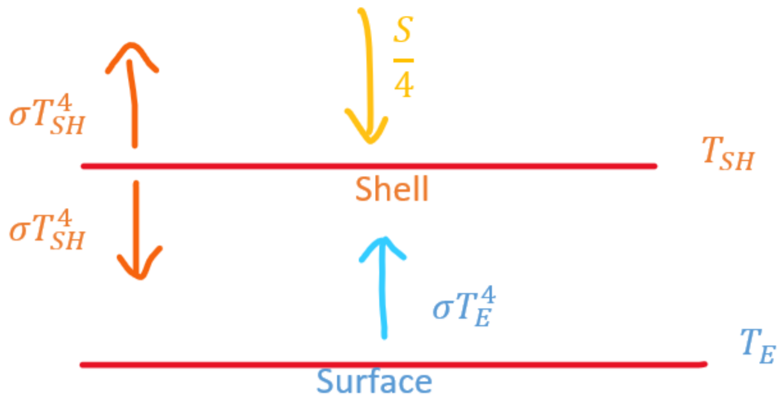
In the exponential albedo function the change in albedo close to 'T_ice_free' and 'T_ice_covered' is gradual at first after which there is a sudden drop(the rate of change of albedo appears proportional to the exponent). This sudden drop accounts for the larger drop in T_s in the exponential case and a fewer number of unstable states. In the quadratic case the change in albedo is not that steep at any point hence lesser drop in T_s

1.2 Plot the dynamics of the 0-D model for cloud forcing of values -5, 0, 5, 10 in a single plot. Does adding cloud forcing make the dynamics more geologically feasible? if no, why not? if yes, feasible in what way?

Yes adding cloud forcing makes the dynamics more feasible.
This is because the intermediate states are possible over a larger range of concentration of CO_2 values

1.3 0.5-D models energy balance equations

1.3.1 The shell absorbs all incoming shortwave radiation and is transparent to longwave radiation



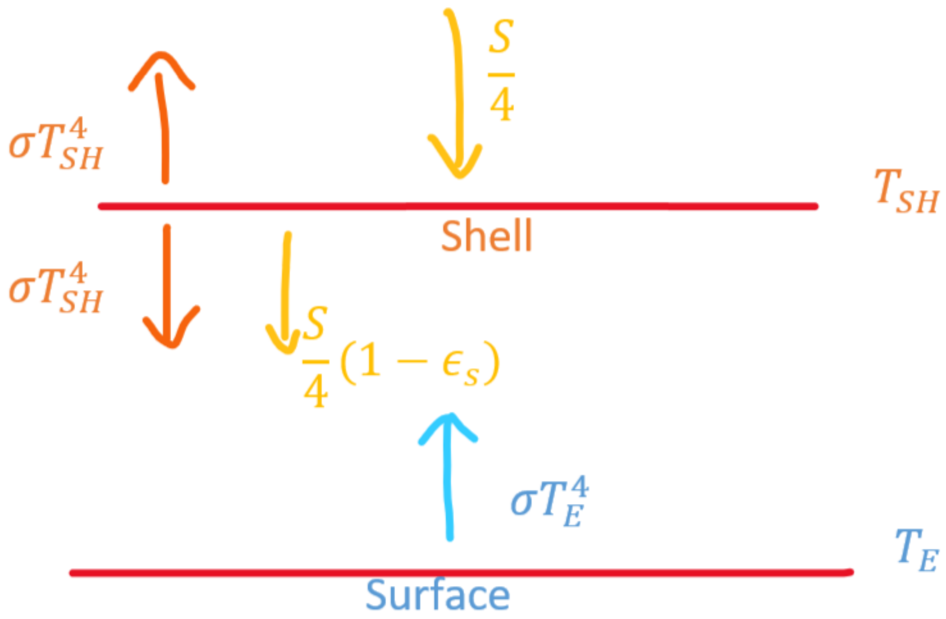
Energy balance for **shell**:

$$\frac{S}{4} = \sigma T_{SH}^4$$

Energy balance for **surface**:

$$\sigma T_{SH}^4 = \sigma T_E^4$$
$$\implies T_{SH} = T_E$$

1.3.2 The shell partially absorbs both shortwave (with coefficient ϵ_S) and longwave (with coefficient ϵ_L) radiation.



Energy balance for **shell**:

$$\frac{S}{4}\epsilon_S + \sigma T_E^4 \epsilon_L = \sigma T_{SH}^4$$

$$\implies \frac{S}{4} = \frac{\sigma T_{SH}^4 - \sigma T_E^4 \epsilon_L}{\epsilon_S} \quad (1)$$

Energy balance for **surface**:

$$\sigma T_{SH}^4 + \frac{S}{4}(1-\epsilon_S) = \sigma T_E^4$$

From (1):

$$T_{SH}^4 = T_E^4(\epsilon_S + \epsilon_L - \epsilon_S \epsilon_L)$$

For isothermal profile ($T_{SH} = T_E$):

$$(1-\epsilon_S)(1-\epsilon_L) = 0$$

Hence $\epsilon_S = 1$ or $\epsilon_L = 1$