The Greenhouse Effect Definition

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ABSTRACT

The greenhouse effect concept explains the Earth's elevated temperature. The IPCC endorses the anthropogenic global warming theory, and it assumes that the greenhouse (GH) effect is due to the longwave (LW) absorption by GH gases and clouds. The IPCC's GH definition lets to understand that the LW absorption is responsible for the downward radiation to the surface. According to the energy laws, it is not possible that the LW absorption of 155.6 Wm^{-2} by the GH gases could re-emit downward LW radiation of 345.6 Wm^{-2} on the Earth's surface. When the shortwave (SW) absorption is decreased from this total LW radiation, the rest of the radiation is 270.6 Wm^{-2}. This LW radiation downward is the imminent cause for the GH effect increasing the surface temperature by the 33°C. It includes LW absorption by the GH gases and clouds in the atmosphere and the latent and sensible heating effects. Without the latent and sensible heating impacts in the atmosphere, the downward LW radiation could not close the energy balance of the surface. The contribution of CO_2 in the GH effect is 7.4% corresponding to 2.5 ^{0} C in temperature. This result does not only mutilate the image of CO_2 as a strong GH gas, but it has further consequences in climate models. It turned out that the IPCC's climate model showing a climate sensitivity CS of 1.2 °C could not be fitted into the total GH effect of CO_2. A climate model showing a CS of 0.6 °C matches the CO_2 contribution in the GH effect.

Keywords: Greenhouse effect; climate change; climate sensitivity; climate model

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1. INTRODUCTION

The greenhouse (GH) effect is the basic concept of the IPCC in global warming. The definition of the GH effect, according to AR5 [1], is: *"The longwave radiation (LWR, also referred to as infrared radiation) emitted from the Earth's surface is largely absorbed by certain atmospheric constituents - (greenhouse gases and clouds) - which themselves emit LWR into all directions. The downward directed component of this LWR adds heat to the lower layers of the atmosphere and to the Earth's surface (greenhouse effect)."*

Hartmann [2] summarizes the final details of the GH effect in this way*: "Most of this emitted infrared radiation is absorbed by trace gases and clouds in the overlying atmosphere. The atmosphere also emits radiation, primarily at infrared wavelengths, in all directions. Radiation emitted downward from the atmosphere adds to the warming of Earth's surface by sunlight. This enhanced warming is termed the greenhouse effect.*" According to Hartmann, the atmosphere emits radiation and not only GH gases and clouds, which is an essential difference to the IPCC's definition.

Ollila [3] has analyzed the Earth's energy balance and the energy fluxes connected to the GH effect. His conclusion is that the IPCC's definition violates the physical laws, because the downward LW radiation to the surface is much greater than the LW absorption by GH gases and clouds: in all-sky conditions 345.6 Wm^{-2} versus 155.6 Wm^{-2}.

Ollila has included the SW absorption by the atmosphere into the GH effect. The main objective of this study is to analyze if this is a feasible and justified conclusion.

2. CALCULATION BASIS OF THE GREENHOUSE EFFECT

The author has used the energy flux values of the previous study [3], and they have been depicted for illustrating the GH effect in Figure 1. In this study, only all-sky values have been applied, if not specified otherwise. The accurate flux values have been applied, even though it is known that a typical uncertainty limit is ±5 Wm^{-2} [3].

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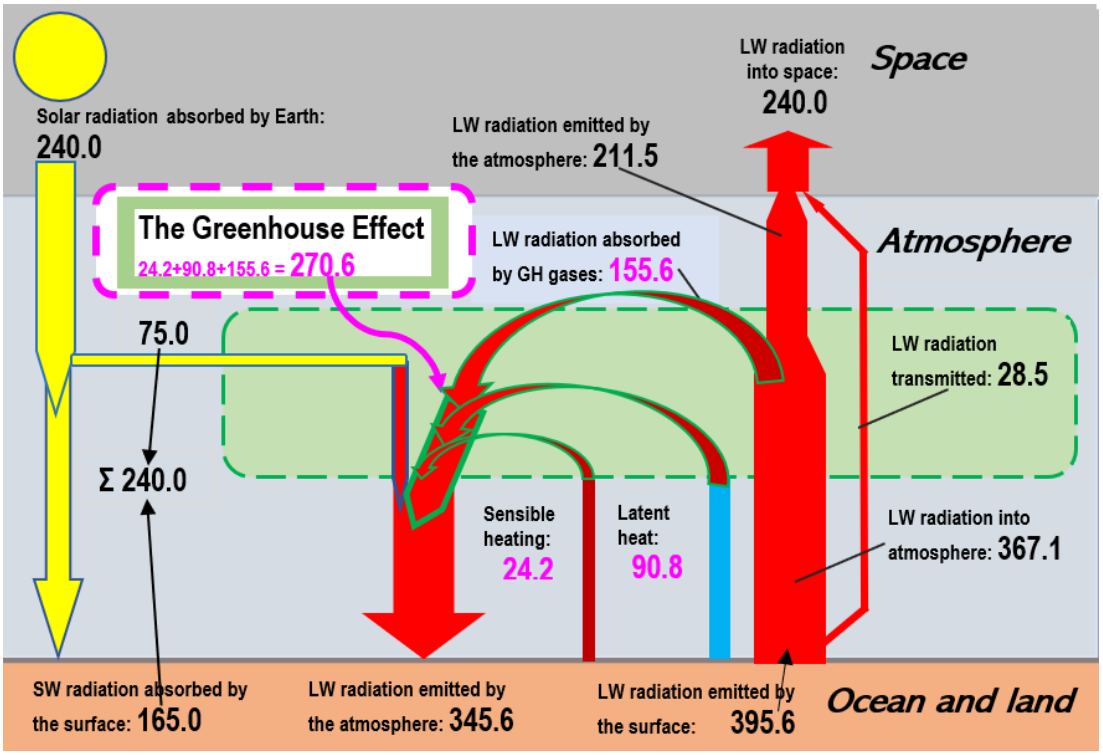

Figure 1. Energy fluxes contributing to the greenhouse effect in all-sky conditions (Wm^{-2}).

In this figure is a difference in respect to the same of the previous study [3]. The SW absorption flux by the atmosphere has not been included into the GH effect. The Earth receives a net energy 240 Wm^{-2} based on the incoming insolation and the reflected SW flux at the TOA (Top of the Atmosphere). Based on the observations the Earth's surface absorbs 165 Wm^{-2}, and therefore the atmosphere absorbs 240 – 165 = 75 Wm^{-2}. The satellite observations confirm that the Earth radiates 240 Wm^{-2} LW radiation into space. Because this 240 Wm^{-2} corresponds about -18°C black surface temperature and the average surface temperature is +15°C, there is a warming/isolation mechanism making this difference possible, which is called the GH effect.

The obvious reason for the GH effect seems to be the downward LW radiation from the atmosphere to the surface and its magnitude is 345.6 Wm^{-2} (LW_{dn}). The first question is if LW_{dn} should be regarded to totally responsible for the GH effect as assessed earlier [3]. LW_{dn} includes the SW absorption flux by the atmosphere and it is part of the net energy received from the Sun. Therefore, it can be excluded from the GH effect. When the SW flux is decreased from LW_{dn}, the rest of this flux is 345.6 – 75.0 = 270.6 Wm^{-2}. This flux is called a GH flux (GH_{dn}), because it is the only available extra energy warming the Earth's surface.

The GH_{dn} flux is the sum of three different energy source, which has been already identified [3] and they are: LW absorption by the GH gases and clouds (155.6 Wm^{-2}), latent heating 90.8 Wm^{-2}, and sensible heating 24.2 Wm^{-2}. Together with the SW absorption flux, these fluxes summarize exactly the LW_{dn} flux value of 345.6 Wm^{-2}.

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This approach does not create a physical contradiction that an energy source of 155.6 Wm^{-2} could create an energy flux of 270.6 Wm^{-2}, which provides the real extra warming effect on the Earth's surface making the GH effect possible.

The percentages of individual GH effect contributors have been calculated by removing one factor a time from the atmospheric model and recording the reduction of the total absorption value. This is the same method as used by Kiehl and Trenberth [4]. The results are depicted in Table 1.

Table 1. Greenhouse effects according to individual contributors in all-sky conditions.

LW absorption	All-sky	Contr.-%	°C
Water	90.9	33.6	11.1
Carbon dioxide	20.1	7.4	2.5
Ozone	6.9	2.6	0.8
Methane & Nitrogen oxide	1.8	0.7	0.2
Clouds	35.9	13.3	4.4
LW absorption	155.6		
Latent heating	90.8	33.6	11.1
Sensible heating	24.2	8.9	2.9
GH effect	270.6		

The greatest difference in comparison to the earlier study [3] is the contribution of clouds, which is 13.3 % corresponding to 35.9 Wm^{-2} of radiation effect. This value is very close to the same of Schmidt et al. [5], which is 38.75 Wm^{-2}. In percentages, the difference is much greater (13.3% versus 25%) because in the latter study latent and sensible heating are not included in the total absorption GH_{dn} value. The contribution of CO_2 is only 7.4%, which is insignificantly greater than the earlier value of 7.3% [3].

3. FITTING THE SIMPLE CLIMATE MODELS INTO THE GREENHOUSE EFFECT

Ollila has analyzed in the earlier study the effects of the new GH effect definition on the climate models. He has used two simple models, which can be used for calculating the temperature effect of increased CO_2 concentration up to the concentration of 1370 ppm

$$dT = \lambda * k * \ln(C/280) \qquad (1)$$

where dT is the global surface temperature change (K) starting from the year 1750, λ is the climate sensitivity parameter (K/(Wm^{-2}) being 0.324 in the IPCC model [5], and 0.27 in the Ollila model and k is a parameter being 5.35 in the IPCC model and 3.12 in the Ollila model.

These IPCC model parameters give Transient Climate Sensitivity (TCS) values of 1.2°C and 0.6°C value for the Ollila model. IPCC has reported [6] that the TCS value is 1.2°C if there are no feedbacks included. These two curves have been depicted in Figure 2. The CO_2 warming impact curves have been adapted to give a total warming value of 2.5 ^{0} C caused by the CO_2 concentration of 400.9 ppm [3]. The warming change from CO_2 concentration 0

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ppm to 280 ppm (dashed curves) is based on the absorption decrease by spectral calculations [3].

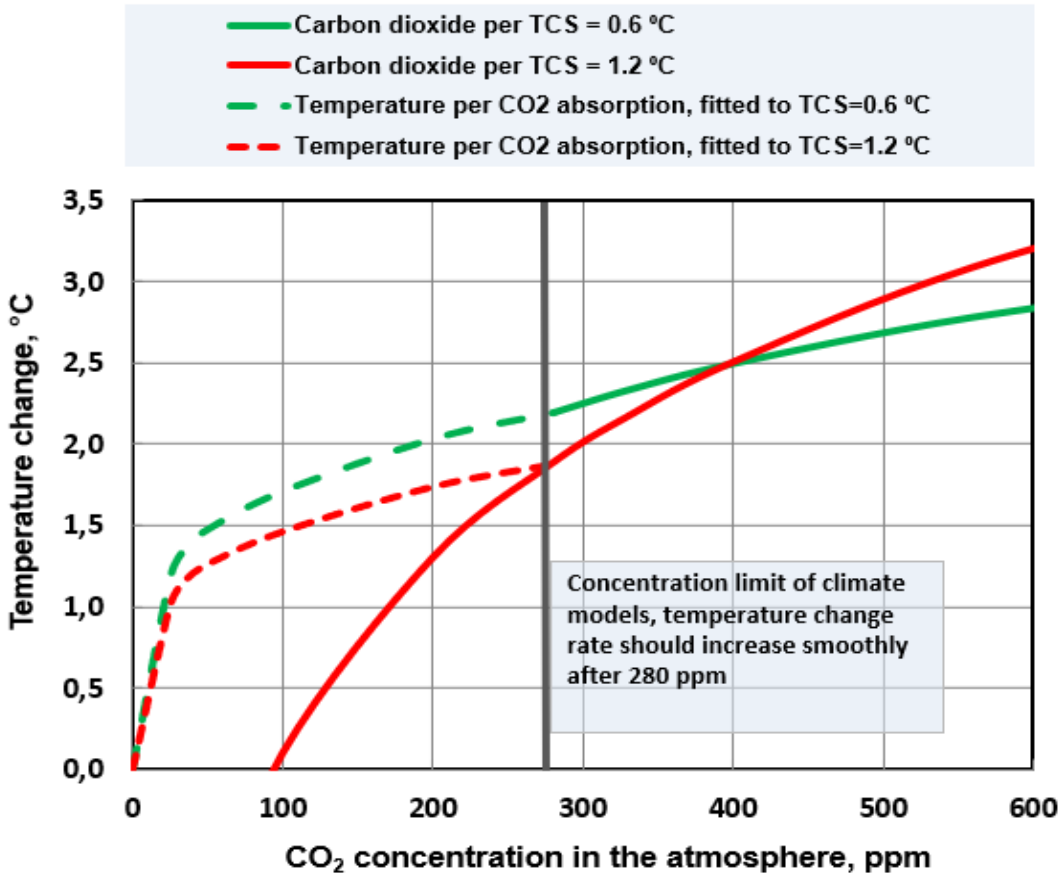

Figure 2. Warming effects of CO_2 according to the new greenhouse effect of CO_2 being 2.5 ^{0} C in 2014 (400.9 ppm). CO_2 warming effects from 280 ppm onward are per a green curve, TCS = 0.6 ^{0} C, and per IPCC (2013), a red curve, TCS = 1.2 ^{0} C.

The general feature of absorption is that the absorption rate change, i.e. the angle coefficient of the absorption curve, diminishes with increasing GH gas concentration. The absorption due to a GH gas follows also another general rule of absorption, which is that increasing concentration change from zero upward has the strongest effect in the beginning. The starting phase approximately follows the Beer-Lambert law, which states that absorbance depends linearly on the concentration and path length. When the concentration increases, this relationship is no longer valid. There is a very nonlinear dependency from 20 to 100 ppm for CO_2, and thereafter the relationship is slightly nonlinear after 280 ppm, which can be approximated by a logarithmic relationship very well.

The curve of the model (TCS = 0.6 ^{0} C) according to Eq. (7) of this study shows a smooth feature of a warming rate without a transition point at the 280 ppm. The curve of the IPCC model (TCS = 1.2 °C) has a transition point at 280 ppm, because the angle coefficient starts to increase after 280 ppm, when it should steadily diminish. This curve fitting shows that the IPCC model cannot be fitted into this new GH effect magnitude.

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4 DISCUSSION

There is quite a lot of confusion if Planck's law is applicable in the troposphere where 98% of absorption happens and the downward LW radiation to the surface. The IPCC's definition [1] lets to understand that only GH gases emit infrared radiation but Hartmann [2] writes that the atmosphere radiates.

The surface energy balance value is 510.6 Wm^{-2}. There are only two fluxes entering the surface: the SW flux of 165 Wm^{-2} and LW_{dn} of 365.6 Wm^{-2}, a totally of 510.6 Wm^{-2}. If the LW_{dn} flux would be the same as LW absorbed flux 155.6 Wm^{-2} plus the SW absorption of 75 Wm^{-2}, the surface energy fluxes would not be in balance. The energy balance of the atmosphere shows that the downward LW radiation must include latent and sensible heating effects because then the surface in and out energy fluxes are perfectly in balance.

The GH gases and clouds absorb both LW and SW radiation fluxes and this process increases the temperature of the atmosphere. Also, latent and sensible heating increases the atmospheric temperature. The atmosphere emits radiation according to its temperature as Planck's law dictates. If this would not happen, the LW_{dn} would not be exactly the sum of these four energy fluxes. The absorption by the GH gases and clouds in the atmosphere has no special role in maintaining the atmospheric temperature profile. Latent and sensible heating also maintain this profile even though the heat transfer process is different.

It should be noticed that although clouds have clearly positive impact on the GH effect, the permanently increased cloudiness does not increase the surface temperature. This is due to the fact that increased cloudiness decreases at the same time the incoming solar radiation and the net effect is the decrease in the surface temperature.

The AGW theory emphasizes the role of CO_2. In this theory the contribution of CO_2 has been considered higher than its contribution calculated by the method of removing its impact in spectral calculations. The basis for this increased effect is that the atmosphere, if CO_2 were removed from it, would cool and much of water vapor would rain out. This would cause more raining, and this would cause further cooling resulting even glaciated snowball state [1].

A more realistic state of the climate is to think about the situation of climate zones if the CO_2 concentration would be zero. The total absorption in the tropics would be only 2.2 % smaller having an insignificant impact on the surface temperature. The surface temperature of the polar summer is the same as the average global climate and the reduction of the total absorption would the same as the global average temperature (2.5 °C). Although the absolute water amount would decrease, it would not be enough to cause a glaciation of the Earth.

5 CONCLUSION

The first conclusion of this study is that the GH effect definitions should be changed to be like this: *"The Earth's surface emits LW radiation (infrared radiation) and it transfers heat energy in the form of latent and sensible heating into the atmosphere. Most of the emitted infrared radiation is absorbed by trace gases and clouds in the atmosphere. All three energy fluxes increase the temperature of the atmosphere. The part of the infrared radiation due to these three energy sources emitted downward from the atmosphere adds to the warming of Earth's surface by sunlight and it is called the greenhouse effect."*

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The second conclusion is the warming effects of the increasing carbon dioxide concentration according to the IPCC's applied models cannot be fitted into the total magnitude of the CO_2 contribution for the GH effect.

COMPETING INTERESTS

The author has declared that no competing interests exist.

REFERENCES

[1] IPCC. The Physical Science Basis, Chapter 8.1. Working Group I Contribution to the IPCC Fourth Assessment Report. Cambridge University Press, Cambridge; 2011.

[2] Hartmann DL. Global Physical Climatology, Elsevier Science, USA; 2015.

[3] Ollila A. Challenging the greenhouse effect specification and the climate sensitivity of the IPCC. Phys Sci Int J 2019;22(2):1-19.

[4] Kiehl JT, Trenberth KE. Earth's annual global mean energy budget. Bull Amer Meteor Soc 1997;90:311-323.

[5] Schmidt GA, Ruedy RA, Miller RL, Lacis AA. Attribution of the present-day total greenhouse effect. J Geophys Res 2010;115,D20106:1-6.

[6] IPCC. The Physical Science Basis, Chapter 1.5, Working Group I Contribution to the IPCC Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge; 2007.

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