第 2 次作业

危国锐 516021910080
（上海交通大学电子信息与电气工程学院，上海 200240）

摘 要：第二章作业.
关键词：关键词 1，关键词 2

Homework 2

Guorui Wei 516021910080
(*School of Electronic Information and Electrical Engineering*,
Shanghai Jiao Tong University, *Shanghai* 200240, *China*)

Abstract: Selected exercises for chapter 2.
Keywords: keyword 1, keyword 2

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1 Question 1

"Calculate the emission temperature of Earth if the solar luminosity is 30% less, as it is hypothesized to have been early in solar system history. Use today's albedo and Earth-Sun distance."(Hartmann, 2016, p. 48)

1.1 Solution

Using Eq. (2.10), the emission temperature of Earth

$$T_{\mathrm{e}}=\sqrt[4]{\frac{S_0'\left(1-\alpha_{\mathrm{p}}\right)}{4\sigma}}=\left(\frac{1360\times(1-30\%)\times(1-0.29)}{4\times(5.67\times10^{-8})}\right)^{\frac{1}{4}}=234\ \mathrm{K}.$$

2 Question 2

"Using the data in Fig. 2.4, estimate the blackbody temperature of Earth's surface and the blackbody temperature of the atmosphere as viewed from Earth's surface. How well do these temperatures agree with the temperatures derived from the model shown in Fig. 2.3?" (Hartmann, 2016, p. 48)

2.1 Solution

Applying the Stefan–Boltzmann law, the blackbody temperature of Earth's surface is

$$T_{\mathrm{S,BB}}=\left(\frac{E_{\mathrm{S,BB}}}{\sigma}\right)^{1/4}=\left(\frac{396}{5.67\times10^{-8}}\right)^{1/4}=289\ \mathrm{K},$$

and the blackbody temperature of the atmosphere as viewed from Earth's surface is

$$T_{\mathrm{A,BB}}=\left(\frac{E_{\mathrm{A,BB}}}{\sigma}\right)^{1/4}=\left(\frac{345}{5.67\times10^{-8}}\right)^{1/4}=279\ \mathrm{K}.$$

In the model shown in Fig. 2.3, we obtained

$$T_{\mathrm{S}}=\sqrt[4]{2}T_{\mathrm{A}}=\sqrt[4]{2}\sqrt[4]{\frac{S_0\left(1-\alpha_{\mathrm{p}}\right)}{4\sigma}}=\sqrt[4]{2}\times255\ \mathrm{K}=304\ \mathrm{K}$$

from Eq. (2.13) and (2.14).

We see that $T_{\mathrm{A}}<T_{\mathrm{A,BB}}$ but $T_{\mathrm{S}}>T_{\mathrm{S,BB}}$, i.e. compared to the observed global mean surface or atmosphere temperature (equivalent black body radiation temperature), the atmosphere temperature in the model shown in Fig. 2.3 is higher. However, the surface temperature in the model shown in Fig. 2.3 is lower than the observed temperature.

"This is because we have not taken into account the vertical transport of energy by atmospheric motions." (Hartmann, 2016, p. 33)

References

Hartmann, D. L. (2016). Chapter 2 - The Global Energy Balance. In D. L. Hartmann (Ed.), *Global Physical Climatology (Second Edition)* (pp. 25-48). Elsevier. https://doi.org/10.1016/B978-0-12-328531-7.00002-5