The Greenhouse Effect Definition

Abstract:

The greenhouse effect concept explains the Earth's elevated temperature. The IPCC endorses the anthropogenic global warming theory, and it defines that the greenhouse (GH) effect is due to longwave (LW) absorption by GH gases and clouds. The IPCC's GH definition gives the understanding that LW absorption is responsible for the downward radiation to the surface. According to 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 shortwave (SW) absorption is decreased from the 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 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 not only mutilates the image of CO_2 as a strong GH gas, but it has further consequences in climate models. Clouds have a positive impact on the GH effect but the net impact on the surface temperature is negative. It turns 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 definition; carbon dioxide forcing; climate change; climate sensitivity; climate model

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, not only GH gases and clouds, which is an essential difference from the IPCC's definition.

Ollila [3] has analyzed the Earth's energy balance and energy fluxes connected to the GH effect. His conclusion is that the IPCC's definition violates 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, it is 345.6 Wm^{-2} versus 155.6 Wm^{-2}.

Ollila [3] has included the SW absorption by the atmosphere into the GH effect. The main objective of this study is to analyze whether this is a feasible and justified conclusion.

2. Calculation basis of the greenhouse effect

The author has used the energy flux values from the previous study [3], and they have been depicted to illustrate the GH effect in Fig. 1. In this study, only accurate all-sky flux values have been applied even though it is known that a typical uncertainty limit is ±5 Wm^{-2} [3].
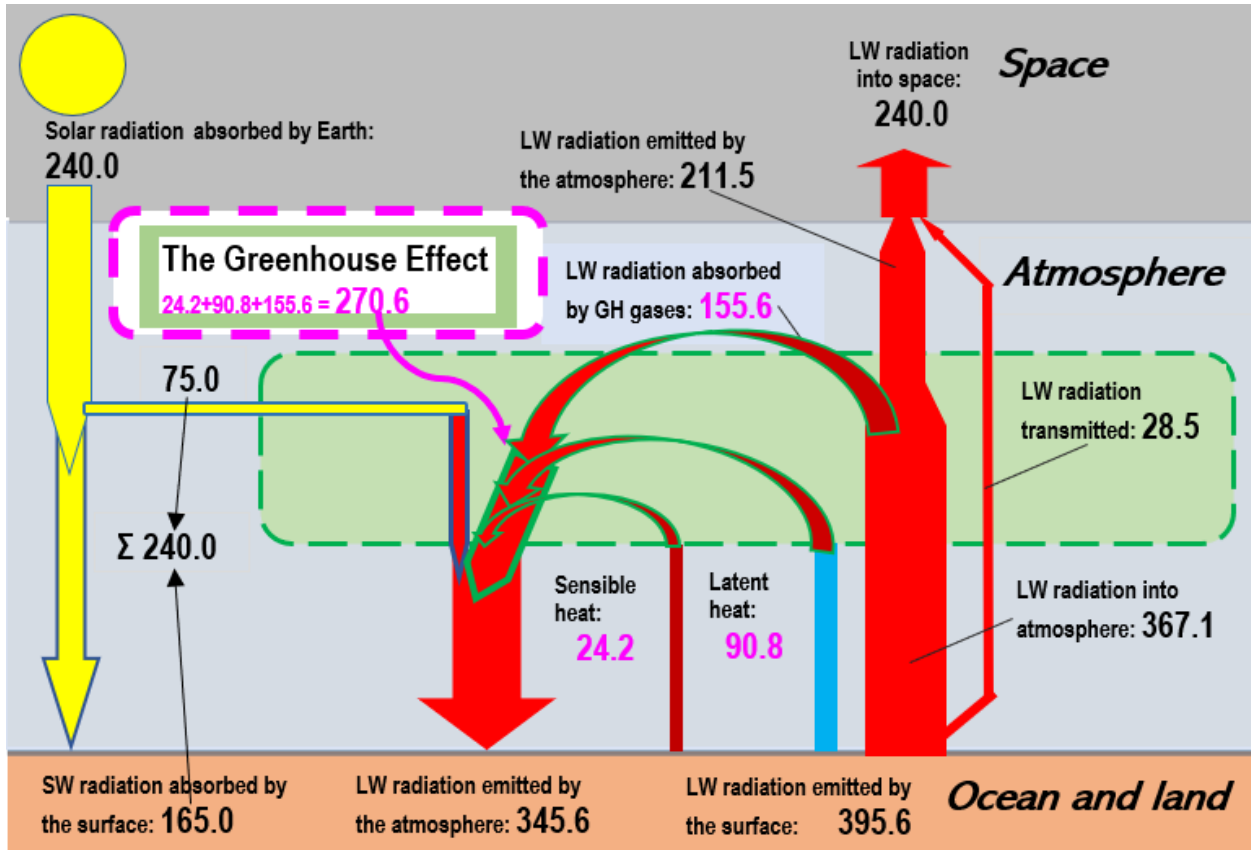
Fig. 1. Energy fluxes contributing to the greenhouse effect in all-sky conditions (Wm^{-2}).

In Fig. 1, there is a difference in respect to the SW radiation of the previous study [3]. The SW absorption flux by the atmosphere has not been included in the GH effect in this study. The Earth receives a net energy of 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 to about -18 °C black surface temperature and the average surface temperature is +15 °C, there is a special 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 (LW$_{dn}$) from the atmosphere to the surface, and its magnitude is 345.6 Wm^{-2}. The first question is whether LW$_{dn}$ should be regarded as totally responsible for the GH effect as assessed earlier [3], and also defined in the IPCC's definition. LW$_{dn}$ includes the SW absorption flux by the atmosphere, and it is part of the net energy received from the Sun. Therefore, it should be excluded from the GH effect. When the SW flux is decreased from LW$_{dn}$, the rest of this flux is 346.5 – 75 = 270.6 Wm^{-2}. This flux is called a here GH flux (GH$_{dn}$) because it is the only available extra energy besides the solar insolation warming the Earth's surface.

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75 It should be noticed that any energy source affecting the Earth's surface temperature must have its
76 impact on the surface – the impact on the atmosphere does not affect directly the surface temperature.
77 The GH_{dn} flux is the sum of three different energy sources, which are LW absorption by the GH gases
78 and clouds 155.6 Wm^{-2}, latent heating 90.8 Wm^{-2}, and sensible heating 24.2 Wm^{-2}. Together with the SW
79 absorption flux, these fluxes summarize exactly the LW_{dn} flux value of 345.6 Wm^{-2}.
80
81 This approach does not create a physical contradiction that an energy source of 155.6 Wm^{-2} could create
82 an energy flux of 270.6 Wm^{-2} (or even 345.6 Wm^{-2}), which provides the real extra warming effect on the
83 Earth's surface, making the GH effect possible.
84
85 The percentages of individual GH effect contributors have been calculated by removing one factor at a
86 time from the atmospheric model and recording the reduction of the total absorption value. This is the
87 same method as used by Kiehl and Trenberth [4]. The results are depicted in Table 1.
88
89 **Table 1.** Greenhouse effects according to individual contributors in all-sky conditions

90 Factor	Wm^{-2}	%	°C
91 Water	90.9	33.6	11.1
92 Latent heating	90.8	33.6	11.1
93 Clouds	35.9	13.3	4.4
94 Sensible heating	24.2	8.9	2.9
95 Carbon dioxide	20.1	7.4	2.5
96 Ozone	6.9	2.5	0.8
97 Methane & Nitrogen oxide	1.8	0.7	0.2
98 Total GH effect	270.6	100.0	33.0

99

100 The greatest difference in comparison to the earlier study [3] is the contribution of clouds, which is 13.3%,
101 corresponding to 35.9 Wm^{-2} of the radiation effect. This is very close to Schmidt et al. [5], who found the
102 value to be 38.75 Wm^{-2}. In percentages, the difference is much greater (13.3% versus 25%) because, in
103 the latter study, latent and sensible heating are not included in the total absorption GH_{dn} value. The
104 contribution of CO_2 is 20.1 Wm^{-2} and the same value of Schmidt et al. [5] is 21.7 Wm^{-2}. The total
105 absorption by GH gases is very sensitive to the absolute water vapor amount of the atmospheric model.
106 The most important result of this study is that the contribution of CO_2 is only 7.4% in the GH effect, which
107 is significantly smaller than the value of 19% by Schmidt et al. [5].
108
109 **3. Fitting the simple climate models into the greenhouse effect**
110
111 In the earlier study, Ollila has analyzed the effects of the new GH effect definition on the climate models.
112 He has used two simple models, which can be used to calculate the temperature effect of increased CO_2
113 concentration up to the concentration of 1370 ppm
114
115 $dT = \lambda * k * \ln(C/280)$ (1)
116
117 where dT is the global surface temperature change (K) starting from the year 1750, λ is the climate
118 sensitivity parameter ($K/(Wm^{-2})$) being 0.324 in the IPCC model [6] and 0.27 in the Ollila model, and k is a
119 parameter being 5.35 in the IPCC model and 3.12 in the Ollila model [3].
120
121 These IPCC model parameters give Transient Climate Sensitivity (TCS) values of 1.2 °C and 0.6 °C for
122 the Ollila model. The IPCC has reported [6] that the TCS value is 1.2 °C if there are no feedbacks
123 included. These two curves have been depicted in Fig. 2. The CO_2 warming impact curves have been
124 adapted to give a total warming value of 2.5 °C, caused by the CO_2 concentration of 400.9 ppm, as
125 shown in this study. The warming change from CO_2 concentration 0 ppm to 280 ppm (dashed curves) is
126 based on the absorption decrease by spectral calculations [3].

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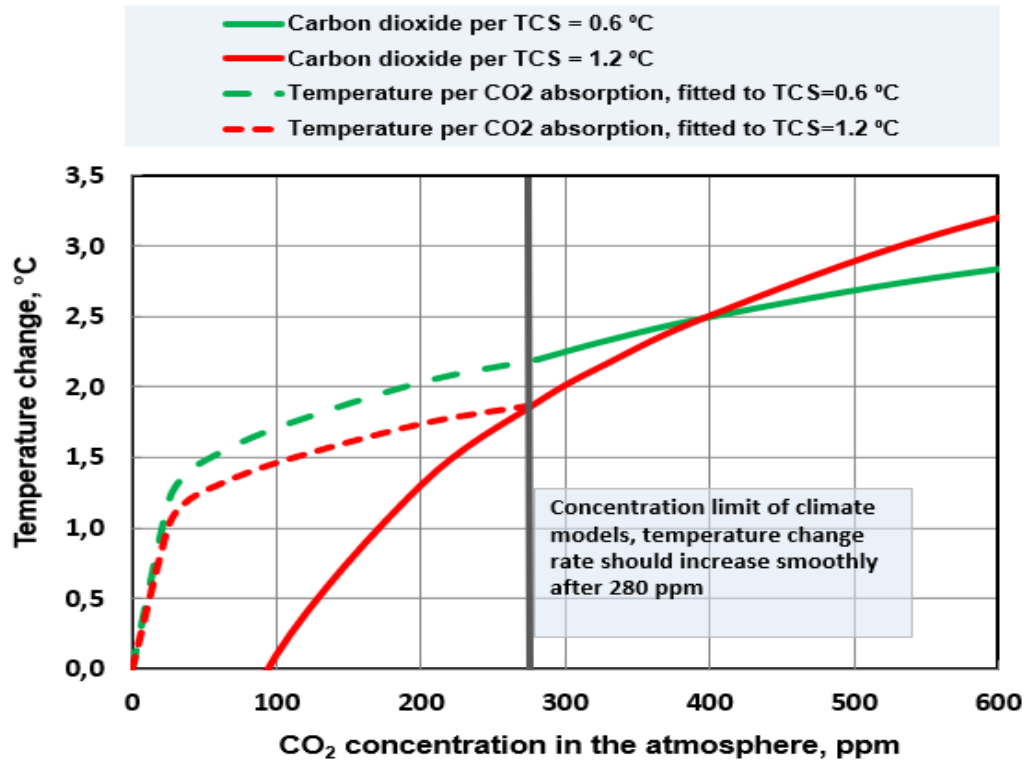
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129 **Fig. 2**. Warming effects of CO_2 according to the new greenhouse effect of CO_2 being 2.5 ^{0} C in 2014
130 (400.9 ppm). CO_2 warming effects from 280 ppm onward are per a green curve, TCS = 0.6 ^{0} C, and per
131 IPCC [6] a red curve, TCS = 1.2 ^{0} C.

132 The results show that the IPCC model cannot be fitted into this new GH effect magnitude.

133
134 **4. Discussion**

135
136 There is quite a lot of confusion as to whether Planck's law is applicable in the troposphere, where
137 happens 98% absorption and downward LW radiation to the surface. The IPCC's definition [1] gives the
138 understanding that only GH gases emit infrared radiation, but Hartmann [2] writes that the atmosphere
139 radiates.

140
141 The surface energy balance value is 510.6 Wm^{-2}. There are only two fluxes entering the surface: the SW
142 flux of 165 Wm^{-2} and the LW_{dn} of 365.6 Wm^{-2}, a total of 510.6 Wm^{-2}. If the LW_{dn} flux were the same as the
143 LW-absorbed flux of 155.6 Wm^{-2} plus the SW absorption of 75 Wm^{-2}, the surface energy fluxes would not
144 be balanced. The energy balance of the atmosphere shows that the downward LW radiation must include
145 latent and sensible heating effects because then the surface in and out energy fluxes are perfectly
146 balanced. This also means that the atmosphere emits radiation according to its temperature including all
147 the energy fluxes affecting the atmospheric temperature as Planck's law dictates.

148
149 The positive effect of clouds in the GH effect is not the whole truth, because clouds have a negative
150 impact on the incoming SW radiation. Clouding is like a football player who can score during a season
151 totally of 27 goals looking a marvelous player. During the same season, he makes 47 own goals meaning
152 that his impact is negative to his team by 20 goals. The energy balance shows that totally cloudy sky
153 increases the GH effect on the surface by 27.4 Wm^{-2} and decreases the SW radiation effect by 47.2
154 Wm^{-2} causing a net cooling effect of -19.8 Wm^{-2} [3]. Permanent clouding increase has always a negative
155 effect on the surface temperature and therefore one key figure of clouds' contribution to the GH effect

156 may give the wrong idea. However, the positive contribution of clouds in the GH effect is real and it also
157 reduces the relative percentual contributions of the GH gases.
158
159 **5. Conclusion**

160 The first conclusion of this study is that the GH effect definitions should be changed to state the following:
161 *"The Earth's surface emits LW radiation (infrared radiation) and most of the emitted infrared radiation is*
162 *absorbed by trace gases and clouds in the atmosphere. The Earth's surface also transfers heat energy in*
163 *the form of latent and sensible heating into the atmosphere. All three energy fluxes increase the*
164 *temperature of the atmosphere. The part of the infrared radiation due to these three energy sources*
165 *emitted downward from the atmosphere adds to the warming of Earth's surface by sun insolation and it is*
166 *called the greenhouse effect."*
167
168 Another conclusion is that the warming effects of the increasing carbon dioxide concentration, according
169 to the IPCC's applied models, cannot be fitted into the total magnitude of the CO_2 contribution for the GH
170 effect.
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173 **Competing interests**
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175 The author has declared that no competing interests exist.
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177 **References**
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