Climate of the ocean – Exercise 1 **26.10.2016**

Task 1:

Calculate based on the values given in Figure 1

a) The albedo α of the earth.
b) The transmissivity of the atmosphere for the incoming shortwave radiation τ_{SW}.
c) The transmissivity of the atmosphere for the outgoing longwave radiation τ_{LW}.

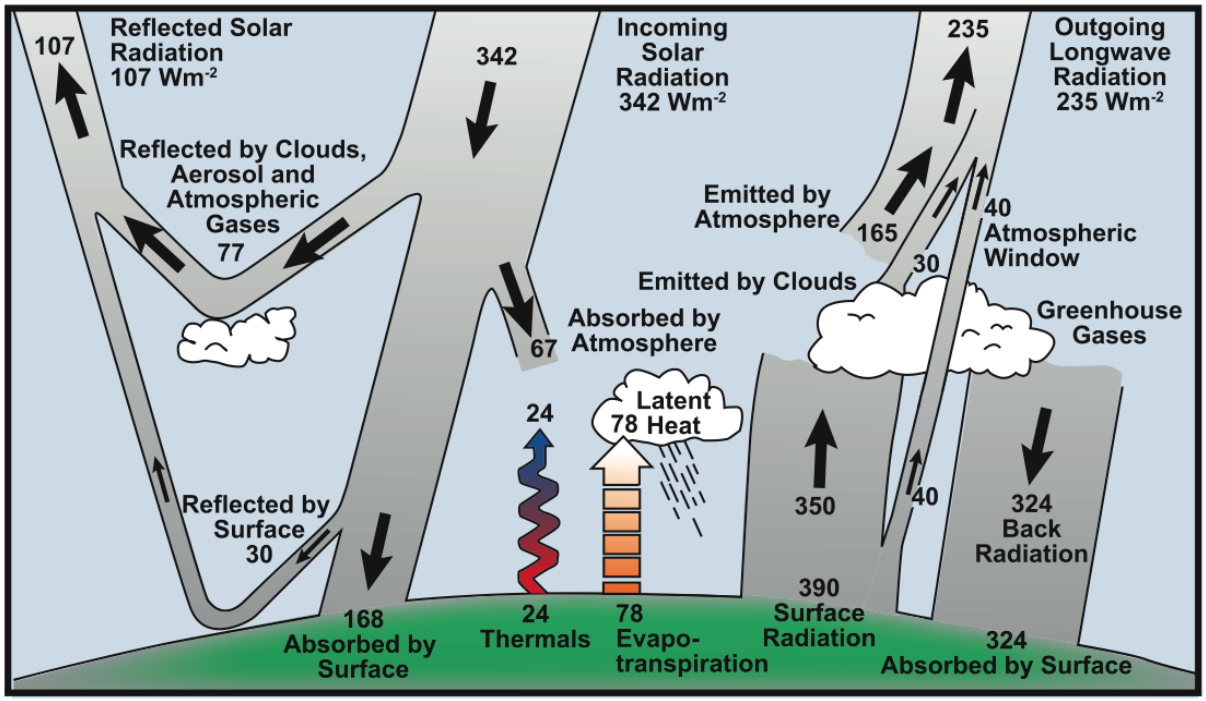

Figure 1: Global energy balance, Kiehl and Trenberth (2007)

Task 2:

Using the parameters calculated in task 1 calculate the surface temperature T_{surf} of the simple radiation balance model depicted in figure 2. ($\overline{S}$ – solar radiation, $F_{surf} = \sigma T_{surf}^4$, σ=5.67x10^{-8}W m^{-2} K^{-4}).

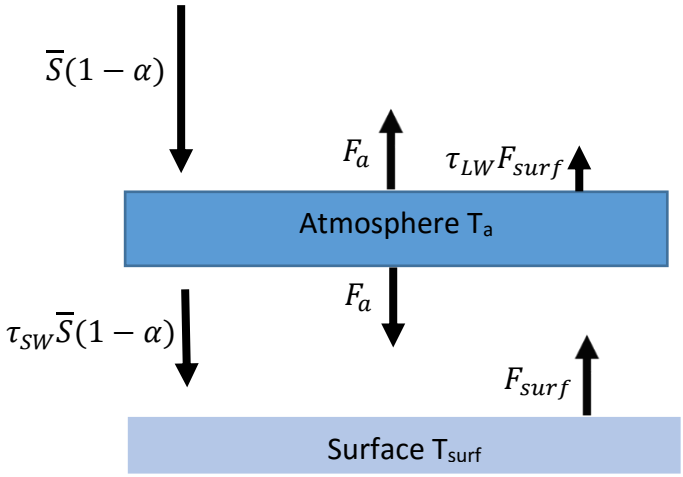

Figure 2: Simple radiation balance model with greenhouse effect

Task 3:

The albedo of the earth α_p is defined as:

$$\alpha_p = \alpha_L \; \forall \; T_{surf} < T_L$$

$$\alpha_p = \alpha_L + \frac{\Delta\alpha}{\Delta T}\left(T_{surf} - T_L\right) \; \forall \; T_L < T_{surf} < T_U$$

$$\alpha_p = \alpha_U \; \forall \; T_U < \; T_{surf}$$

with α_L=0.62, α_U=0.3, T_L=-10°C, T_U=0°C (see also Fig. 3).

In equilibrium:

$$F_{solar} = F_{thermal}$$

$$\frac{1}{4}\left(1 - \alpha_p\left(T_{surf}\right)\right) S_0 = \sigma T_{surf}^4 \quad \left(S_0 = 1368 \frac{W}{m^2}\right)$$

For the right-hand side one can apply the Budyko linearization:

$$\frac{1}{4}\left(1 - \alpha_p(T_{surf})\right) S_0 = A + B * (T_{surf} - 273.15))$$

with A=203.3 W/m^2 and B=2.09 W/m^2/K.

a) Calculate the equilibrium temperatures.
b) Are these equilibriums stable?

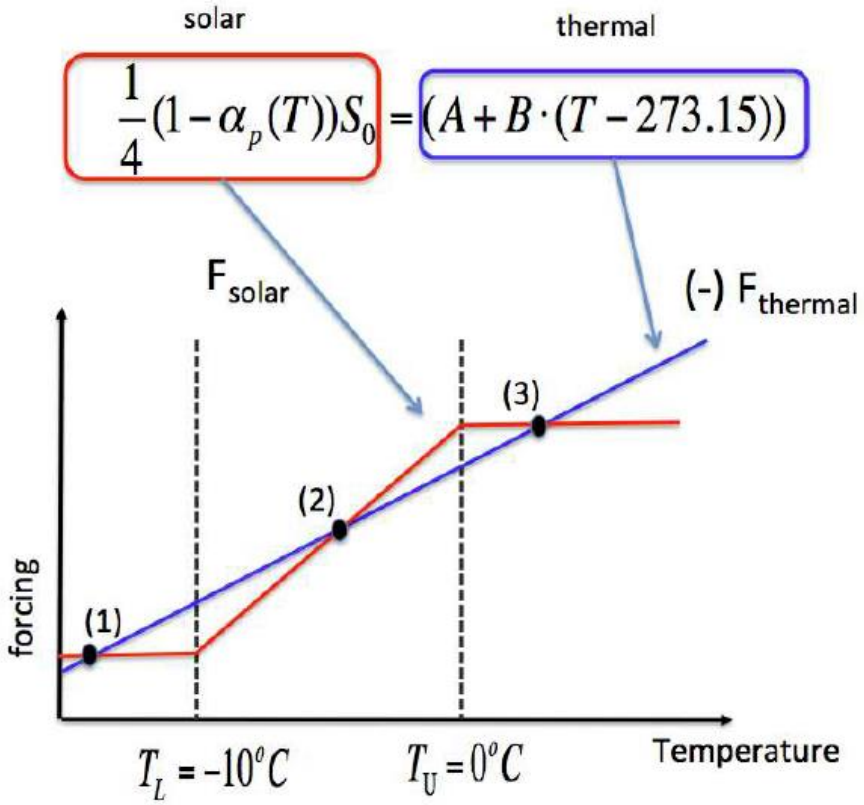

Figure 3: Radiation forcings of the Budyko model with ice albedo feedback.

Task 4:

The ice albedo feedback as displayed above is one example for a climate feedback. Explain in your own words the meanings of climate feedbacks and climate sensitivity and how the two are related.