Lab 1: coding a N-layer atmosphere model

Q1)

Une image contenant texte, écriture manuscrite, nombre, Police

Le contenu généré par l’IA peut être incorrect.

Une image contenant texte, écriture manuscrite, nombre, Police

Le contenu généré par l’IA peut être incorrect.

Q2)

I proceeded as suggested in the HW, I create, populate the matrix and vectors, inverse the matrix and calculate the flux. I paid attention to the fact that the formula to derive the Earth’s surface temperature from its flux is different than the other one since the emissivity of Earth’s surface is always equal to one.

The function that will run the N-layer atmosphere is called “solve\_N\_layer” and the function to validate if I did not make any mistake is called “validate\_model”.

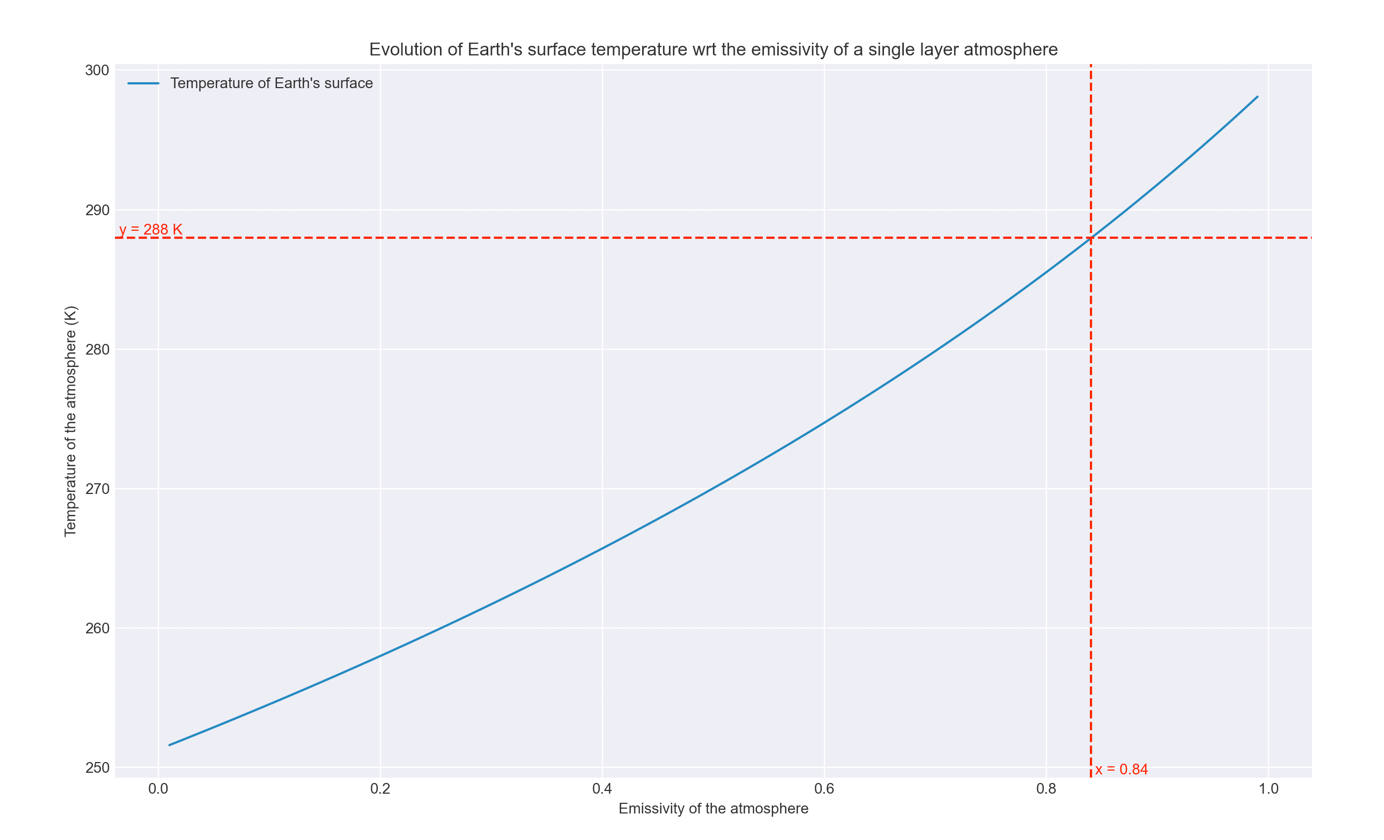
To validate the model I compared the temperatures given by my function with the temperatures given in <https://singh.sci.monash.edu/models/Nlayer/N_layer.html> in two situations. There are two possibilities to verify the model,

* If you just want to know what is the maximum difference between both, use validate\_model(0)
* If you want to know for each layer what is the difference with the website, use validate\_model(1)

3) How does the surface temperature of Earth depend on emissivity and the number of layers?

To answer the science question, we should try to plot the individual influence of each parameter.

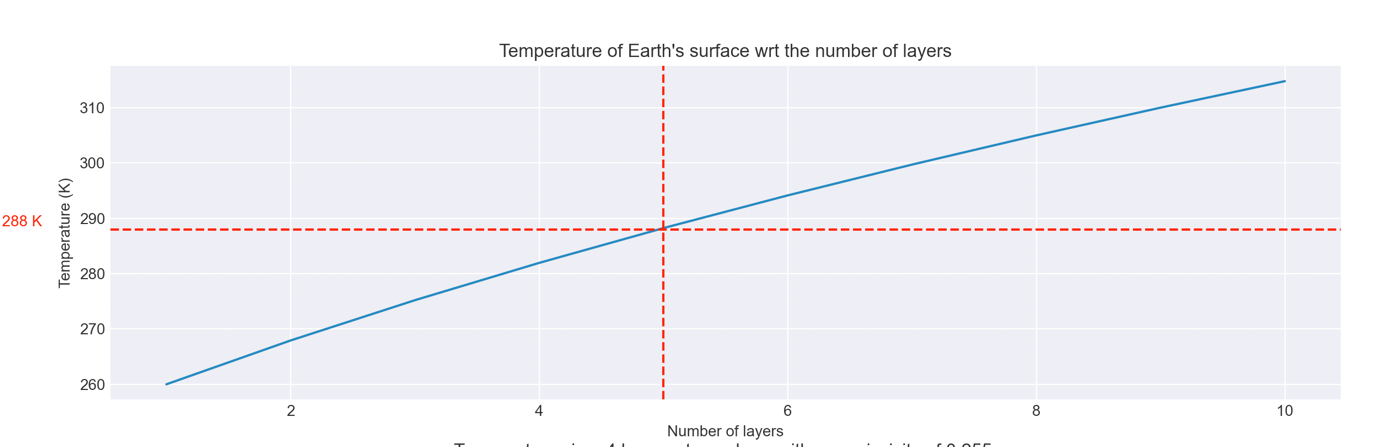
1. In the first case I set the number of layers to be one, the solar constant to be S0=1350W/m2, the earth albedo to 0.33, and I calculated Earth’s surface temperature (with the N-layer model described before) for emissivity from 0.01 to 0.99 with a step of 0.01.



As we can see on the figure, the Earth’s surface temperature increases with the emissivity of the atmosphere. The curve is non-linear but modelling it with a linear curve could be a good-enough approximation. The surface temperature would be 252K if there was no atmosphere (emissivity of 0.01) and 298K if the single layer was opaque to longwave radiation. This behaviour is expected, indeed, because we made the hypothesis that emissivity=absorptivity, when we increase the emissivity of the layer, we increase its absorptivity. Thus, more Earth longwave radiation is being absorbed and the greenhouse effect is more important.

I found that the emissivity of the single layer should be equal to 0.84 to match Earth’s surface temperature (288 K). This emissivity (=absorptivity) is high, it means that 84% of the radiation emitted from earth would be absorbed by the layer. Therefore, a single layer cannot model properly earth’s atmosphere, we should take into consideration multiple layers.

b) In the second case, we want to see the influence of the number of layers on the surface temperature. I set the emissivity of the layers to be 0.255 (the effective emissivity of Earth’s atmosphere). the solar constant to be S0=1350W/m2, and the earth albedo to 0.33, and I calculated Earth’s surface temperature for number of layers from 1 to 10.



In the figure we can see that the Temperature increase almost linearly with the number of layers (at least between 0 and 10 layers), Earth’s surface temperature increases with the number of layers from 260 K with 1 layer to 315 K with 10 layers.

I found that if we consider an atmosphere with many layers of emissivity 0.255, 4 layers are necessary to match Earth’s surface temperature. In fact, to match this temperature, it would require between 4 and 5 layers, which I cannot simulate with the current model. This could be done using an changing emissivity between the layers, but this was not the goal of this simple model.

To plot the temperature with ratio to altitude, I used two simplifications:

* I considered that the layers are evenly distributed within the atmosphere
* I considered that the atmosphere height is 100km

With these two hypotheses, we can plot the Temperature of the atmosphere with ratio to the altitude.

Une image contenant ligne, Tracé, diagramme, texte

Le contenu généré par l’IA peut être incorrect.

On this graph we can see that there is slope that is really lower for the first 25km. This slope corresponds to the variation between the layer 0–Earth’s surface–and the first layer of atmosphere. We can explain the slope difference by the fact that we considered Earth as emitting with an emissivity of 1 whereas all the layer of atmosphere will have an emissivity of 0.255.

Q4) How many atmospheric layers do we expect on the planet Venus?

To answer this I used the same technique than for question 3)b): I plotted the surface temperature of Venus for a varying number of layers from 1 to 100. Then I

Une image contenant ligne, Tracé, diagramme, texte

Le contenu généré par l’IA peut être incorrect.

Q5)

Put arbitrary albedo for opaque layer

Consider that all layers have the same emissivity for LW radiation, and that the first layer is opaque to SW radiation -> all sun light (but albedo 0.4 chosen by me ) is absorbed

229 K for the whole atmosphere 229 K for the top layer

Une image contenant texte, capture d’écran, ligne, Rectangle

Le contenu généré par l’IA peut être incorrect.

Add a discussion part, limiting….

Balanced ? dynamics ? converction, water …

Explains what and why you choose data not given in the HW