An Explanation of Global Warming without Supercomputing

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Abstract

A new analytic solution of the radiative transfer equation is proposed. It is an extension of the semi-gray model developed by Weaver and Ramanathan. We consider the two parts of thermal spectra independently. In the first the infrared absorption (or radiation) is only due to water vapor. In the second both water vapor and carbon dioxide are active. The pre-industrial values of the corresponding two optical depths are determined so as to reproduce the global average temperature and the infrared spectrum observed by satellite spectrometer. Then, their post-industrial values are calculated on the assumption that the optical depth of carbon dioxide is proportional to its concentration but the optical depth of water vapor is fixed. As a result we can reproduce the climate change after 1850 fairly well. It is also found that the climate sensitivity never exceeds 6 °C. Consequently, the anthropogenic global warming is severely limited because the Earth is a planet of water.

1 Introduction

Now, it is well known that most of climate scientists attribute the climate change since the industrial revolution to the growing concentration of carbon dioxide (CO_2) by burning fossil fuel. Their *consensus* [1,2,3] on this anthropogenic global warming (AGW) is essentially based on the results of elaborate and enormous computer simulations as seen in Figure 9.5 on the 4th Assessment Report (AR4) [4] of Intergovernmental Panel on Climate Change (IPCC).

In this respect we note the following statement by Dr. Weart in "Forum on Physics & Society" on the website of American Physical Society [5]:

"*Physics is rich in phenomena that are simple in appearance but cannot be calculated in simple terms. Global warming is like that.*"

However, there will be not a few physicists who do not agree with him. See Fig. 1. The observed trend of global warming after 1850 clearly reflects the growing of CO_2 concentration. Contrary to climate scientists, some physicists will expect from the result that the global warming can be reproduced in a relatively simple way only on the basic theory of greenhouse gas (GHG). In the present work I challenge the subject.

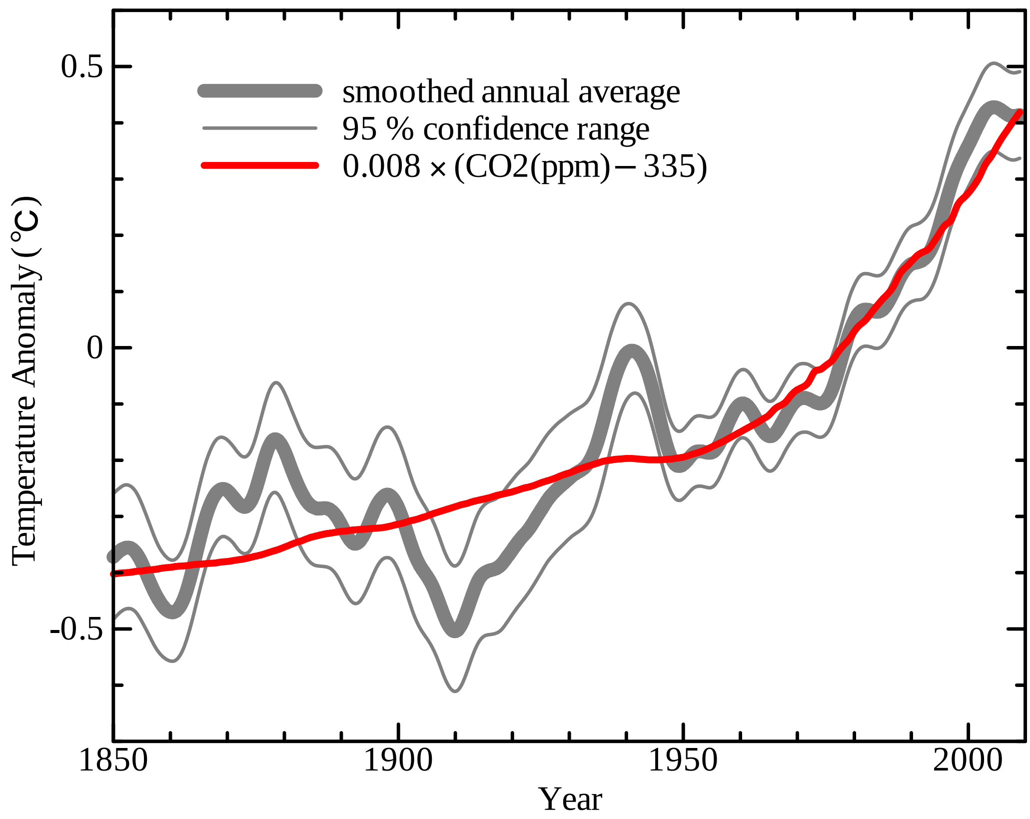

Figure 1: The gray curves are the observed temperature anomalies of Met Office Hadley Centre observations datasets [6]. The anomaly means the difference from an average temperature between 1961 and 1990. The blue curve is the calculated result of $0.008 \times (n - 335)$, where n is CO_2 concentration (ppm) from Carbon Dioxide Information Analysis Center (CDAIC) [7] and National Oceanic and Atmospheric Administration (NOAA) [8].

2 Extension of Ramanathan's semi-gray model

The atmospheric absorption of infrared radiation (IR) from the earth surface and the atmospheric back-radiation to the surface is formulated in the theory of radiative transfer. The basic equation is the following Schwarzschild equation [9,10]:

$$\cos\theta \frac{d I_\lambda}{d \tau_\lambda} = I_\lambda - B_\lambda(T) \,, \tag{1}$$

where I_λ is the intensity of radiation with wavelength λ, τ_λ is the corresponding optical depth, $B_\lambda(T)$ is the Plank function of temperature T and θ is the zenith angle of the direction of radiation. Under the approximation of plain-parallel gray atmosphere, Eq. (1) is solved analytically and the surface air temperature is given by

$$T(\tau^*)^4 = \frac{2 + 3\tau^*}{4} T_{eff}^4, \tag{2}$$

where τ^* is the total optical depth of atmosphere and $T_{eff} = 255\,\mathrm{K}$.

Equation (2) however has a serious deficiency. The surface air temperature diverges when the atmosphere is a black body. But, if the temperature of black body is infinite, the Kirchhoff law, on which the Schwarzschild equation is based, has not been found. Surprisingly, climate scientists have ignored this inconsistency until Weaver and Ramanathan [11] have resolved the problem at 1995. They modified the gray model to take into account the spectral window in thermal spectrum and obtained the following result in place of Eq. (2):

$$T\,(\tau^*)^4 = \frac{2 + 3\,\tau^*}{4 + 3\,(1-\beta)\,\tau^*}\,T_{eff}^{\,4}, \tag{3}$$

where the fraction $1-\beta \simeq 0.3$ of total thermal spectrum is transparent to thermal radiation. (It is noted that β in the present work corresponds to $1-\beta$ in Ref. [11].)

However, the Weaver-Ramanathan semi-gray model is not beyond the original gray model in the sense that it does not distinguish CO_2 and the other GHGs. Because the atmospheric greenhouse effect is mainly due to water vapor and CO_2 but the AGW is due to the growing concentration of the latter, we should distinguish the greenhouse effects of water vapor and CO_2 so as to explain the AGW. For the purpose we divide the fraction $\beta \simeq 0.7$ of total thermal spectrum, which is opaque to IR, into two regions as follows:

$$\bar{I}_I = \int_{\lambda_1}^{\lambda_2} I_\lambda\, d\,\lambda\;, \tag{4}$$

$$\bar{I}_{II} = \int_{\lambda_3}^{\lambda_4} I_\lambda\, d\,\lambda, \tag{5}$$

where CO_2 is active only within $\lambda_3 \le \lambda \le \lambda_4$ while water vapor is active over $\lambda_1 \le \lambda \le \lambda_2$ and $\lambda_3 \le \lambda \le \lambda_4$. It is noted that Eq. (4) has only schematic meaning, because in fact the thermal window cuts the absorption spectrum of water vapor into two regions. However, such a detailed structure of thermal spectrum does not affect the results below.

Then, we integrate Plank function similarly:

$$S_I \equiv \pi \int_{\lambda_1}^{\lambda_2} B_\lambda(T)\, d\lambda \;= \beta_I\, \sigma\, T^4, \tag{6}$$

$$S_{II} \equiv \pi \int_{\lambda_3}^{\lambda_4} B_\lambda(T)\, d\lambda = \beta_{II}\, \sigma\, T^4, \tag{7}$$

where σ is the Stefan-Boltzmann constant. The sum of β_I and β_{II} equals to β in Eq. (3):

$$\beta = \beta_I + \beta_{II}. \tag{8}$$

In the present work, it is assumed that β_I, β_{II} and β are independent on temperature according to Ref. [11].

Next, we use the Eddington approximation:

$$S_I \simeq \pi \left(C_I^{(0)} + C_I^{(1)} \, \tau_I \right) , \tag{9}$$

$$S_{II} \simeq \pi \left(C_{II}^{(0)} + C_{II}^{(1)} \, \tau_{II} \right) , \tag{10}$$

where in each of the spectra I and II the optical depth is independent on wavelength. The upwelling and downwelling fluxes are given by

$$F_I^{\uparrow\downarrow} \left(\tau_I \right) = \pi \left(C_I^{(0)} + C_I^{(1)} \tau_I \right) \pm \frac{2\,\pi}{3} \, C_I^{(1)}, \tag{11}$$

$$F_{II}^{\uparrow\downarrow} \left(\tau_{II} \right) = \pi \left(C_{II}^{(0)} + C_{II}^{(1)} \tau_{II} \right) \pm \frac{2\,\pi}{3} \, C_{II}^{(1)}, \tag{12}$$

where the sign of the second term in the right hand side is + for upwelling and − for downwelling flux, respectively.

Because there are no downwelling fluxes at the top of atmosphere (TOA), we have the following two conditions:

$$\begin{aligned} &\left[F_I^{\uparrow} \left(\tau_I = 0 \right) + F_I^{\downarrow} \left(\tau_I = 0 \right) \right] + \left[F_{II}^{\uparrow} \left(\tau_{II} = 0 \right) + F_{II}^{\downarrow} \left(\tau_{II} = 0 \right) \right] + \left(1 - \beta \right) \sigma \, T_g^4 \\ &\qquad = 2\,\pi \left[\, C_I^{(0)} + C_{II}^{(0)} \, \right] + \left(1 - \beta \right) \sigma \, T_g^4 \; = \; \sigma \, T_{eff}^4, \end{aligned} \tag{13}$$

$$\begin{aligned} &\left[F_I^{\uparrow} \left(\tau_I = 0 \right) - F_I^{\downarrow} \left(\tau_I = 0 \right) \right] + \left[F_{II}^{\uparrow} \left(\tau_{II} = 0 \right) - F_{II}^{\downarrow} \left(\tau_{II} = 0 \right) \right] + \left(1 - \beta \right) \sigma \, T_g^4 \\ &\qquad = \frac{4\,\pi}{3} \left[\, C_I^{(1)} + C_{II}^{(1)} \, \right] + \left(1 - \beta \right) \sigma \, T_g^4 \; = \; \sigma \, T_{eff}^4, \end{aligned} \tag{14}$$

where T_g is the surface temperature.

From Eqs. (6) and (9) the temperature at TOA is

$$\sigma \, T \left(\tau_I = 0 \right)^4 = \pi \, \frac{C_I^{(0)}}{\beta_I}, \tag{15}$$

while from Eqs. (7) and (10) it is

$$\sigma \, T \left(\tau_{II} = 0 \right)^4 = \pi \, \frac{C_{II}^{(0)}}{\beta_{II}}. \tag{16}$$

Because of $T \left(\tau_I = 0 \right) = T \left(\tau_{II} = 0 \right)$, from Eq. (13) we have

$$C_I^{(0)} = \frac{1}{2\,\pi} \, \frac{\beta_I}{\beta} \, \sigma \left[\, T_{eff}^4 - \left(1 - \beta \right) T_g^4 \, \right] , \tag{17}$$

$$C_{II}^{(0)} = \frac{1}{2\,\pi} \, \frac{\beta_{II}}{\beta} \, \sigma \left[\, T_{eff}^4 - \left(1 - \beta \right) T_g^4 \, \right] . \tag{18}$$

Moreover, from Eqs. (6) and (9) the surface air temperature is

$$\sigma\, T\left(\tau_I^*\right)^4 = \pi\, \frac{C_I^{(0)} + C_I^{(1)}\, \tau_I^*}{\beta_I}, \tag{19}$$

while from Eqs. (7) and (10) it is

$$\sigma\, T\left(\tau_{II}^*\right)^4 = \pi\, \frac{C_{II}^{(0)} + C_{II}^{(1)}\, \tau_{II}^*}{\beta_{II}}. \tag{20}$$

Because of $T\left(\tau_I^*\right) = T\left(\tau_{II}^*\right)$, from Eq. (14) we have

$$C_I^{(1)} = \frac{3}{4\pi}\, \frac{\beta_I\, \tau_{II}^*}{\beta_I\, \tau_{II}^* + \beta_{II}\, \tau_I^*}\, \sigma\left[T_{eff}^4 - (1-\beta)\, T_g^4\right], \tag{21}$$

$$C_{II}^{(1)} = \frac{3}{4\pi}\, \frac{\beta_{II}\, \tau_I^*}{\beta_I\, \tau_{II}^* + \beta_{II}\, \tau_I^*}\, \sigma\left[T_{eff}^4 - (1-\beta)\, T_g^4\right]. \tag{22}$$

Consequently, the upwelling and downwelling fluxes at any optical depth are

$$F_I^{\uparrow}(\tau_I) + F_{II}^{\uparrow}(\tau_{II}) = \left(1 + \frac{3}{4}\,\tau\right) \sigma\left[T_{eff}^4 - (1-\beta)\, T_g^4\right], \tag{23}$$

$$F_I^{\downarrow}(\tau_I) + F_{II}^{\downarrow}(\tau_{II}) = \frac{3}{4}\,\tau\, \sigma\left[T_{eff}^4 - (1-\beta)\, T_g^4\right], \tag{24}$$

where

$$\tau = \frac{\beta_I\, \tau_{II}^*\, \tau_I + \beta_{II}\, \tau_I^*\, \tau_{II}}{\beta_I\, \tau_{II}^* + \beta_{II}\, \tau_I^*}. \tag{25}$$

The radiative equilibrium is really satisfied.

From the radiative equilibrium condition at surface

$$F_I^{\downarrow}(\tau_I^*) + F_{II}^{\downarrow}(\tau_{II}^*) + \sigma\, T_{eff}^4 = \sigma\, T_g^4, \tag{26}$$

the surface temperature is given by

$$T_g^4 = \frac{4 + 3\,\tau^*}{4 + 3\,(1-\beta)\,\tau^*}\, T_{eff}^4, \tag{27}$$

where

$$\frac{1}{\tau^*} = \frac{\beta_I}{\beta}\, \frac{1}{\tau_I^*} + \frac{\beta_{II}}{\beta}\, \frac{1}{\tau_{II}^*}. \tag{28}$$

Utilizing this equation, Eq. (25) is rewritten as

$$\frac{\tau}{\tau^*} = \frac{\beta_I}{\beta}\, \frac{\tau_I}{\tau_I^*} + \frac{\beta_{II}}{\beta}\, \frac{\tau_{II}}{\tau_{II}^*}. \tag{29}$$

Substituting Eqs. (17) and (21) into Eq. (9) and using Eq. (27), we have

$$T\left(\tau_I\right)^4 = \frac{2+3\left(\tau^*/\tau_I^*\right)\tau_I}{4+3\left(1-\beta\right)\tau^*}\,T_{eff}^4. \tag{30}$$

Similarly, substituting Eqs. (18) and (22) into Eq. (10) and using Eq. (27), we have

$$T\left(\tau_{II}\right)^4 = \frac{2+3\left(\tau^*/\tau_{II}^*\right)\tau_{II}}{4+3\left(1-\beta\right)\tau^*}\,T_{eff}^4. \tag{31}$$

Because of

$$\beta\,\sigma\,T\left(\tau\right)^4 = \beta_I\,\sigma\,T\left(\tau_I\right)^4 + \beta_{II}\,\sigma\,T\left(\tau_{II}\right)^4, \tag{32}$$

the temperature profile of atmosphere is given by

$$T\left(\tau\right)^4 = \frac{2+3\,\tau}{4+3\left(1-\beta\right)\tau^*}\,T_{eff}^4. \tag{33}$$

Consequently, the surface air temperature is given by the same form as Eq. (3).

Finally, the above results are easily generalized by using

$$\beta = \beta_I + \beta_{II} + \beta_{III} + \cdots, \tag{34}$$

$$\frac{1}{\tau^*} = \frac{\beta_I}{\beta}\frac{1}{\tau_I^*} + \frac{\beta_{II}}{\beta}\frac{1}{\tau_{II}^*} + \frac{\beta_{III}}{\beta}\frac{1}{\tau_{III}^*} + \cdots, \tag{35}$$

$$\frac{\tau}{\tau^*} = \frac{\beta_I}{\beta}\frac{\tau_I}{\tau_I^*} + \frac{\beta_{II}}{\beta}\frac{\tau_{II}}{\tau_{II}^*} + \frac{\beta_{III}}{\beta}\frac{\tau_{III}}{\tau_{III}^*} + \cdots, \tag{36}$$

in place of Eqs. (8), (28) and (29).

3 Analyses and Discussion

Now, we apply the above model to AGW. For the purpose the values of β_I, β_{II} and β should be determined. First, we choose $\beta = 0.7$ according to Ref. [11]. Second, β_{II} is determined as follows:

$$\beta_{II} = \left(\pi \int_{\lambda_3}^{\lambda_4} B_\lambda\left(T\right)\right) \Big/ \left(\sigma\,T^4\right) = 0.2, \tag{37}$$

where $\lambda_3^{-1} = 1250\,\mathrm{cm}^{-1}$, $\lambda_4^{-1} = 800\,\mathrm{cm}^{-1}$ and $T = 300\,\mathrm{K}$. (In the present work we take into account water vapor and CO_2 but O_3 is not considered.) Consequently, $\beta_I = 0.5$.

Next, we determine the values of $\tau_I^*\left(n_0\right)$ and $\tau_{II}^*\left(n_0\right)$ for the pre-industrial level of CO_2 concentration $n_0 = 280\,\mathrm{ppm}$. Two conditions are necessary. One of them is obvious.

We can employ Eq. (3).

$$\frac{2+3\,\tau^*(n_0)}{4+3\,(1-\beta)\,\tau^*(n_0)}\,(255\,\mathrm{K})^4=(288\,\mathrm{K})^4\,. \tag{38}$$

Consequently, $\tau^*(n_0)=2.94$ is obtained.

Another condition is a problem. In the present work we note the earth's radiation spectrum around $15\mu m$ CO_2 band is well reproduced by the blackbody radiation of the brightness temperature $T_{II}\approx 215\,\mathrm{K}$ irrespective of surface temperature. (See Fig. 8.3 in Ref [12].) This indicates that the upwelling flux in the spectrum II is suitable to determine the pre-industrial values of the optical depths although the satellite observation is far later than the industrial revolution. Therefore, we have

$$F_{II}^{\uparrow}(\tau_{II}=0)=2\,\beta_{II}\,\frac{1+\tau^*/\tau_{II}^*}{4+3\,(1-\beta)\,\tau^*}\,\sigma\,T_{eff}^4=\beta_{II}\,\sigma\,T_{II}^4. \tag{39}$$

Consequently,

$$\tau_{II}^*(n_0)=\frac{2\,\tau^*(n_0)\,T_{eff}^4}{[\,4+3\,(1-\beta)\,\tau^*(n_0)]\,T_{II}^4-2\,T_{eff}^4}=4.33. \tag{40}$$

Substituting Eq. (40) into Eq. (28) we have

$$\tau_I^*(n_0)=\frac{2\,\beta_I\,\tau^*(n_0)\,T_{eff}^4}{2\,(\beta_{II}+\beta)\,T_{eff}^4-\beta_{II}\,[\,4+3\,(1-\beta)\,\tau^*(n_0)]\,T_{II}^4}=2.6. \tag{41}$$

Next, we assume $\tau_{II}^*-\tau_I^*=\tau_{\mathrm{CO2}}^*$ because in our model the optical depth of water vapor or CO_2 is independent on wavelength. Then, the post-industrial value of τ_{CO2}^* is evaluated in a following simple way:

$$\tau_{\mathrm{CO2}}^*(n)=\frac{n}{n_0}\,\tau_{\mathrm{CO2}}^*(n_0)\,, \tag{42}$$

where n is the post-industrial value of CO_2 concentration. On the other hand, we assume that τ_I^* is invariable:

$$\tau_I^*(n)=\tau_I^*(n_0)\,. \tag{43}$$

Then, we calculate the post-industrial value of $\tau_{II}^*(n)=\tau_I^*(n)+\tau_{\mathrm{CO2}}^*(n)$ using the data of CDAIC [7] and NOAA [8]. Substituting the values of $\tau_I^*(n)$ and $\tau_{II}^*(n)$ into Eq. (28), the post-industrial value of $\tau^*(n)$ is calculated. Finally, substituting the resultant value into Eq. (3) the climate change due to the growing CO_2 concentration is calculated.

The result is shown in Fig. 2. It is found that the global warming trend is well reproduced by a simple analytic model. Although we have compared our model with the combined land-surface air temperature and sea-surface temperature rather than the pure land-surface air temperature, it is reasonable because the brightness temperature T_{II} in Eq. (39) has a constant value of 215 K whether the radiation is from land or sea.

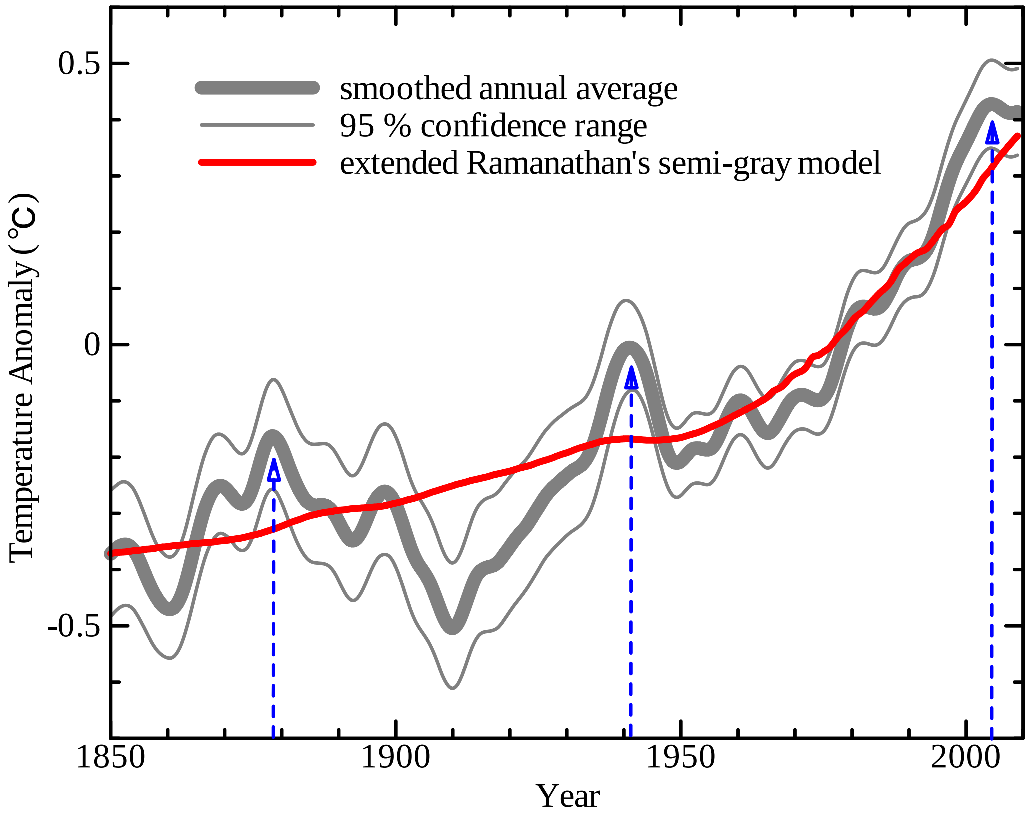

Figure 2: The gray curves are the same as Fig.1 while the red curve is the result of the extended Ramanathan's semi-gray model developed in section 2. The blue dashed arrows indicate the peaks in natural periodic climate oscillations of 60-years cycle.

It is well known [13] that the feedback between the increasing temperature and the growing CO_2 concentration plays a crucial role in AGW. Where is the feedback in our model? Because the optical depths $\tau^*(n_0)$ and $\tau^*_{II}(n_0)$ are determined from observations, $\tau^*_{\mathrm{CO2}}(n_0)$ naturally contains the feedback of pre-industrial level. On the other hand, the prescription (42) appropriately derives the feedback of post-industrial level. (In this sense, the optical depths determined by Eqs. (40), (41) and (42) are different from their original definitions.) This is the reason of the successful result in Fig. 2.

The success of our model using a fixed value of τ^*_I imposes a crucial limitation on AGW. Because of Eqs. (42) and (43), $\tau^*_{II} \gg \tau^*_I$ is satisfied if the CO_2 concentration becomes large. Thus, we have the upper limit of the optical depth $\tau^*(n \to \infty) = (\beta/\beta_I)\,\tau^*_I(n_0) = 3.64$ from Eq. (28). Consequently, from Eq. (3) the upper limit of AGW is

$$\lim_{\tau^*_{II}\to\infty} T(\tau^*_{II}) - (288\,\mathrm{K}) = \left[\frac{2\,\beta_I + 3\,\beta\,\tau^*_I(n_0)}{4\,\beta_I + 3\,\beta\,(1-\beta)\,\tau^*_I(n_0)}\right]^{1/4} \times (255\,\mathrm{K}) - (288\,\mathrm{K}) = 6.4\,^\circ\mathrm{C}. \tag{44}$$

Although the recent report [14] mentions that adding 1km to the CO_2 fog layer will heat the surface climate by 6.5 °C, it is unlikely that such a crisis is realized.

Here, we have to note that the limitation on AGW is due to the optical depth of water vapor $\tau_I^*(n_0)$. It is therefore concluded that the AGW is limited because the Earth is a planet of water against Venus. Of course, the above value is the limit of greenhouse effect. If the atmospheric pressure becomes high as on Venus, it is meaningless. However, the CO_2 concentration never becomes infinite. In our model the atmospheric temperature rises by 6 °C at $n = 50\, n_0$. Even then, only 2% of atmosphere is composed of CO_2. Moreover, the increase of CO_2 by burning fossil fuel decreases O_2. Therefore, even if the atmospheric temperature rises up to 6 °C owing to the loose anthropogenic CO_2 emission, the component and pressure of atmosphere on the Earth are completely different from those on Venus.

Although the global warming up to 6 °C will cause serious effects, the recent investigation [15] reveals that a peak Antarctic interglacial temperature was at least 6 °C higher than that of the present day. This indicates that the AGW never destroys the earth ecosystem until it cannot return to the pre-industrial state. To the contrary, at 1992 Article 2 [16] of the United Nations Framework Convention on Climate Change (UNFCCC) gave a warning to the dangerous anthropogenic interference (DAI) with the climate system so as to avert irreversible climate catastrophe. Then, it has been circulated among scientists, economists and policymakers [17] that the threshold for DAI is 2 °C global warming from pre-industrial level. Moreover, some scientists alarm [18,19] that the present CO_2 concentration already represents DAI. It is however unlikely that such an extreme alarmism is meaningful.

Equation (44) also indicates that the so-called climate sensitivity $\Delta T = T\,(n = 2\, n_0) - T\,(n_0)$ never exceeds 6 °C. This conclusion is consistent with Ref. [20]. To the contrary, the elaborate and enormous computer simulation of AGW predicts the climate sensitivity as much as 11.5 °C [21] that is far beyond the limit. This suggests that the computer simulation outputs unphysical results. Moreover, as seen in Table 9.3 of AR4 [4], many investigations based on the analyses of observations predict the climate sensitivities being much larger than the limit. It is however unlikely that they are realized. (Fairly speaking, the recent work [22] criticizes that Ref. [20] does not convincingly reduce the large uncertainty of climate sensitivity remaining in previous observationally based studies.)

The IPCC itself concludes that the climate sensitivity is likely to lie between 2 °C and 4.5 °C with a most likely value of approximately 3 °C. Because 2 °C is now believed to be the DAI threshold value, it is a crucial problem whether the climate sensitivity is above or below 2 °C. In this sense, our model is clearly opposite to IPCC prediction because the climate sensitivity in our model is $\Delta T = 1.7$ °C.

Because our model is only based on the fundamental theory of GHG, it cannot reproduce the climate oscillation due to natural cause. This suggests that the climate changes indicated by the dashed arrows in Fig. 2 are the results of natural oscillation of about 60-years cycle. To the contrary, as seen in FAQ. 3.1 of AR4 [4] the IPCC regards the rapid warming after 1980 as a prominent evidence of AGW. Which of these is reliable? The elaborate and enormous computer simulations should take into account natural forcing on climate change in contrast to our simple model. Nevertheless, as seen in Fig. 9.5 of AR4 [4] the IPCC cannot reproduce the apparent warming [23] around 1940. This indicates that the computer simulations are not yet successful in elucidating natural climate oscillation. On the other hand, no observation of global warming after 2000 [24,25] strongly suggests that the rapid warming before 2000 is not AGW. Moreover, the detailed analysis of observation [26] clearly reveals the natural climate oscillation of about 60-years cycle. It is therefore likely that the apparent warming around 2000 is a result of natural climate oscillation. Consequently, our simple analytic model is more consistent and so is more reliable than the elaborate and enormous IPCC report.

4 Conclusion

A prominent climate scientist, Dr. Goody says in his famous textbook [27] as follows:

"*Recent history has demonstrated that such complex numerical calculations may be flowed ; they may yield unphysical results and equally competent investigators can disagree. An outsider can make no judgment. ... Although numerical methods may be essential for accurate numbers, a valuable level of understanding of atmospheric problem can also be achieved with approximate equations.*"

Another prominent climate scientist Dr. Ramanathan emphasizes at the beginning of Ref. [11] as follows:

"*Simple models of complex systems have great heuristic value, in that their results illustrate fundamental principles without being obscured by details.*"

I fully agree with these statements. Thus, I have tried to *illustrate fundamental principles of AGW without being obscured by details.* As a result we have found that the AGW is severely limited because the Earth is a planet of water. The climate sensitivity never exceeds 6 °C, which is equivalent to the peak temperature in the past interglacial period. Consequently, most of works referred in IPCC AR4 are ruled out because they predict much higher values of climate sensitivity. I have also found that the rapid global warming after 1990 is the natural climate oscillation of 60-years cycle. Consequently, most of computer simulations referred in IPCC AR4 are ruled out because they predict that the rapid warming is a clear evidence of AGW. It is therefore concluded that IPCC obviously overestimates AGW.

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