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FALSIFICATION OF THE ATMOSPHERIC CO_2 GREENHOUSE EFFECTS WITHIN THE FRAME OF PHYSICS

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The atmospheric greenhouse effect, an idea that many authors trace back to the traditional works of Fourier (1824), Tyndall (1861), and Arrhenius (1896), and which is still supported in global climatology, essentially describes a fictitious mechanism, in which a planetary atmosphere acts as a heat pump driven by an environment that is *radiatively interacting with* but *radiatively equilibrated to* the atmospheric system. According to the second law of thermodynamics, such a planetary machine can never exist. Nevertheless, in almost all texts of global climatology and in a widespread secondary literature, it is taken for granted that such a mechanism is real and stands on a firm scientific foundation. In this paper, the popular conjecture is analyzed and the underlying physical principles are clarified. By showing that (a) there are no common physical laws between the warming phenomenon in glass houses and the fictitious atmospheric greenhouse effects, (b) there are no calculations to determine an average surface temperature of a planet, (c) the frequently mentioned difference of 33° is a meaningless number calculated wrongly, (d) the formulas of cavity radiation are used inappropriately, (e) the assumption of a radiative balance is unphysical, (f) thermal conductivity and friction must not be set to zero, the atmospheric greenhouse conjecture is falsified.

Keywords: Greenhouse effect; Gibbs thermodynamics; radiation theory.

1. Introduction

1.1. *Problem background*

Recently, there have been lots of discussions regarding the economic and political implications of climate variability, in particular, global warming as a measurable effect of an anthropogenic, i.e., human-made, climate change.[1–13] Many authors assume that carbon dioxide emissions from fossil-fuel consumption represent a

Table 1. Atmospheric concentration of carbon dioxide in volume parts per million (1958–2007).

Date	CO_2 concentration [ppmv]	Source
March 1958	315.56	Ref. 14
March 1967	322.88	Ref. 14
March 1977	334.53	Ref. 14
March 1987	349.24	Ref. 14
March 1996	363.99	Ref. 14
March 2007	377.3	Ref. 15

Table 2. Three versions of an idealized Earth's atmosphere and the associated gas volume concentrations, including the working hypothesis chosen for this paper.

Gas	Formula	U.S. Standard (1976) Ref. 14 [Vol %]	Hardy *et al.* (2005) Ref. 8 [Vol %]	Working hypothesis [Vol %]
Nitrogen	N_2	78.084	78.09	78.09
Oxygen	O_2	20.9476	20.95	20.94
Argon	Ar	0.934	0.93	0.93
Carbon dioxide	CO_2	0.0314	0.03	0.04

serious danger to the health of our planet, since they are supposed to influence the climates, in particular, the average temperatures of the surface and lower atmosphere of the Earth. However, carbon dioxide is a rare trace gas, a very small part of the atmosphere found in concentrations as low as $0,03\,\mathrm{Vol}\,\%$ (cf. Tables 1 and 2; see also Ref. 16).[a]

A physicist starts his analysis of the problem by pointing his attention to two fundamental thermodynamic properties, namely

- the *thermal conductivity* λ, a property that determines how much heat per time unit and temperature difference flows in a medium;
- the *isochoric thermal diffusivity* a_v, a property that determines how rapidly a temperature change will spread, expressed in terms of an area per time unit.

Both quantities are related by

$$a_v = \frac{\lambda}{\varrho c_v} \tag{1}$$

the proportionality constant of the heat equation

$$\frac{\partial T}{\partial t} = a_v \cdot \Delta T \tag{2}$$

[a] In a recent paper on "180 Years accurate CO2 Gas analysis of Air by Chemical Methods," the German biologist Ernst-Georg Beck argues that the IPCC reliance of ice core CO_2 figures is wrong.[17,18] Though interesting on its own that even the CO_2 data themselves are subject to a discussion, it does not influence the rationale of this paper which is to show that the concentration of CO_2 is *completely* irrelevant.

Table 3. Mass densities of gases at normal atmospheric pressure (101.325 kPa) and standard temperature (298 K).

Gas	Formula	Mass density ϱ [kg/m^3]	Source
Nitrogen	N_2	1.1449	Ref. 14
Oxygen	O_2	1.3080	Ref. 14
Argon	Ar	1.6328	Ref. 14
Carbon Dioxide	CO_2	1.7989	Ref. 14

Table 4. Volume percent versus mass percent: The volume concentration x_v and the mass concentration x_m of the gaseous components of an idealized Earth's atmosphere.

Gas	Formula	x_v [Vol %]	ϱ (298 K) [kg/m^3]	x_m [Mass %]
Nitrogen	N_2	78.09	1.1449	75.52
Oxygen	O_2	20.94	1.3080	23.14
Argon	Ar	0.93	1.6328	1.28
Carbon dioxide	CO_2	0.04	1.7989	0.06

Table 5. Thermal conductivities of the gaseous components of the Earth's atmosphere at normal pressure (101.325 kPa).

Gas	Formula	λ (200 K) [W/mK] Ref. 14	λ (298 K) [W/mK] (interpolated)	λ (300 K) [W/mK] Ref. 14	λ (400 K) [W/mK] Ref. 14
Nitrogen	N_2	0.0187	0.0259	0.0260	0.0323
Oxygen	O_2	0.0184	0.0262	0.0263	0.0337
Argon	Ar	0.0124	0.0178	0.0179	0.0226
Carbon dioxide	CO_2	0.0096	0.0167	0.0168	0.0251

where T is the temperature, ϱ is the mass density, and c_v is the isochoric specific heat.

To calculate the relevant data from the gaseous components of the air, one has to use their mass concentrations as weights to calculate the properties of the mixture "air" according to Gibbs thermodynamics.[19,20b] Data on volume concentrations (Table 2) can be converted into mass concentrations with the aid of known mass densities (Table 3).

A comparison of volume percents and mass percents for CO_2 shows that the current mass concentration, which is the physically relevant concentration, is approximately 0.06% and not the often quoted 0.03% (Table 4).

From known thermal conductivities (Table 5), isochoric heat capacities, and mass densities the isochoric thermal diffusivities of the components of the air are

[b]The thermal conductivity of a mixture of two gases does not, in general, vary linearly with the composition of the mixture. However, for comparable molecular weight and small concentrations, the nonlinearity is negligible.[21]

Table 6. Isobaric heat capacities c_p, relative molar masses M_r, isochoric heat capacities $c_v \approx c_p - R/M_r$ with universal gas constant $R = 8.314472$ J/mol K, mass densities ϱ, thermal conductivities λ, and effective thermal conductivities $\lambda_{\rm eff} = \lambda/(\varrho \cdot c_v)$ of the gaseous components of the Earth's atmosphere at normal pressure (101.325 kPa).

Gas	c_p [J/kg K]	M_r [g/mol]	R/M_r [J/kg K]	c_v [J/kg K]	ϱ [kg/m^3]	λ [Js/mK]	$\lambda_{\rm eff}$ [m^2/s]
N_2	1039	28.01	297	742	1.1449	0.0259	$3.038 \cdot 10^{-5}$
O_2	919	32.00	260	659	1.3080	0.0262	$3.040 \cdot 10^{-5}$
Ar	521	39.95	208	304	1.6328	0.0178	$3.586 \cdot 10^{-5}$
CO_2	843	44.01	189	654	1.7989	0.0167	$1.427 \cdot 10^{-5}$

Table 7. The calculation of the effective thermal conductivity $\lambda_{\rm eff} = \lambda/(\varrho \cdot c_v)$ of the air and its gaseous components for the current CO_2 concentration (0.06 Mass %) and for a *fictitiously doubled* CO_2 concentration (0.12 Mass %) at normal pressure (101.325 kPa).

Gas	x_m [Mass %]	M_r [g/mol]	c_p [J/kg K]	c_v [J/kg K]	ϱ [kg/m^3]	λ [Js/mK]	$\lambda_{\rm eff}$ [m^2/s]
N_2	75.52	28.01	1039	742	1.1449	0.0259	$3.038 \cdot 10^{-5}$
O_2	23.14	32.00	929	659	1.3080	0.0262	$3.040 \cdot 10^{-5}$
Ar	1.28	39.95	512	304	1.6328	0.0178	$3.586 \cdot 10^{-5}$
CO_2	0.06	44.01	843	654	1.7989	0.0167	$1.427 \cdot 10^{-5}$
Air	100.00	29.10	1005	719	1.1923	0.02586	$3.0166 \cdot 10^{-5}$

Gas	x_m [Mass %]	M_r [g/mol]	c_p [J/kg K]	c_v [J/kg K]	ϱ [kg/m^3]	λ [Js/mK]	$\lambda_{\rm eff}$ [m^2/s]
N_2	75.52	28.01	1039	742	1.1449	0.0259	$3.038 \cdot 10^{-5}$
O_2	**23.08**	32.00	929	659	1.3080	0.0262	$3.040 \cdot 10^{-5}$
Ar	1.28	39.95	512	304	1.6328	0.0178	$3.586 \cdot 10^{-5}$
CO_2	**0.12**	44.01	843	654	1.7989	0.0167	$1.427 \cdot 10^{-5}$
Air	100.00	**29.10**	**1005**	**719**	**1.1926**	**0.02585**	$\mathbf{3.0146 \cdot 10^{-5}}$

determined (Table 6). This allows to estimate the change of the effective thermal conductivity of the air in dependence of a doubling of the CO_2 concentration, expected to happen within the next 300 years (Table 7).

It is obvious that a doubling of the concentration of the trace gas CO_2, whose thermal conductivity is approximately one-half than that of nitrogen and oxygen, does change the thermal conductivity at most by 0.03% and the isochoric thermal diffusivity at most by 0.07%. These numbers lie within the range of the measuring inaccuracy and other uncertainties such as rounding errors, and therefore have no significance at all.

1.2. *The greenhouse effect hypothesis*

Among climatologists, in particular, those who are affiliated with the Intergovernmental Panel of Climate Change (IPCC),[c] there is a "scientific consensus,"[22] that

[c]The IPCC was created in 1988 by the World Meteorological Organization (WHO) and the United Nations Environmental Program (UNEP).

the relevant mechanism is the atmospheric greenhouse effect, a mechanism heavily relying on the assumption that radiative heat transfer clearly dominates over the other forms of heat transfer such as thermal conductivity, convection, condensation, etc.[23–30]

In all past IPCC reports and other such scientific summaries, the following point evocated in Ref. 24, p. 5, is central to the discussion:

> "One of the most important factors is the **greenhouse effect**; a simplified explanation of which is as follows. Short-wave solar radiation can pass through the clear atmosphere relatively unimpeded. But long-wave terrestrial radiation emitted by the warm surface of the Earth is partially absorbed and then re-emitted by a number of trace gases in the cooler atmosphere above. Since, on average, the outgoing long-wave radiation balances the incoming solar radiation, both the atmosphere and the surface will be warmer than they would be without the greenhouse gases ... The greenhouse effect is real; it is a well-understood effect, based on established scientific principles."

To make things more precise, supposedly, the notion of *radiative forcing* was introduced by the IPCC and related to the assumption of *radiative equilibrium*. In Ref. 27, pp. 7–6, one finds the statement:

> "*A change* in average net radiation at the top of the troposphere (known as the tropopause), because of a change in either solar or infrared radiation, is defined for the purpose of this report as a *radiative forcing*. A radiative forcing perturbs the balance between incoming and outgoing radiation. Over time, climate responds to the perturbation to re-establish the radiative balance. A positive radiative forcing tends on average to warm the surface; a negative radiative forcing on average tends to cool the surface. As defined here, the incoming solar radiation is not considered a radiative forcing, but a change in the amount of incoming solar radiation would be a radiative forcing ... For example, an increase in atmospheric CO_2 concentration leads to a reduction in outgoing infrared radiation and a positive radiative forcing."

However, in general, "scientific consensus" is not related whatsoever to scientific truth as countless examples in history have shown. "Consensus" is a political term, not a scientific term. In particular, from the viewpoint of theoretical physics the radiative approach, which uses physical laws such as Planck's law and Stefan–Boltzmann's law that only have a limited range of validity that definitely does not cover the atmospheric problem, must be highly questioned.[31–35] For instance, in many calculations, climatologists perform calculations where idealized black surfaces e.g., representing a CO_2 layer and the ground, respectively, radiate against each other. In reality, we must consider a bulk problem, in which at concentrations of 300 ppmv at normal state still

$$
\begin{aligned}
N &\approx 3 \cdot 10^{-4} \cdot V \cdot N_L \\
&\approx 3 \cdot 10^{-4} \cdot (10 \cdot 10^{-6})^3 \cdot 2.687 \cdot 10^{25} \\
&= 3 \cdot 10^{-4} \cdot 10^{-15} \cdot 2.687 \cdot 10^{25} \\
&\approx 8 \cdot 10^{6}
\end{aligned} \tag{3}
$$

CO_2 molecules are distributed within a cube V with edge length 10 μm, a typical wavelength of the relevant infrared radiation.[d] In this context, an application of the formulas of cavity radiation is sheer nonsense.

It cannot be overemphasized that a microscopic theory providing the base for a derivation of macroscopic quantities like thermal or electrical transport coefficients must be a highly involved many-body theory. Of course, heat transfer is due to interatomic electromagnetic interactions mediated by the electromagnetic field. But it is misleading to visualize a photon as a simple particle or wave packet traveling from one atom to another, for example. Things are pretty much more complex and cannot be understood even in a (one-)particle-wave duality or Feynman graph picture.

On the other hand, the macroscopic thermodynamical quantities contain a lot of information and can be measured directly and accurately in the physics lab. It is an interesting point that the thermal conductivity of CO_2 is only one-half of that of nitrogen or oxygen. In a 100 percent CO_2 atmosphere, a conventional light bulb shines brighter than in a nitrogen-oxygen atmosphere due to the lowered thermal conductivity of its environment. But this has nothing to do with the supposed CO_2 greenhouse effect which refers to trace gas concentrations. Global climatologists claim that the Earth's natural greenhouse effect keeps the Earth 33°C warmer than it would be without the trace gases in the atmosphere. About 80 percent of this warming is attributed to water vapor and 20 percent to the 0.03 volume percent CO_2. If such an extreme effect existed, it would show up even in a laboratory experiment involving concentrated CO_2 as a thermal conductivity anomaly. It would manifest itself as a new kind of "superinsulation" violating the conventional heat conduction equation. However, for CO_2, such anomalous heat transport properties have never been observed.

Therefore, in this paper, the popular greenhouse ideas entertained by the global climatology community are reconsidered within the limits of theoretical and experimental physics. Authors trace back their origins to the works of Fourier[37,38] (1824), Tyndall[39–43] (1861), and Arrhenius[44–46] (1896). A careful analysis of the original papers shows that Fourier's and Tyndall's works did not really include the concept of the atmospheric greenhouse effect, whereas Arrhenius's work fundamentally differs from the versions of today. With the exception of Ref. 46, the traditional

[d] N_L is determined by the well-known Loschmidt number.[36]

works precede the seminal papers of modern physics, such as Planck's work on the radiation of a black body.[33,34] Although the arguments of Arrhenius were falsified by his contemporaries they were picked up by Callendar[47–53] and Keeling,[54–60] the founders of the modern greenhouse hypothesis.[e] Interestingly, this hypothesis has been vague ever since it has been used. Even Keeling stated (1978)[57]:

> "The idea that CO_2 from fossil fuel burning might accumulate in air and cause warming of the lower atmosphere was speculated upon as early as the latter the nineteenth century (Arrhenius, 1903). At that time the use of fossil fuel was slight to expect a rise in atmospheric CO_2 to be detectable. The idea was convincingly expressed by Callendar (1938, 1940) but still without solid evidence rise in CO_2."

The influence of CO_2 on the climate was also discussed thoroughly in a number of publications that appeared between 1909 and 1980, mainly in Germany.[61–88] The most influential authors were Möller,[69,80–86] who also wrote a textbook on meteorology,[89,90] and Manabe.[73–77,85] It seems that the joint work of Möller and Manabe[85] has had a significant influence on the formulation of the modern atmospheric CO_2 greenhouse conjectures and hypotheses, respectively.

In a very comprehensive report of the US Department of Energy (DOE), which appeared in 1985,[91] the atmospheric greenhouse hypothesis had been cast into its final form and became the cornerstone in all subsequent IPCC publications.[23–30]

Of course, it may be that even if the oversimplified picture entertained in IPCC global climatology is physically incorrect, a thorough discussion may reveal a nonneglible influence of certain radiative effects (apart from sunlight) on the weather, and hence on its local averages, the climates, which may be dubbed the CO_2 greenhouse effect. But then three key questions will remain, even if the effect is claimed to serve only as a genuine trigger of a network of complex reactions:

(1) Is there a fundamental CO_2 greenhouse effect in physics?
(2) If so, what is the fundamental physical principle behind this CO_2 greenhouse effect?
(3) Is it physically correct to consider radiative heat transfer as the fundamental mechanism controlling the weather setting thermal conductivity and friction to zero?

The aim of this paper is to give an affirmative *negative* answer to all of these questions rendering them rhetoric.

[e]Recently, von Storch criticized the anthropogenic global warming scepticism by characterizing the discussion as "a discussion of yesterday and the day before yesterday."[1] Ironically, it was Calendar and Keeling who once reactivated "a discussion of yesterday and the day before yesterday" based on *already falsified* arguments.

1.3. *This paper*

In the language of physics, *an effect* is a not necessarily evident but a reproducible *and* measurable phenomenon *together with* its theoretical explanation.

Neither the warming mechanism in a glass house *nor* the supposed anthropogenic warming is due to an effect in the sense of this definition:

- In the first case (the glass house), one encounters a straightforward phenomenon.
- In the second case (the Earth's atmosphere), one cannot measure something; rather, one only makes heuristic calculations.

The explanation of the warming mechanism in a real greenhouse is a standard problem in undergraduate courses, in which optics, nuclear physics, and classical radiation theory are dealt with. On this level neither the mathematical formulation of the first and second law of thermodynamics nor the partial differential equations of hydrodynamics or irreversible thermodynamics are known; the phenomenon has thus to be analyzed with comparatively elementary means.

However, looking up the search terms "glass house effect," "greenhouse effect," or the German word "Treibhauseffekt" in classical textbooks on experimental physics or theoretical physics, one finds — possibly to one's surprise and disappointment — that this effect does not appear anywhere — with a few exceptions, where in updated editions of some books publications in climatology are cited. One prominent example is the textbook by Kittel who added a " supplement" to the 1990 edition of his Thermal Physics on page 115[92]:

> "The Greenhouse Effect describes the warming of the surface of the Earth caused by the infrared absorbent layer of water, as vapor and in clouds, and of carbon dioxide on the atmosphere between the Sun and the Earth. The water may contribute as much as 90 percent of the warming effect."

Kittel's "supplement" refers to the 1990 and 1992 books of J. T. Houghton *et al.* on Climate Change, which are nothing but the standard IPCC assessments.[23,25] In general, most climatologic texts do not refer to any fundamental work of thermodynamics and radiation theory. Sometimes the classical astrophysical work of Chandrasekhar[93] is cited, but it is not clear at all which results are applied where, and how the conclusions of Chandrasekhar fit into the framework of infrared radiation transfer in planetary atmospheres.

There seems to exist no source where an atmospheric greenhouse effect is introduced from fundamental university physics alone.

Evidently, the atmospheric greenhouse problem is not a fundamental problem of the philosophy of science, which is best described by the Münchhausen trilemma,[f]

[f] The term was coined by the critical rationalist Hans Albert, see e.g., Ref. 94. For the current discussion on global warming Albert's work may be particularly interesting. According to Albert, new insights are not easy to be spread, because there is often an ideological obstacle, for which Albert coined the notion of *immunity against criticism*.

stating that one is left with the ternary alternative[g]

infinite regression — dogma — circular reasoning.

Rather, the atmospheric greenhouse mechanism is a conjecture, which may be proved or disproved already in concrete engineering thermodynamics.[95–97] Exactly, this was done well many years ago by an expert in this field, namely Alfred Schack, who wrote a classical textbook on this subject.[95] In 1972, he showed that the radiative component of heat transfer of CO_2, though relevant at the temperatures in combustion chambers, can be neglected at atmospheric temperatures. The influence of carbonic acid on the Earth's climates is definitively unmeasurable.[98]

The remaining part of this paper is organized as follows:

- In Sec. 2, the warming effect in real greenhouses, which has to be distinguished strictly from the (in-) famous conjecture of Arrhenius, is discussed.
- Section 3 is devoted to the atmospheric greenhouse problem. It is shown that this effect neither has experimental nor theoretical foundations and must be considered as *fictitious.* The claim that CO_2 emissions give rise to anthropogenic climate changes has no physical basis.
- In Sec. 4, theoretical physics and climatology are discussed in context of the philosophy of science. The question is raised, how far global climatology fits into the framework of exact sciences such as physics.
- The final Sec. 5 is a physicist's summary.

2. The Warming Mechanism in Real Greenhouses

2.1. *Radiation basics*

2.1.1. *Introduction*

For years, the warming mechanism in real greenhouses, paraphrased as "the greenhouse effect," has been commonly misused to explain the conjectured atmospheric greenhouse effect. In school books, in popular scientific articles, and even in high-level scientific debates, it has been stated that the mechanism observed within a glass house bears some similarity to the anthropogenic global warming. Meanwhile, even mainstream climatologists admit that the warming mechanism in real glass houses has to be distinguished strictly from the claimed CO_2 greenhouse effect.

Nevertheless, one should have a look at the classical glass house problem to recapitulate some fundamental principles of thermodynamics and radiation theory. Later on, the relevant radiation dynamics of the atmospheric system will be elaborated on and distinguished from the glass house setup.

Heat is the kinetic energy of molecules and atoms and will be transferred by contact or radiation. Microscopically, both interactions are mediated by photons.

[g] Originally, an *alternative* is a choice between two options, not one of the options itself. A ternary alternative generalizes an ordinary alternative to a threefold choice.

In the former case, which is governed by the Coulomb respective van der Waals interaction, these are the virtual or off-shell photons; in the latter case these are the real or on-shell photons. The interaction between photons and electrons (and other particles that are electrically charged or have a nonvanishing magnetic momentum) is microscopically described by the laws of quantum theory. Hence, in principle, thermal conductivity and radiative transfer may be described in a unified framework. However, the nonequilibrium many-body problem is a highly nontrivial one and subject to the discipline of physical kinetics unifying quantum theory and nonequilibrium statistical mechanics.

Fortunately, an analysis of the problem by applying the methods and results of classical radiation theory already leads to interesting insights.

2.1.2. *The infinitesimal specific intensity*

In classical radiation theory[93] the main quantity is the *specific intensity* I_ν. It is defined in terms of the *amount of radiant energy* dE_ν in a specified frequency interval $[\nu, \nu + d\nu]$ that is transported across an area element $d\mathbf{F}_1$ in the direction of another area element $d\mathbf{F}_2$ during a time dt:

$$dE_\nu = I_\nu d\nu dt \frac{(\mathbf{r}\, d\mathbf{F}_1)\, (\mathbf{r}\, d\mathbf{F}_2)}{|\mathbf{r}|^4} \tag{4}$$

where $\mathbf{r}$ is the distance vector pointing from $d\mathbf{F}_1$ to $d\mathbf{F}_2$ (Fig. 1).

For a general radiation field, one may write

$$I_\nu = I_\nu(x, y, z; l, m, n; t) \tag{5}$$

where (x, y, z) denote the coordinates, (l, m, n) the direction cosines, t the time, respectively, to which I_ν refers.

With the aid of the definition of the scalar product Eq. (4) may be cast into the form

$$dE_\nu = I_\nu d\nu dt \cdot \frac{(\cos\vartheta_1\, d\mathrm{F}_1) \cdot (\cos\vartheta_2\, d\mathrm{F}_2)}{\mathrm{r}^2}\,. \tag{6}$$

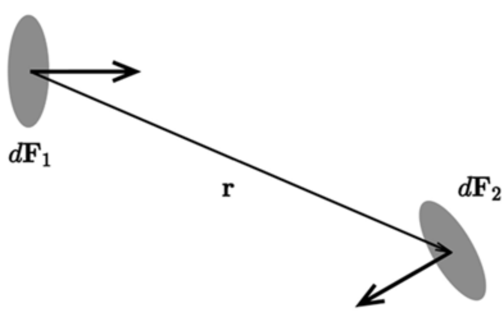


Fig. 1. The geometry of classical radiation: A radiating infinitesimal area $d\mathbf{F}_1$ and an illuminated infinitesimal area $d\mathbf{F}_2$ at distance $\mathbf{r}$.

A special case is given by

$$\cos\vartheta_2 = 1\,. \tag{7}$$

With

$$\begin{aligned}\vartheta &= \vartheta_1\\ \sigma &= dF_1\\ d\omega &= dF_2/r^2\end{aligned} \tag{8}$$

Equation (6) becomes

$$dE_\nu = I_\nu d\nu dt\,\cos\vartheta d\sigma\, d\omega \tag{9}$$

defining the *pencil of radiation*.[93]

Equation (6), which will be used below, is slightly more general than Eq. (9), which is more common in the literature. Both can be simplified by introducing an *integrated intensity*

$$I_0 = \int_0^\infty I_\nu\, d\nu \tag{10}$$

and a *radiant power* dP. For example, Eq. (6) may be cast into the form

$$dP = I_0 \cdot \frac{(\cos\vartheta_1 d\mathrm{F}_1)\cdot(\cos\vartheta_2 d\mathrm{F}_2)}{r^2}\,. \tag{11}$$

2.1.3. *Integration*

When performing integration, one has to bookkeep the dimensions of the physical quantities involved. Usually, the area dF_1 is integrated and the equation is rearranged in such a way that there is an intensity I (respectively an intensity times an area element IdF) on both sides of the equation. Three cases are particularly interesting:

(a) *Two parallel areas with distance a*
According to Fig. 2, one may write

$$\vartheta_1 = \vartheta_2 =: \vartheta\,. \tag{12}$$

By setting

$$r^2 = r_0^2 + a^2 \tag{13}$$

$$2r dr = 2r_0 dr_0 \tag{14}$$

$$\cos\vartheta = \frac{a}{r} \tag{15}$$

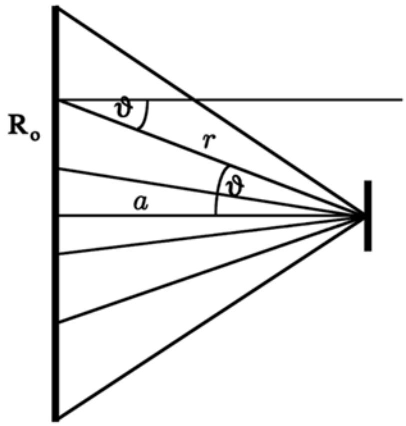


Fig. 2. Two parallel areas with distance a.

one obtains

$$
\begin{aligned}
I_{\text{parallel areas}} &= \int_0^{2\pi}\int_0^{R_0} I_0 \frac{(\cos\vartheta)^2}{r^2} r_0 dr_0 d\varphi \\
&= \int_0^{2\pi}\int_0^{R_0} I_0 \frac{a^2}{r^4} r_0 dr_0 d\varphi \\
&= \int_0^{2\pi}\int_a^{\sqrt{R_0^2+a^2}} I_0 \frac{a^2}{r^4} r dr d\varphi \\
&= 2\pi \cdot I_0 \cdot a^2 \cdot \int_a^{\sqrt{R_0^2+a^2}} \frac{1}{r^3} dr \\
&= 2\pi \cdot I_0 \cdot a^2 \cdot \left(-\frac{1}{2r^2}\bigg|_a^{\sqrt{R_0^2+a^2}} \right) \\
&= \pi \cdot I_0 \cdot a^2 \cdot \left(\frac{1}{a^2} - \frac{1}{R_0^2+a^2} \right) \\
&= \pi \cdot I_0 \cdot \frac{R_0^2}{R_0^2+a^2} \,. \qquad (16)
\end{aligned}
$$

(b) *Two parallel areas with distance* $a \to 0$

If the distance a is becoming very small whereas R_0 is kept finite, one will have

$$I_{\text{parallel areas}\,(a\to 0)} = \lim_{a\to 0}\left(\pi \cdot I_0 \cdot \frac{R_0^2}{R_0^2+a^2}\right) = \pi I_0 \,. \qquad (17)$$

This relation corresponds to the total half-space intensity for a radiation from a unit surface.

(c) *The Earth illuminated by the Sun*

With I_0^{Sun} being the factor I_0 for the Sun, the solar total half-space intensity is given by

$$I_{\text{Sun's surface}} = \pi \cdot I_0^{\text{Sun}} . \tag{18}$$

Setting

$$a = R_{\text{Earth's orbit}} \tag{19}$$

$$R_0 = \mathrm{R}_{\text{Sun}} \tag{20}$$

one gets for the solar intensity at the Earth's orbit

$$\begin{aligned} I_{\text{Earth's orbit}} &= \pi \cdot I_0^{\text{Sun}} \cdot \frac{\mathrm{R}_{\text{Sun}}^2}{\mathrm{R}_{\text{Sun}}^2 + \mathrm{R}_{\text{Earth's orbit}}^2} \\ &= I_{\text{Sun's surface}} \cdot \frac{\mathrm{R}_{\text{Sun}}^2}{\mathrm{R}_{\text{Sun}}^2 + \mathrm{R}_{\text{Earth's orbit}}^2} \\ &\approx I_{\text{Sun's surface}} \cdot \frac{\mathrm{R}_{\text{Sun}}^2}{\mathrm{R}_{\text{Earth's orbit}}^2} \\ &\approx I_{\text{Sun's surface}} \cdot \frac{1}{(215)^2} \end{aligned} \tag{21}$$

2.1.4. *The Stefan–Boltzmann law*

For a perfect black body and a unit area positioned in its proximity, we can compute the intensity I with the aid of the Kirchhoff–Planck-function, which comes in two versions

$$B_\nu(T) = \frac{2h\nu^3}{c^2}\left[\exp\left(\frac{h\nu}{kT}\right) - 1\right]^{-1} \tag{22}$$

$$B_\lambda(T) = \frac{2hc^2}{\lambda^5}\left[\exp\left(\frac{hc}{\lambda kT}\right) - 1\right]^{-1} \tag{23}$$

that are related to each other by

$$B_\nu(T)d\nu = B_\nu(T)\frac{d\nu}{d\lambda}d\lambda = B_\nu(T)\frac{c}{\lambda^2}d\lambda =: -B_\lambda(T)d\lambda \tag{24}$$

with

$$\nu = c/\lambda \tag{25}$$

where c is the speed of light, h is the Planck constant, k is the Boltzmann constant, λ is the wavelength, ν is the frequency, and T is the absolute temperature, respectively. Integrating over all frequencies or wavelengths we obtain the Stefan–Boltzmann T^4 law

$$I = \pi \cdot \int_0^\infty B_\nu(T)d\nu = \pi \cdot \int_0^\infty B_\lambda(T)d\lambda = \sigma T^4 \tag{26}$$

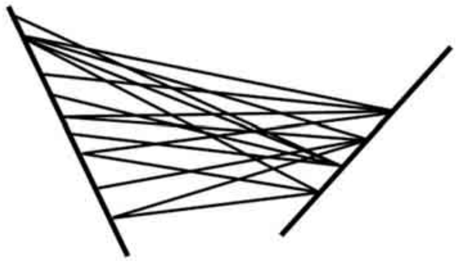


Fig. 3. The geometry of classical radiation: Two surfaces radiating against each other.

with

$$\sigma = \pi \cdot \frac{2\pi^4 k^4}{15c^2h^3} = 5.670400 \cdot 10^{-8} \frac{W}{m^2K^4} \,. \tag{27}$$

One conveniently writes

$$S(T) = 5.67 \cdot \left(\frac{T}{100}\right)^4 \frac{W}{m^2} \,. \tag{28}$$

This is the net radiation energy per unit time per unit area placed in the neighborhood of a radiating plane surface of a black body.

2.1.5. *Conclusion*

Three facts should be emphasized here:

- In *classical radiation theory*, radiation is *not* described by a vector field assigning to every space point a corresponding vector. Rather, with each point of space, many rays are associated (Fig. 3). This is in sharp contrast to the modern description of the radiation field as an electromagnetic field with the Poynting vector field as the relevant quantity.[99]
- The constant σ appearing in the T^4 law is *not* a universal constant of physics. It strongly depends on the particular geometry of the problem considered.[h]
- The T^4-law will no longer hold if one integrates only over a filtered spectrum, appropriate to real world situations. This is illustrated in Fig. 4 .

Many pseudo-explanations in the context of global climatology are already falsified by these three fundamental observations of mathematical physics.

[h] For instance, to compute the radiative transfer in a multi-layer setup, the correct point of departure is the infinitesimal expression for the radiation intensity, not an integrated Stefan–Boltzmann expression already computed for an entirely different situation.

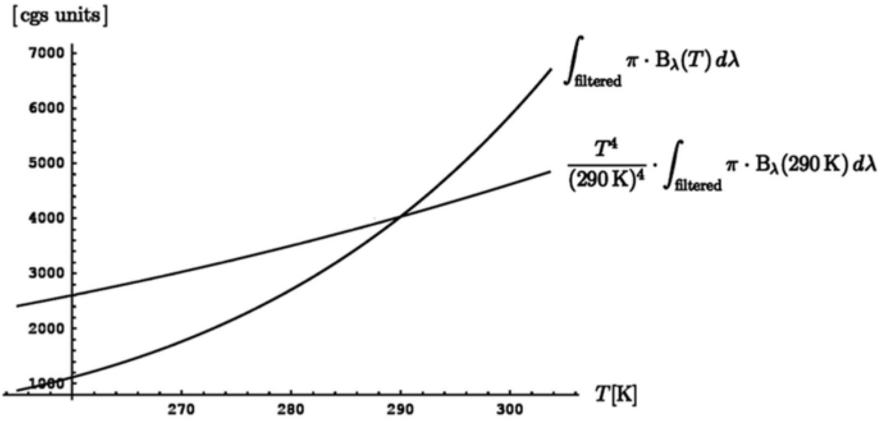


Fig. 4. Black body radiation compared to the wradiation of a sample colored body. The nonuniversal constant σ is normalized in such a way that both curves coincide at $T = 290$ K. The Stefan–Boltzmann T^4 law does no longer hold in the latter case, where only two bands are integrated over, namely that of visible light and of infrared radiation from 3 μm to 5 μm, giving rise to a steeper curve.

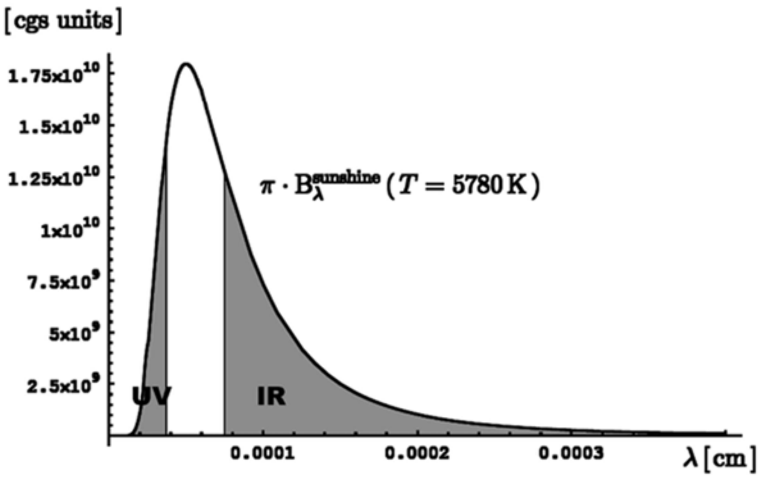


Fig. 5. The spectrum of the sunlight assuming the Sun is a black body at $T = 5780$ K.

2.2. *The Sun as a black body radiator*

The Kirchhoff–Planck function describes an ideal black body radiator. For matter of convenience one may define

$$B_\lambda^{\text{sunshine}} = B_\lambda^{\text{Sun}} \cdot \frac{R_{\text{Sun}}^2}{R_{\text{Earth's orbit}}^2} = B_\lambda^{\text{Sun}} \cdot \frac{1}{(215)^2}\,. \tag{29}$$

Table 8. The proportional portion of the ultraviolet, visible, and infrared sunlight, respectively.

Band	Range [nm]	Portion [%]
ultraviolet	$0 - 380$	10.0
visible	$380 - 760$	44,8
infrared	$760 - \infty$	45,2

Figure 5 shows the spectrum of the sunlight, assuming the Sun is a black body of temperature $T = 5780$ K.

To compute the part of radiation for a certain wavelength interval $[\lambda_1, \lambda_2]$, one has to evaluate the expression

$$\frac{\displaystyle\int_{\lambda_1}^{\lambda_2} B_\lambda^{\text{sunshine}}(5780)d\lambda}{\displaystyle\int_0^{\infty} B_\lambda^{\text{sunshine}}(5780)d\lambda}\,. \tag{30}$$

Table 8 shows the proportional portions of the ultraviolet, visible, and infrared sunlight, respectively.

Here, the visible range of the light is assumed to lie between 380 nm and 760 nm. It should be mentioned that the visible range depends on the individuum.

In any case, a larger portion of the incoming sunlight lies in the infrared range than in the visible range. In most papers, discussing the supposed greenhouse effect this important fact is completely ignored.

2.3. *The radiation on a very nice day*

2.3.1. *The phenomenon*

Especially after a year's hot summer, every car driver knows a sort of glass house or greenhouse effect: If he parks his normally tempered car in the morning and the Sun shines into the interior of the car until he gets back into it at noon, he will almost burn his fingers at the steering wheel, if the dashboard area had been subject to direct Sun radiation. Furthermore, the air inside the car is unbearably hot, even if it is quite nice outside. One opens the window and the slide roof, but unpleasant hot air may still hit one from the dashboard while driving. One can notice a similar effect in the winter, only then one will probably welcome the fact that it is warmer inside the car than outside. In greenhouses or glass houses, this effect is put to use: the ecologically friendly solar energy, for which no energy taxes are probably going to be levied even in the distant future, is used for heating. Nevertheless, glass houses have not replaced conventional buildings in our temperate climate zone not only because most people prefer to pay energy taxes to heat in the winter, and to live in a cooler apartment on summer days, but because glass houses have other disadvantages as well.

2.3.2. *The sunshine*

One does not need to be an expert in physics to explain immediately why the car is so hot inside: It is the Sun, which has heated the car inside like this. However, it is a bit harder to answer the question why it is not as hot outside the car, although there the Sun shines onto the ground without obstacles. Undergraduate students with their standard physical recipes at hand can easily "explain" this kind of a greenhouse effect: The main part of the Sun's radiation (Fig. 6) passes through the glass, as the maximum (Fig. 7) of the solar radiation is of blue-green wavelength

$$\lambda_{\text{bluegreen}} = 0.5\ \mu\text{m} \tag{31}$$

which the glass lets through. This part can be calculated with the Kirchhoff–Planck-function.

Evidently, the result depends on the type of glass. For instance, if it is transparent to electromagnetic radiation in the 300 nm–1000 nm range one will have

$$\frac{\displaystyle\int_{0.3\,\mu\text{m}}^{1\,\mu\text{m}} B_\lambda^{\text{sunshine}}(5780)d\lambda}{\displaystyle\int_0^\infty B_\lambda^{\text{sunshine}}(5780)d\lambda} = 77,2\%\,. \tag{32}$$

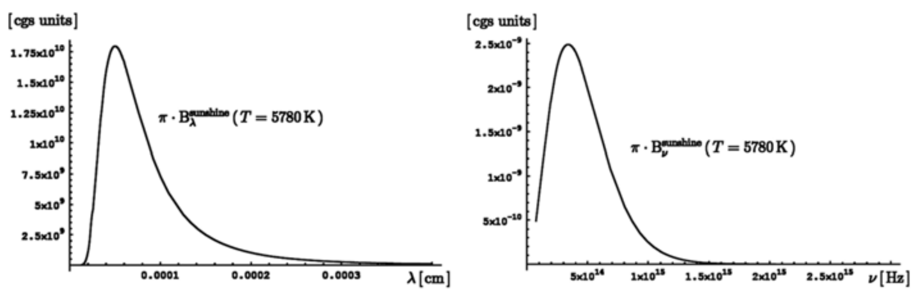


Fig. 6. The unfiltered spectral distribution of the sunshine on Earth under the assumption that the Sun is a black body with temperature $T = 5780$ K (left: in wavelength space, right: in frequency space).

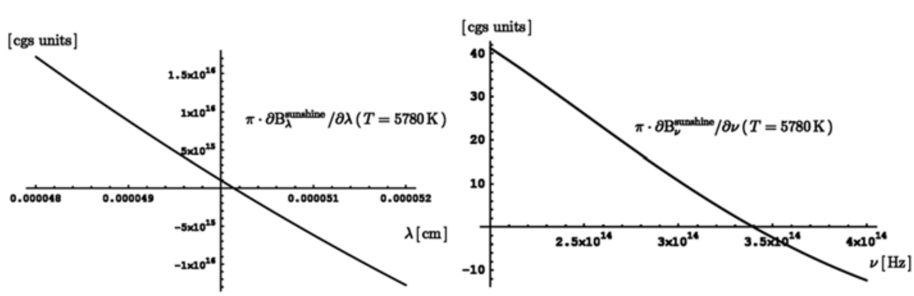


Fig. 7. The exact location of the zero of the partial derivatives of the radiation intensities of the sunshine on Earth (left: in wavelength space, right: in frequency space).

In the case of a glass, which is assumed to be transparent only to visible light (380 nm–760 nm) one gets

$$\frac{\displaystyle\int_{0.380\,\mu\mathrm{m}}^{0.760\,\mu\mathrm{m}} B_\lambda^{\mathrm{sunshine}}(5780)d\lambda}{\displaystyle\int_0^\infty B_\lambda^{\mathrm{sunshine}}(5780)d\lambda} = 44,8\%\,. \tag{33}$$

Because of the Fresnel reflection[99] at both pane boundaries, one has to subtract 8–10 percent and only 60–70 percent (respectively 40 percent) of the solar radiation reach the interior of the vehicle. High performance tinted glass which is also referred to as *spectrally selective tinted glass* reduces solar heat gain typically by a factor of 0.50 (only by a factor of 0.69 in the visible range) compared to standard glass.[100]

2.3.3. *The radiation of the ground*

The bottom of a glass house has a temperature of approximately 290 K (Fig. 8). The maximum of a black body's radiation can be calculated with the help of Wien's displacement law (cf. Figs. 9 and 10)

$$\lambda_{\max}(T)\cdot T = \mathrm{const.} \tag{34}$$

giving

$$\lambda_{\max}(300\,\mathrm{K}) = \frac{6000\,\mathrm{K}}{300\,\mathrm{K}}\cdot\lambda_{\max}(6000\,\mathrm{K}) = 10\,\mu\mathrm{m}\,. \tag{35}$$

This is far within the infrared wave range, where glass reflects practically all light, according to Beer's formula.[101] Practically 100 percent of a black body's radiation at ground temperatures lie above the wavelengths of 3.5 μm. The thermal radiation of the ground is thus "trapped" by the panes.

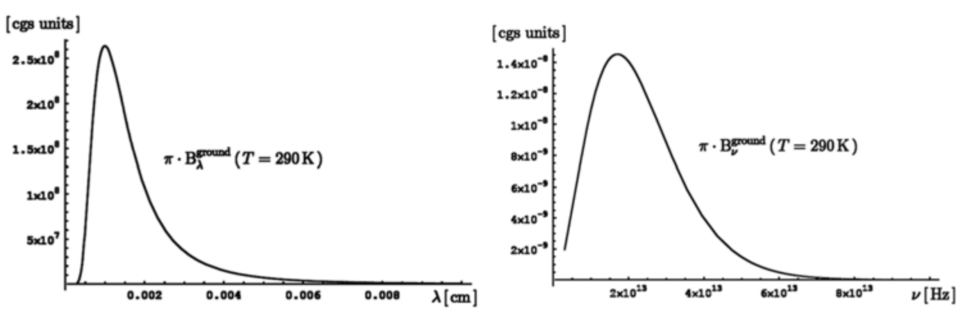


Fig. 8. The unfiltered spectral distribution of the radiation of the ground under the assumption that the Earth is a black body with temperature $T = 290$ K (left: in wavelength space, right: in frequency space).

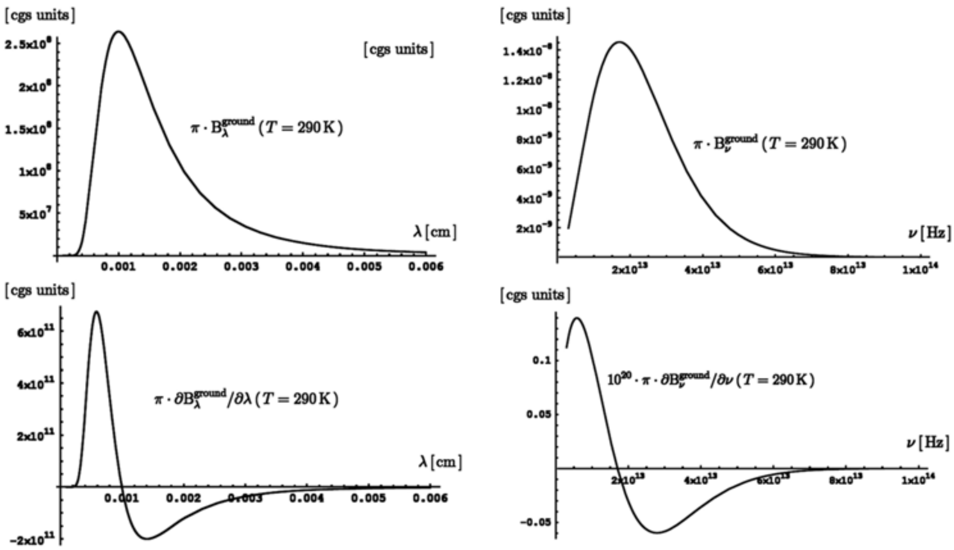


Fig. 9. The radiation intensity of the ground *and* its partial derivative as a function of the wavelength λ (left column) and of the frequency ν (right column).

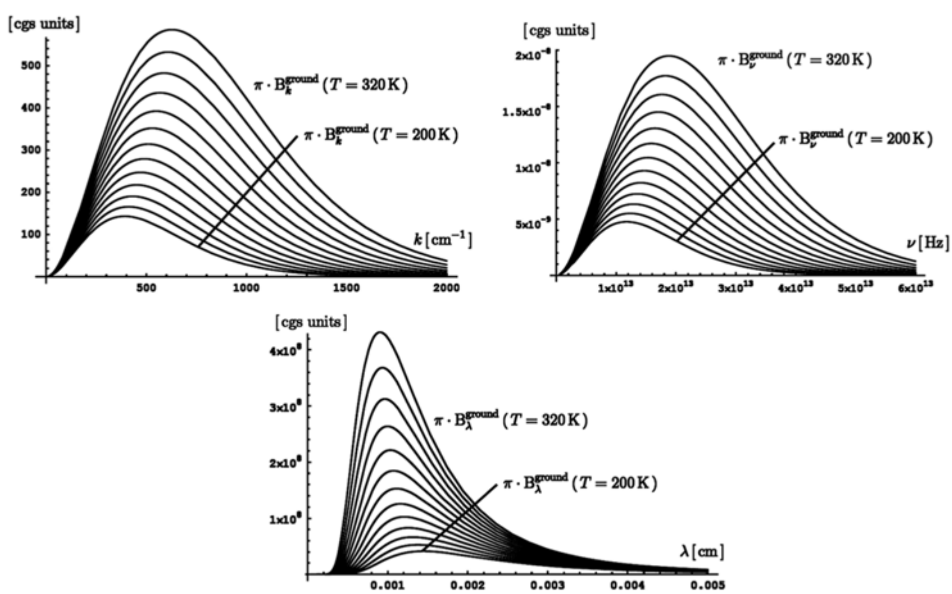


Fig. 10. Three versions of radiation curve families of the radiation of the ground (as a function of the wave number k, of the frequency ν, of the wavelength λ, respectively), assuming that the Earth is a black radiator.

According to Wien's power law describing the intensity of the maximum wavelength

$$B_{\lambda_{\max}}(T) \propto T^5 \tag{36}$$

the intensity of the radiation on the ground at the maximum is

$$\frac{T^5_{\text{Sun}}}{T^5_{\text{Earth's ground}}} \approx \frac{6000^5}{300^5} 20^5 = 3.2 \cdot 10^6 \tag{37}$$

times smaller than on the Sun and

$$\frac{T^5_{\text{Sun}}}{T^5_{\text{Earth's ground}}} \cdot \frac{R^2_{\text{Sun}}}{R^2_{\text{Earth's orbit}}} \approx 20^5 \cdot \frac{1}{215^2} \approx 70 \tag{38}$$

times smaller than the solar radiation on Earth.

The *total radiation* can be calculated from the Stefan–Boltzmann law

$$B_{\text{total}}(T) = \sigma \cdot T^4 \,. \tag{39}$$

Hence, the ratio of the intensities of the sunshine and the ground radiation is given by

$$\frac{T^4_{\text{Sun}}}{T^4_{\text{Earth's ground}}} \cdot \frac{R^2_{\text{Sun}}}{R^2_{\text{Earth's orbit}}} \approx 20^4 \cdot \frac{1}{215^2} \approx 3.46 \,. \tag{40}$$

Loosely speaking, the radiation of the ground is about four times weaker than the incoming solar radiation.

2.3.4. *Sunshine versus ground radiation*

To make these differences even clearer, it is convenient to graphically represent the spectral distribution of intensity at the Earth's orbit and of a black radiator of 290 K, respectively, in relation to the wavelength (Figs. 11, 12, and 13).

To fit both curves into one drawing, one makes use of the technique of superelevation and/or applies an appropriate re-scaling. It becomes clearly visible

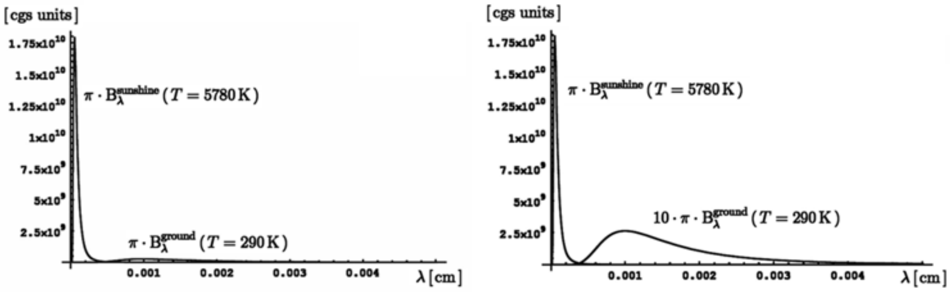


Fig. 11. The unfiltered spectral distribution of the sunshine on Earth under the assumption that the Sun is a black body with temperature $T = 5780$ K *and* the unfiltered spectral distribution of the radiation of the ground under the assumption that the Earth is a black body with temperature $T = 290$ K, *both* in one diagram (left: normal, right: super elevated by a factor of 10 for the radiation of the ground).

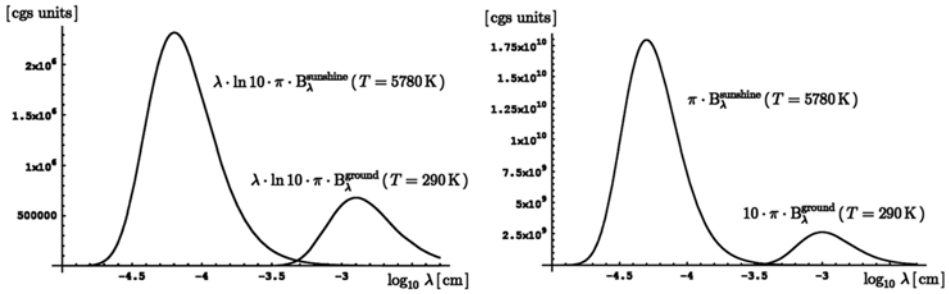


Fig. 12. The unfiltered spectral distribution of the sunshine on Earth under the assumption that the Sun is a black body with temperature $T = 5780$ K *and* the unfiltered spectral distribution of the radiation of the ground under the assumption that the Earth is a black body with temperature $T = 290$ K, *both* in one semi-logarithmic diagram (left: normalized in such a way that equal areas correspond to equal intensities, right: super elevated by a factor of 10 for the radiation of the ground).

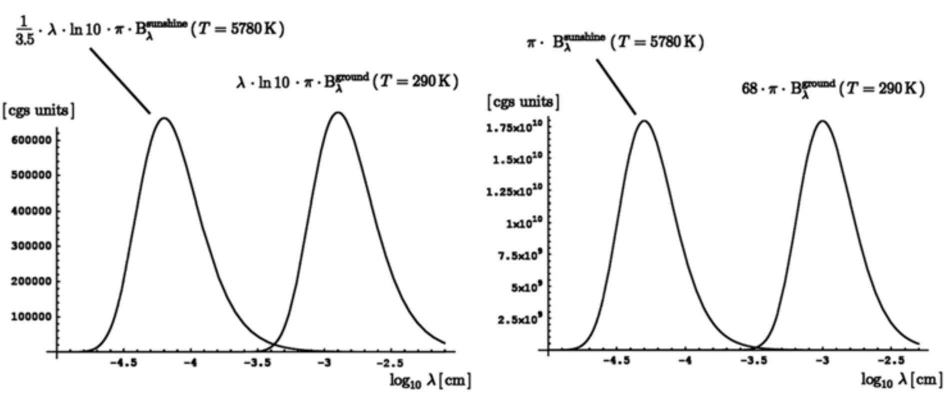


Fig. 13. The unfiltered spectral distribution of the sunshine on Earth under the assumption that the Sun is a black body with temperature $T = 5780$ K *and* the unfiltered spectral distribution of the radiation of the ground under the assumption that the Earth is a black body with temperature $T = 290$ K, *both* in one semi-logarithmic diagram (left: normalized in such a way that equal areas correspond to equal intensities with an additional re-scaling of the sunshine curve by a factor of 1/3.5, right: super elevated by a factor of 68 for the radiation of the ground).

- that the maxima are at 0.5 μm or 10 μm, respectively;
- that the intensities of the maxima differ by more than an order of 10;
- that above 0.8 μm (infrared) the solar luminosity has a notable intensity.

Figure 13 is an obscene picture, since it is physically misleading. The obscenity will not remain in the eye of the beholder, if the latter takes a look at the obscure scaling factors already applied by Bakan and Raschke in an undocumented way in their paper on the so-called natural greenhouse effect.[102] This is scientific misconduct as is the missing citation. Bakan and Raschke borrowed this figure from Ref. 103

where the scaling factors, which are of utmost importance for the whole discussion, are left unspecified. This is scientific misconduct as well.

2.3.5. *Conclusion*

Although in most cases the preceding "explanation" suffices to provide an accepted solution to the standard problem, presented in the undergraduate course, the analysis leaves the main question untouched, namely, why the air inside the car is warmer than outside and why the dashboard is hotter than the ground outside the car. Therefore, in the following, the situation inside the car is approached experimentally.

2.4. *High school experiments*

On a hot summer afternoon, temperature measurements were performed with a standard digital thermometer by the first author[104–108] and were recently reproduced by the other author.

In the summertime, such measurements can be reproduced by everyone very easily. The results are listed in Table 9.

Against these measurements, one may object that one had to take the dampness of the ground into account: at some time during the year the stones certainly got wet in the rain. The above mentioned measurements were made at a time, when it had not rained for weeks. They are real measured values, not average values over all breadths and lengths of the Earth, day and night and all seasons and changes of weather. These measurements are recommended to every climatologist, who believes in the CO_2-greenhouse effect, because he feels already while measuring, that the just described effect **has nothing to do with** trapped thermal radiation. One can touch the car's windows and notice that the panes, which absorb the infrared light, are rather cool and do not heat the inside of the car in any way. If one holds his hand in the shade next to a very hot part of the dashboard that lies in the Sun, one will practically feel no thermal radiation despite the high temperature of 70°C, whereas one clearly feels the hot air. Above the ground one sees why it is cooler there than inside the car: the air inside the car "stands still," above the ground one always feels a slight movement of the air. The ground is never completely plain,

Table 9. Measured temperatures inside and outside a car on a hot summer day.

Thermometer located ...	Temperature
inside the car, in direct Sun	71°C
inside the car, in the shade	39°C
next to the car, in direct Sun, above the ground	31°C
next to the car, in the shade, above the ground	29°C
in the living room	25°C

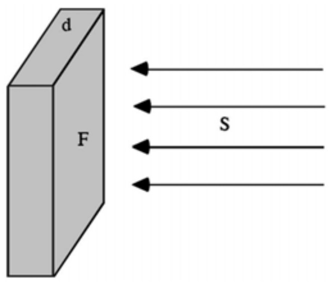


Fig. 14. A solid parallelepiped of thickness d and cross section F subject to solar radiation.

so there is always light and shadow, which keep the circulation going. This effect was formerly used for many old buildings in the city of Braunschweig, Germany. The south side of the houses had convexities. Hence, for most of the time during the day, parts of the walls are in the shade and, because of the thus additionally stimulated circulation, the walls are heated less.

In order to study the warming effect one can look at a body of specific heat c_{v} and width d, whose cross section F is subject to the radiation intensity S (see Fig. 14). One has

$$\varrho \mathrm{F} \mathrm{d} c_v \frac{dT}{dt} = \mathrm{FS} \tag{41}$$

or, respectively,

$$\frac{dT}{dt} = \frac{S}{\varrho c_v \mathrm{d}} \tag{42}$$

which may be integrated yielding

$$T = T_0 + \frac{S}{\varrho c_v \mathrm{d}} (t - t_0) \,. \tag{43}$$

In this approximation, there is a linear rise of the temperature in time because of the irradiated intensity. One sees that the temperature rises particularly fast in absorbing bodies of small diameter: Thin layers are heated especially fast to high temperatures by solar radiation. The same applies to the heat capacity per unit volume:

- If the heat capacity is large, the change of temperature will be slow.
- If the heat capacity is small, the change in temperature will be fast.

Thus, the irradiated intensity is responsible for the quick change of temperature, *not* for its value. This rise in temperature is stopped by the heat transfer of the body to its environment.

Especially in engineering thermodynamics the different kinds of heat transfer and their interplay are discussed thoroughly.[95–97] A comprehensive source is the classical textbook by Schack.[95] The results have been tested e.g., in combustion chambers and thus have a strong experimental background.

One has to distinguish between

- Conduction
- Convection
- Radiation
- Transfer of latent heat in phase transitions such as condensation and sublimation[i]

Conduction, condensation, and radiation, which slow down the rise in temperature, work practically the same inside and outside the car. Therefore, the only possible reason for *a difference* in final temperatures must be convection: A volume element of air above the ground, which has been heated by radiation, is heated up (by heat transfer through conduction), rises and is replaced by cooler air. This way, there is, in the average, a higher difference of temperatures between the ground and the air and a higher heat transmission compared to a situation, where the air would not be replaced. This happens inside the car as well, but there the air stays locked in and the air which replaces the rising air is getting warmer and warmer, which causes lower heat transmission. Outside the car, there is of course a lot more cooler air than inside. On the whole, there is a higher temperature for the sunlight absorbing surfaces as well as for the air.

Of course, the exposed body loses energy by thermal radiation as well. The warmer body inside the car would lose more heat in unit of time than the colder ground outside, which would lead to a higher temperature outside, if this temperature rise were not absorbed by another mechanism! If one considers, that only a small part of the formerly reckoned 60–70 percent of solar radiation intensity reaches the inside of the car through its metal parts, this effect would contribute far stronger to the temperature outside! The "explanation" of the physical greenhouse effect only with attention to the radiation balance would therefore lead to the reverse effect! The formerly discussed effect of the "trapped" heat radiation by reflecting glass panes remains, which one can read as hindered heat transmission in this context. So this means a deceleration of the cooling process. However, as this heat transmission is less important compared to the convection, nothing remains of the absorption and reflection properties of glass for infrared radiation to explain the physical greenhouse effect. Neither the absorption nor the reflection coefficient of glass for the infrared light is relevant for this explanation of the physical greenhouse effect, but only the movement of air, hindered by the panes of glass.

Although meteorologists have known this for a long time,[109,110] some of them still use the physical greenhouse effect to explain temperature effects of planetary atmospheres. For instance, in their book on the atmospheric greenhouse effect, Schönwiese and Diekmann build their arguments upon the glass house effect.[111] Their list of references contains a seminal publication that clearly shows that this is inadmissable.[91]

[i]Among those phenomena governed by the exchange of latent heat there is *radiation frost*, a striking example for a cooling of the Earth's surface through emission of infrared radiation.

2.5. *Experiment by Wood*

Although the warming phenomenon in a glass house is due to the suppression of convection, say air cooling,[j] it remains true that most glasses absorb infrared light at wavelength 1 μm and higher almost completely.

An *experimentum crucis* therefore is to build a glass house with panes consisting of NaCl or KCl, which are transparent to visible light as well as infrared light. For rock salt (NaCl) such an experiment was realized as early as 1909 by Wood[112–115]:

> "There appears to be a widespread belief that the comparatively high temperature produced within a closed space covered with glass, and exposed to solar radiation, results from a transformation of wavelength, that is, that the heat waves from the Sun, which are able to penetrate the glass, fall upon the walls of the enclosure and raise its temperature: the heat energy is re-emitted by the walls in the form of much longer waves, which are unable to penetrate the glass, the greenhouse acting as a radiation trap.
>
> I have always felt some doubt as to whether this action played a very large part in the elevation of temperature. It appeared much more probable that the part played by the glass was the prevention of the escape of the warm air heated by the ground within the enclosure. If we open the doors of a greenhouse on a cold and windy day, the trapping of radiation appears to lose much of its efficacy. As a matter of fact I am of the opinion that a greenhouse made of a glass transparent to waves of every possible length would show a temperature nearly, if not quite, as high as that observed in a glass house. The transparent screen allows the solar radiation to warm the ground, and the ground in turn warms the air, but only the limited amount within the enclosure. In the "open," the ground is continually brought into contact with cold air by convection currents.
>
> To test the matter, I constructed two enclosures of dead black cardboard, one covered with a glass plate, the other with a plate of rock-salt of equal thickness. The bulb of a thermometer was inserted in each enclosure and the whole packed in cotton, with the exception of the transparent plates which were exposed. When exposed to sunlight, the temperature rose gradually to 65°C, the enclosure covered with the salt plate keeping a little ahead of the other, owing to the fact that it transmitted the longer waves from the Sun, which were stopped by the glass. In order to eliminate this action the sunlight was first passed through a glass plate.
>
> There was now scarcely a difference of one degree between the temperatures of the two enclosures. The maximum temperature reached was about 55°C. From what we know about the distribution of energy in the spectrum of the radiation emitted by a body at 55°C, it is clear that the rock-salt plate is capable of transmitting practically all of it, while the glass plate

[j] A problem familiar to those who are involved in PC hardware problems.

> stops it entirely. This shows us that the loss of temperature of the ground by radiation is very small in comparison to the loss by convection, in other words that we gain very little from the circumstance that the radiation is trapped.
>
> Is it therefore necessary to pay attention to trapped radiation in deducing the temperature of a planet as affected by its atmosphere? The solar rays penetrate the atmosphere, warm the ground which in turn warms the atmosphere by contact and by convection currents. The heat received is thus stored up in the atmosphere, remaining there on account of the very low radiating power of a gas. It seems to me very doubtful if the atmosphere is warmed to any great extent by absorbing the radiation from the ground, even under the most favourable conditions.
>
> I do not pretend to have gone very deeply into the matter, and publish this note merely to draw attention to the fact that trapped radiation appears to play but a very small part in the actual cases with which we are familiar."

This text is a recommended reading for all global climatologists referring to the greenhouse effect.

2.6. *Glass house summary*

It is not the "trapped" infrared radiation, which explains the warming phenomenon in a real greenhouse, but it is the suppression of air cooling.[k]

3. The Fictitious Atmospheric Greenhouse Effects

3.1. *Definition of the problem*

After it has been thoroughly discussed, that the physical greenhouse effect is essentially the explanation why air temperatures in a closed glass house or in a closed car are higher than outside, one should have a closer look at the fictitious atmospheric greenhouse effects.

Meanwhile, there are many different phenomena and different explanations for these effects, so it is justified to pluralize here.

Depending on the particular school and the degree of popularization, the assumption that the atmosphere is transparent for visible light but opaque for infrared radiation is supposed to lead to

- a warming of the Earth's surface *and/or*
- a warming of the lower atmosphere *and/or*
- a warming of a certain layer of the atmosphere *and/or*
- a slow-down of the natural cooling of the Earth's surface

[k] As almost everybody knows, this is also a standard problem in PCs.

and so forth.

Unfortunately, there is no source in the literature, where the greenhouse effect is introduced in harmony with the scientific standards of theoretical physics. As already emphasized, the "supplement" to Kittel's book on thermal physics[92] only refers to the IPCC assessments.[23,25] Prominent global climatologists (as well as "climate sceptics") often present their ideas in handbooks, encyclopedias, and in secondary and tertiary literature.

3.2. *Scientific error versus scientific fraud*

Recently, the German climatologist Graßl emphasized that errors in science are unavoidable, even in climate research.[116] And the IPCC weights most of its official statements with a kind of a "probability measure."[2] So it seems that, even in the mainstream discussion on the supposed anthropogenic global warming, there is room left for scientific errors and their corrections.

However, some authors and filmmakers have argued that the greenhouse effect hypothesis is not based on an error, but clearly is a kind of a scientific fraud.

Five examples:

- As early as 1990 the Australian movie entitled "The Greenhouse Conspiracy" showed that the case for the greenhouse effect rests on four pillars[117]:
  - (a) the *factual evidence*, i.e., the climate records, that supposedly suggest that a global warming has been observed and is exceptional;
  - (b) the *assumption* that carbon dioxide is the cause of these changes;
  - (c) the *predictions of climate models* that claim that a doubling of CO_2 leads to a predictable global warming;
  - (d) the *underlined physics*.

In the movie these four pillars were dismantled bringing the building down. The speaker states:

> "In a recent paper on the effects of carbon dioxide, Professor Ellsaesser of the Lawrence Livermore Laboratories, a major US research establishment in California, concluded that a doubling of carbon dioxide would have little or no effect on the temperature at the surface and, if anything, might cause the surface to cool."

The reader is referred to Ellsaesser's original work.[118]

- Two books by the popular German meteorologist and sociologist Wolfgang Thüne, entitled *The Greenhouse Swindle* (in German, 1998)[119] and *Aquittal* for CO_2 (in German, 2002)[120] tried to demonstrate that the CO_2 greenhouse effect hypothesis is pure nonsense.
- A book written by Heinz Hug entitled *Those Who Play the Trumpet of Fear* (in German, 2002) elucidated the history and the background of the current greenhouse business.[121]

- Another movie was shown recently on Channel 4 (UK) entitled "The Great Global Warming Swindle" supporting the thesis that the supposed CO_2 induced anthropogenic global warming has no scientific basis.[122]
- In his paper, "CO_2: The Greatest Scientific Scandal of Our Time" the eminent atmospheric scientist Jaworowski made a well-founded statement.[12]

On the other hand, Sir David King, the science advisor of the British government, stated that "global warming is a greater threat to humanity than terrorism" (Singer),[l] other individuals put anthropogenic global warming deniers in the same category as holocaust deniers, and so on. In an uncountable number of contributions to newspapers and TV shows in Germany, the popular climatologist Latif[m] continues to warn the public about the consequences of rising greenhouse gas (GHG) emissions.[123] But until today it is *impossible* to find a book on nonequilibrium thermodynamics or radiation transfer where this effect is derived from first principles.

The main objective of this paper is not to draw the line between error and fraud, but to find out where the greenhouse effect appears or *disappears* within the frame of physics. Therefore, in Sec. 3.3 several different variations of the atmospheric greenhouse hypotheses will be analyzed and disproved. The authors restrict themselves on statements that appeared *after* a publication by Lee in the well-known *Journal of Applied Meteorology* (1973); see Ref. 109 and references therein.

Lee's 1973 paper is a milestone. In the beginning Lee writes:

> "The so-called radiation 'greenhouse' effect is a misnomer. Ironically, while the concept is useful in describing what occurs in the Earth's atmosphere, it is invalid for cryptoclimates created when space is enclosed with glass, e.g., in greenhouses and solar energy collectors. Specifically, elevated temperatures observed under glass cannot be traced to the spectral absorbtivity of glass.
>
> The misconception was demonstrated experimentally by R. W. Wood more than 60 years ago (Wood, 1909)[112] and recently in an analytical manner by Businger (1963).[124] Fleagle and Businger (1963)[125] devoted a section of their text to the point, and suggested that radiation trapping by the Earth's atmosphere should be called 'atmosphere effect' to discourage use of the misnomer. Munn (1966)[126] reiterated that the analogy between 'atmosphere' and 'greenhouse' effect 'is not correct because a major factor in greenhouse climate is the protection the glass gives against turbulent heat losses'. In one instance, Lee (1966),[127] observed that the net flux of radiant energy actually was diminished be more than 10% in a 6-mil polyvinyl enclosure.

[l]cf. Singer's summary at the Stockholm 2006 conference.[1]
[m]Some time ago one of the authors (R.D.T.), in his role as a physics lab teaching assistant, instructed his student Mojib Latif in fundamental university physics.

> In spite of the evidence, modern textbooks on meteorology and climatology not only repeat the misnomer, but frequently support the false notion that 'heat-retaining behavior of the atmosphere is analogous to what happens in a greenhouse' (Miller, 1966),[128] or that 'the function of the [greenhouse] glass is to form a radiation trap' (Peterssen, 1958).[129] (see also Sellers, 1965, Chang, 1968, and Cole, 1970).[130–132] The mistake obviously is subjective, based on similarities of the atmosphere and glass, and on the 'neatness' of the example in teaching. The problem can be rectified through straightforward analysis, suitable for classroom instruction."

Lee continues his analysis with a calculation based on radiative balance equations, which are physically questionable. The same holds for a comment by Berry[110] on Lee's work. Nevertheless, Lee's paper is a milestone marking *the day after* which every serious scientist or science educator is no longer allowed to compare the greenhouse with the atmosphere, even in the classroom, which Lee explicitly refers to.

3.3. *Different versions of the atmospheric greenhouse conjecture*

3.3.1. *Atmospheric greenhouse effect after Möller (1973)*

In his popular textbook on meteorology[89,90] Möller claims:

> "In a real glass house (with no additional heating, i.e., no greenhouse) the window panes are transparent to sunshine, but opaque to terrestrial radiation. The heat exchange must take place through heat conduction within the glass, which requires a certain temperature gradient. Then the colder boundary surface of the window pane can emit heat. In case of the atmosphere water vapor and clouds play the role of the glass."

Disproof: The existence of the greenhouse effect is considered as a necessary condition for thermal conductivity. This is a physical nonsense. Furthermore, it is implied that the spectral transmissivity of a medium determines its thermal conductivity straightforwardly. This is a physical nonsense as well.

3.3.2. *Atmospheric greenhouse effect after Meyer's encyclopedia (1974)*

In the 1974 edition of Meyer's Enzyklopädischem Lexikon one finds under "glass house effect"[133]:

> "Name for the influence of the Earth's atmosphere on the radiation and heat budget of the Earth, which compares to the effect of a glass house: Water vapor and carbon dioxide in the atmosphere let short wave solar radiation go through down to the Earth's surface with a relative weak attenuation and, however, reflect the portion of long wave (heat) radiation which is emitted from the Earth's surface (atmospheric backradiation)."

Disproof: Firstly, the main part of the solar radiation lies outside the visible light. Secondly, reflection is confused with emission. Thirdly, the concept of atmospheric backradiation relies on an inappropriate application of the formulas of cavity radiation. This will be discussed in Sec. 3.5.

3.3.3. *Atmospheric greenhouse effect after Schönwiese* (*1987*)

The prominent climatologist Schönwiese states[111]:

> "... we use the picture of a glass window that is placed between the Sun and the Earth's surface. The window pane lets pass the solar radiation unhindered but absorbs a portion of the heat radiation of the Earth. The glass pane emits, corresponding to its own temperature, heat in both directions: To the Earth's surface and to the interplanetary space. Thus the radiative balance of the Earth's surface is raised. The additional energy coming from the glass pane is absorbed almost completely by the Earth's surface immediately warming up until a new radiative equilibrium is reached."

Disproof: That the window pane lets pass the solar radiation unhindered is simply wrong. Of course, some radiation goes sidewards. As shown experimentally in Sec. 2.4, the panes of the car window are relatively cold. This is only one out of many reasons, why the glass analogy is unusable. Hence the statement is vacuous.

3.3.4. *Atmospheric greenhouse effect after Stichel* (*1995*)

Stichel (the former deputy head of the German Physical Society) stated once[134]:

> "Now it is generally accepted textbook knowledge that the long-wave infrared radiation, emitted by the warmed up surface of the Earth, is partially absorbed and re-emitted by CO_2 and other trace gases in the atmosphere. This effect leads to a warming of the lower atmosphere and, for reasons of the total radiation budget, to a cooling of the stratosphere at the same time."

Disproof: This would be a *Perpetuum Mobile of the Second Kind*. A detailed discussion is given in Sec. 3.9. Furthermore, there is no total radiation budget, since there are no individual conservation laws for the different forms of energy participating in the game. The radiation energies in question are marginal compared to the relevant geophysical and astrophysical energies. Finally, the radiation depends on the temperature and not *vice versa*.

3.3.5. *Atmospheric greenhouse effect after Anonymous 1* (*1995*)

> "The carbon dioxide in the atmosphere lets the radiation of the Sun, whose maximum lies in the visible light, go through completely, while on the other hand it absorbs a part of the heat radiation emitted by the Earth into

space because of its larger wavelength. This leads to higher near-surface air temperatures."

Disproof: The first statement is incorrect since the obviously nonneglible infrared part of the incoming solar radiation is being absorbed (cf. Sec. 2.2). The second statement is falsified by referring to a counterexample known to every housewife: The water pot on the stove. Without water filled in, the bottom of the pot will soon become glowing red. Water is an excellent absorber of infrared radiation. However, with water filled in, the bottom of the pot will be substantially colder. Another example would be the replacement of the vacuum or gas by glass in the space between two panes. Conventional glass absorbs infrared radiation pretty well, but its thermal conductivity shortcuts any thermal isolation.

3.3.6. *Atmospheric greenhouse effect after Anonymous 2 (1995)*

"If one raises the concentration of carbon dioxide, which absorbs the infrared light and lets visible light go through, in the Earth's atmosphere, the ground heated by the solar radiation and/or near-surface air will become warmer, because the cooling of the ground is slowed down."

Disproof: It has already been shown in Sec. 1.1 that the thermal conductivity is changed only marginally even by doubling the CO_2 concentration in the Earth's atmosphere.

3.3.7. *Atmospheric greenhouse effect after Anonymous 3 (1995)*

"If one adds to the Earth's atmosphere a gas, which absorbs parts of the radiation of the ground into the atmosphere, the surface temperatures and near-surface air temperatures will become larger."

Disproof: Again, the counterexample is the water pot on the stove; see Sec. 3.3.5.

3.3.8. *Atmospheric greenhouse effect after German Meteorological Society (1995)*

In its 1995 statement, the German Meteorological Society says[135]:

"As a point of a departure, the radiation budget of the Earth is described. In this case the incident unweakened solar radiation at the Earth's surface is partly absorbed and partly reflected. The absorbed portion is converted into heat and must be re-radiated in the infrared spectrum. Under such circumstances simple model calculations yield an average temperature of about −18°C at the Earth's surface ... Adding an atmosphere, the incident radiation at the Earth's surface is weakened only a little, because the atmosphere is essentially transparent in the visible range of the spectrum.

> Contrary to this, in the infrared range of the spectrum the radiation emitted form the ground is absorbed to a large extent by the atmosphere ... and, depending on the temperature, re-radiated in all directions. Only in the so-called window ranges (in particular in the large atmospheric window 8–13, μm) the infrared radiation can escape into space. The infrared radiation that is emitted downwards from the atmosphere (the so-called back-radiation) raises the energy supply of the Earth's surface. A state of equilibrium can adjust itself if the temperature of the ground rises and, therefore, a raised radiation according to Planck's law is possible. This undisputed natural greenhouse effect gives rise to an increase temperature of the Earth's surface."

Disproof: The concept of a radiation budget is physically wrong. The average of the temperature is calculated incorrectly. Furthermore, a nonnegligible portion of the incident solar radiation is absorbed by the atmosphere. Heat must not be confused with heat radiation. The assumption that if gases emit heat radiation, then they will emit it only downwards, is rather obscure. The described mechanism of re-calibration to equilibrium has no physical basis. The laws of cavity radiation do not apply to fluids and gases.

3.3.9. *Atmospheric greenhouse effect after Graßl* (*1996*)

The former director of the World Meteorological Organization (WMO) climate research program, Professor Hartmut Graßl, states[136]:

> "In so far as the gaseous hull [of the Earth] obstructs the propagation of solar energy down to the planet's surface less than the direct radiation of heat from the surface into space, the ground and the lower atmosphere must become warmer than *without this atmosphere*, in order to re-radiate as much energy as received from the Sun."

Disproof: This statement is vacuous, even in a literal sense. One cannot compare the temperature of a planet's lower atmosphere with the situation where a planetary atmosphere does not exist at all. Furthermore, as shown in Sec. 2.2, the portion of the incoming infrared is larger than the portion of the incoming visible light. Roughly speaking, we have a 50-50 relation. Therefore, the supposed warming from the bottom must compare to an analogous warming from the top. Even within the logics of Graßl's oversimplified (and physically incorrect) conjecture one is left with a zero temperature gradient and thus a null effect.

3.3.10. *Atmospheric greenhouse effect after Ahrens* (*2001*)

In his textbook *Essentials in Meteorology: In Invitation to the Atmosphere* the author Ahrens states[137]:

> "The absorption characteristics of water vapor, CO_2, and other gases such as methane and nitrous oxide ... were, at one time, thought to be similar to the glass of a florists greenhouse. In a greenhouse, the glass allows visible radiation to come in, but inhibits to some degree the passage of outgoing infrared radiation. For this reason, the behavior of the water vapor and CO_2, the atmosphere is popularly called the greenhouse effect. However, studies have shown that the warm air inside a greenhouse is probably caused more by the air's inability to circulate and mix with the cooler outside air, rather than by the entrapment of infrared energy. Because of these findings, some scientists insist that the greenhouse effect should be called the atmosphere effect. To accommodate everyone, we will usually use the term atmospheric greenhouse effect when describing the role that water vapor and CO_2, play in keeping the Earth's mean surface temperature higher than it otherwise would be."

Disproof: The concept of the Earth's mean temperature is ill-defined. Therefore, the concept of a rise of a mean temperature is ill-defined as well.

3.3.11. *Atmospheric greenhouse effect after Dictionary of Geophysics, Astrophysics, and Astronomy* (*2001*)

The Dictionary of Geophysics, Astrophysics, and Astronomy says[138]:

> "Greenhouse Effect: The enhanced warming of a planets surface temperature caused by the trapping of heat in the atmosphere by certain types of gases (called greenhouse gases; primarily carbon dioxide, water vapor, methane, and chlorofluorocarbons). Visible light from the Sun passes through most atmospheres and is absorbed by the body's surface. The surface reradiates this energy as longer-wavelength infrared radiation (heat). If any of the greenhouse gases are present in the body's troposphere, the atmosphere is transparent to the visible but opaque to the infrared, and the infrared radiation will be trapped close to the surface and will cause the temperature close to the surface to be warmer than it would be from solar heating alone."

Disproof: Infrared radiation is confused with heat. It is not explained at all what is meant by "the infrared radiation will be trapped." Is it a MASER, is it "superinsulation", i.e., vanishing thermal conductivity, or is it simple thermalization?

3.3.12. *Atmospheric greenhouse effect after Encyclopaedia of Astronomy and Astrophysics* (*2001*)

The Encyclopaedia of Astronomy and Astrophysics defines the greenhouse effect as follows[139]:

> "The greenhouse effect is the radiative influence exerted by the atmosphere of a planet which causes the temperature at the surface to rise above the value it would normally reach if it were in direct equilibrium with sunlight (taking into account the planetary albedo). This effect stems from the fact that certain atmospheric gases have the ability to transmit most of the solar radiation and to absorb the infrared emission from the surface. The thermal (i.e., infrared) radiation intercepted by the atmosphere is then partially re-emitted towards the surface, thus contributing additional heating of the surface. Although the analogy is not entirely satisfactory in terms of the physical processes involved, it is easy to see the parallels between the greenhouse effect in the atmosphere-surface system of a planet and a horticultural greenhouse: the planetary atmosphere plays the role of the glass cover that lets sunshine through to heat the soil while partly retaining the heat that escapes from the ground. The analogy goes even further, since an atmosphere may present opacity 'windows' allowing infrared radiation from the surface to escape, the equivalent of actual windows that help regulate the temperature inside a domestic greenhouse."

Disproof: The concept of the "direct equilibrium with the sunlight" is physically wrong, as will be shown in detail in Sec. 3.7. The description of the physics of a horticultural greenhouse is incorrect. Thus, the analogy stinks.

3.3.13. *Atmospheric greenhouse effect after Encyclopaedia Britannica Online (2007)*

Encyclopaedia Britannica Online explains the greenhouse effect in the following way[140]:

> "The atmosphere allows most of the visible light from the Sun to pass through and reach the Earth's surface. As the Earth's surface is heated by sunlight, it radiates part of this energy back toward space as infrared radiation. This radiation, unlike visible light, tends to be absorbed by the greenhouse gases in the atmosphere, raising its temperature. The heated atmosphere in turn radiates infrared radiation back toward the Earth's surface. (Despite its name, the greenhouse effect is different from the warming in a greenhouse, where panes of glass transmit visible sunlight but hold heat inside the building by trapping warmed air.) Without the heating caused by the greenhouse effect, the Earth's average surface temperature would be only about $-18°C$ ($0°F$)."

Disproof: The concept of the Earth's average temperature is a physically and mathematically ill-defined and therefore useless concept as will be shown in Sec. 3.7.

3.3.14. *Atmospheric greenhouse effect after Rahmstorf (2007)*

The renowned German climatologist Rahmstorf claims[141]:

> "To the solar radiation reaching Earth's surface ... the portion of the long-wave radiation is added, which is radiated by the molecules partly downward and partly upward. Therefore more radiation arrives down, and for reasons of compensation the surface must deliver more energy and thus has to be warmer (+15°C), in order to reach also there down again an equilibrium. A part of this heat is transported upward from the surface also by atmospheric convection. Without this natural greenhouse effect the Earth would have frozen life-hostilely and completely. The disturbance of the radiative balance [caused by the enrichment of the atmosphere with trace gases] must lead to a heating up of the Earth's surface, as it is actually observed."

Disproof: Obviously, reflection is confused with emission. The concept of radiative balance is faulty. This will be explained in Sec. 3.7.

3.3.15. *Conclusion*

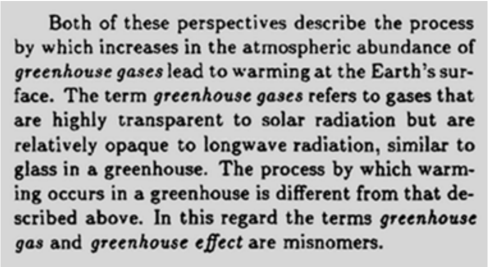
It is interesting to observe,

- that until today the "atmospheric greenhouse effect" does not appear
  - in any fundamental work of thermodynamics,
  - in any fundamental work of physical kinetics,
  - in any fundamental work of radiation theory;
- that the definitions given in the literature beyond straight physics are very different and, partly, **contradict** each other.

3.4. *The conclusion of the US Department of Energy*

All fictitious greenhouse effects have in common, that there is supposed to be one and only one cause for them: An eventual rise in the concentration of CO_2 in the atmosphere is supposed to lead to higher air temperatures near the ground. For convenience, in the context of this paper, it is called *the* CO_2*-greenhouse effect.*[n] Lee's 1973 result[109] that the warming phenomenon in a glass house does not compare to the supposed atmospheric greenhouse effect was confirmed in the 1985 report of the United States Department of Energy "Projecting the climatic effects of increasing carbon dioxide."[91] In this comprehensive pre-IPCC publication MacCracken explicitly states that the terms "greenhouse gas" and " greenhouse effect" are misnomers.[91,142] A copy of the last paragraph of the corresponding section on page 28 in shown is Fig. 15.

[n] The nomenclature naturally extents to other trace gases.



Both of these perspectives describe the process by which increases in the atmospheric abundance of ***greenhouse gases*** lead to warming at the Earth's surface. The term ***greenhouse gases*** refers to gases that are highly transparent to solar radiation but are relatively opaque to longwave radiation, similar to glass in a greenhouse. The process by which warming occurs in a greenhouse is different from that described above. In this regard the terms ***greenhouse gas*** and ***greenhouse effect*** are misnomers.

Fig. 15. An excerpt from page 28 of the DOE report (1985).

The following should be emphasized:

- The warming phenomenon in a glass house and the supposed atmospheric greenhouse effects have the same participants, but in the latter case the situation is reversed.
- Methodically, there is a huge difference: For the physical greenhouse effect one can make measurements, look at the differences of the instruments readings, and observe the effect without any scientific explanation and such without any prejudice.

For the fictitious atmospheric greenhouse effect one cannot watch anything, and only calculations are compared with one another: Formerly extremely simple calculations, they got more and more intransparent. Nowadays computer simulations are used, which virtually nobody can reproduce.[143]

In the following the different aspects of the physics underlying the atmospheric situation are discussed in detail.

Fig. 16. A very popular physical error illustrated in the movie "An Inconvenient Truth" by Davis Guggenheim featuring Al Gore (2006).

3.5. *Absorption/emission is not reflection*

3.5.1. *An inconvenient popularization of physics*

Figure 16 shows a screenshot from a controversial award-winning "documentary film" about "climate change," specifically "global warming," starring Al Gore, the former United States Vice President, and directed by Davis Guggenheim.[144,145] This movie has been supported by managers and policymakers around the world and has been shown in schools and in outside events, respectively. Lewis wrote an interesting "A Skeptic's Guide to An Inconvenient Truth" evaluating Gore's work in detail.[146]

From the view of a trained physicist, Gore's movie is rather grotesque, since it is shockingly wrong. Every licensed radio amateur[o] knows that what is depicted in Fig. 16 would be true only,

- if the radiation graphically represented here was long wave or short wave radiation;
- if the reflecting sphere was a certain layer of the ionosphere.[147]

Short waves (e.g., in the 20 m/14 MHz band) are reflected by the F layer of the ionosphere (located 120–400 km above the Earth's surface) enabling transatlantic connections (QSOs). Things depend pretty much on the solar activity, i.e., on the sun spot cycle, as every old man (OM) knows well. The reflective characteristics of the ionosphere diminish above about 30 MHz. In the very high frequency (VHF) bands (e.g., 2 m/144 MHz band), one encounters the so-called Sporadic-E clouds (90–120 km above the Earth's surface), which still allow QSOs from Germany to Italy, for example. On the other hand, at the extremely low frequencies (ELF, i.e., frequency range 3–30 Hz), the atmosphere of the Earth behaves as a cavity and one encounters the so-called Schumann resonances.[148] These may be used to estimate a lower bound for the mass of the photon[p] and, surprisingly, appear in the climate change discussion.[149]

However, the radio signal of Al Gore's cellular phone (within the centimeter range) does not travel around the world and so does not Bluetooth, Radar, microwave and infrared radiation (i.e., electromagnetic waves in the submillimeter range).

Ionosphere Radars typically work in the 6 m band, i.e., at 50 MHz. Meteorological Radars work in the 0.1–20 cm range (from 90 GHz down to 1.5 GHz); those in the 3–10 cm range (from 10 GHz down to 3 GHz) are used for wind finding and weather watch.[150] It is obvious that Al Gore confuses the ionosphere with the tropopause, the region in the atmosphere that is the boundary between the troposphere and the stratosphere. The latter one is located between 6 km (at the poles)

[o] *Callsign of R.D.T.:* DK8HH
[p] As a teaching assistant at Hamburg University/DESY, R.D.T. learned this from Professor Herwig Schopper.

and 17 km (at the equator) above the surface of the Earth.[q]

Furthermore, Al Gore confuses *absorption/emission* with *reflection*. Unfortunately, this is also done implicitly and explicitly in many climatologic papers, often by using the vaguely defined terms "re-emission," "re-radiation," and "backradiation."

3.5.2. *Reflection*

When electromagnetic waves move from a medium of a given refractive index n_1 into a second medium with refractive index n_2, both reflection and refraction of the waves may occur.[151] In particular, when the jump of the refractive index occurs within a length of the order of a wavelength, there will be a reflection. The fraction of the intensity of incident electromagnetic wave that is reflected from the interface is given by the reflection coefficient R, the fraction refracted at the interface is given by the transmission coefficient T. The Fresnel equations, which are based on the assumption that the two materials are both dielectric, may be used to calculate the reflection coefficient R and the transmission coefficient T in a given situation.

In the case of a normal incidence the formula for the reflection coefficient is

$$R = \left(\frac{n_2 - n_1}{n_2 + n_1} \right)^2 . \tag{44}$$

In the case of strong absorption (large electrical conductivity σ), simple formulas can be given for larger angles γ of incidence, as well (Beer's formula):

$$R_s = \frac{(n_2 - n_1 \cos\gamma)^2 + n_2^2 \sigma^2}{(n_2 + n_1 \cos\gamma)^2 + n_2^2 \sigma^2} \tag{45}$$

and

$$R_p = \frac{(n_1 - n_2 \cos\gamma)^2 + n_2^2 \sigma^2 \cos^2\gamma}{(n_1 + n_2 \cos\gamma)^2 + n_2^2 \sigma^2 \cos^2\gamma} . \tag{46}$$

When the jump of the refractive index occurs within a length of the order of a wavelength, there will be a reflection, which is large at high absorption. In the case of gases, this is only possible for radio waves of a comparatively long wavelength in the ionosphere, which has an electrical conductivity, at a diagonal angle of incidence. There is no reflection in the homogeneous absorbing range. As already elucidated in Sec. 3.5.1 this has been well-known to radio amateurs ever since and affects their activity e.g., in the 15 band, but never in the microwave bands. On the other hand, most glasses absorb the infrared light almost completely at approximately 1 μm and longer wavelength: therefore, the reflection of the infrared waves for normal glasses is very high.

For dielectric media, whose electrical conductivity is zero, one cannot use Beer's formulas. This was a severe problem in Maxwell's theory of light.

[q]Some climatologists claim that there is a CO_2 layer in the troposphere that traps or reflects the infrared radiation coming from the ground.

3.5.3. *Absorption and emission*

If an area is in thermodynamical equilibrium with a field of radiation, the intensity E_ν (respectively E_λ) emitted by the unit solid angle into a frequency unit (respectively a wavelength unit) is equal to the absorptance A_ν (respectively A_λ) multiplied with a universal frequency function $B_\nu(T)$ [respectively a wavelength function $B_\lambda(T)$] of the absolute temperature T. One writes, respectively,

$$E_\nu = A_\nu \cdot B_\nu(T)\,, \tag{47}$$

$$E_\lambda = A_\lambda \cdot B_\lambda(T)\,. \tag{48}$$

This is a theorem by *Kirchhoff.* The function $B_\nu(T)$ [respectively $B_\lambda(T)$] is called the *Kirchhoff–Planck-function.* It was already considered in Sec. 2.1.4.

The *reflectance* is, respectively,

$$R_\nu = 1 - A_\nu \tag{49}$$

$$R_\lambda = 1 - A_\lambda \tag{50}$$

and lies between zero and one, like the *absorptance* A_ν. If R is equal to zero and A is equal to one, the body is called a perfect black body. The emissivity is largest for a perfect black body. The proposal to realize a perfect black body by using a cavity with a small radiating opening had already been made by Kirchhoff and is visualized in Fig. 17. For this reason, the emission of a black body for $A_\nu = 1$ (respectively $A_\lambda = 1$) is called *cavity radiation.* The emitted energy comes from the walls, which are being held at a fixed temperature. If this is realized with a part of a body's surface, it will become clear, that these points of view will only be compatible, if the electromagnetic radiation is emitted and absorbed by an extremely thin surface layer. For this reason, it is impossible to describe the volumes of gases with the model of black cavity radiation. Since thermal radiation is electromagnetic radiation, this radiation would have to be caused by thermal motion in case of gases, which normally does not work effectively at room temperatures. At the temperatures of stars the situation is different: The energy levels of the atoms are thermally excited by impacts.

3.5.4. *Re-emission*

In case of radiation transport calculations, Kirchhoff's law is "generalized" to the situation, in which the corresponding formula for the emission, or respectively, for

Fig. 17. A cavity realizing a perfect black body.

the absorption (per unit length along the direction ds) is supposed to be applicable

$$\varepsilon_\nu ds = \alpha_\nu ds \cdot B_\nu(T)\,. \tag{51}$$

The physical meaning of this "generalization" can be seen most easily, if the above mentioned Kirchhoff law is mathematically extracted out of this formula. For this, one may introduce

$$\varepsilon_\nu = E_\nu \delta(s - s_0) \tag{52}$$

$$\alpha_\nu = A_\nu \delta(s - s_0) \tag{53}$$

with a δ-density localized at the interface. Physically, this means that all of the absorption and emission comes out of a thin superficial plane. Just like with the correct Kirchhoff law, use is made of the fact, that all absorbed radiation is emitted again, as otherwise the volume area would raise its temperature in thermal balance.

This assumption is called the assumption of *Local Thermodynamical Equilibrium (LTE)*. Re-emission does never mean reflection, but, rather, that the absorption *does not cause any rise of temperature in the gas.*

An important physical difference to the correct Kirchhoff law lies in the fact, that there is no formula for the absorption per linear unit analogous to

$$R_\nu = 1 - A_\nu\,. \tag{54}$$

With ρ being the density of the medium one can define an *absorption coefficient* κ_ν and an *emission coefficient* j_ν, respectively, by setting

$$\alpha_\nu = \kappa_\nu \rho\,, \tag{55}$$

$$\varepsilon_\nu = j_\nu \rho\,. \tag{56}$$

The ratio of the emission to the absorption coefficient

$$S_\nu = \frac{j_\nu}{\kappa_\nu} \tag{57}$$

describes the re-emission of the radiation and is called the *source function.*

3.5.5. *Two approaches of radiative transfer*

In a gas the radiation intensity of an area changes in the direction of the path element ds according to

$$-\frac{dI_\nu}{ds} = \alpha_\nu I_\nu - \varepsilon_\nu\,. \tag{58}$$

With the aid of the functions introduced in Eqs. (55)–(57) this can be expressed as

$$\frac{1}{\kappa_\nu \varrho}\frac{dI_\nu}{ds} = I_\nu - S_\nu\,. \tag{59}$$

This equation is called the *radiative transfer equation.*

Two completely different approaches show that this emission function is not just determined by physical laws[93]:

(1) The usual one, i.e., the one in case of LTE, is given by the ansatz

$$S_\nu(x, y, z; l, m, n) = B_\nu(T(x, y, z; l, m, n)) \tag{60}$$

where the coordinates (x, y, z) and the direction cosines (l, m, n) define the point and the direction to which S_ν and B_ν (respectively T) refer. This approach is justified with the aid of the Kirchhoff–Planck-function B_ν and the "generalized" Kirchhoff law introduced in Eq. (51). This assumption of *Local Thermodynamical Equilibrium* (*LTE*) is ruled out by many scientists even for the extremely hot atmospheres of stars. The reader is referred to Chandrasekhar's classical book on radiative transfer.[93] LTE does only bear a certain significance for the radiation transport calculations, if the absorption coefficients were not dependent on the temperature, which is not the case at low temperatures. Nevertheless, in modern climate model computations, this approach is used unscrupulously.[91]

(2) Another approach is the *scattering atmosphere* given by

$$S_\nu = \frac{1}{4\pi}\int_0^\pi \int_0^{2\pi} p(\vartheta, \varphi; \vartheta', \varphi') I_\nu(\vartheta', \varphi') \sin\vartheta' d\vartheta' d\varphi' \,. \tag{61}$$

These extremely different approaches show, that even the physically well-founded radiative transfer calculations are somewhat arbitrary. Formally, the radiative transfer equation (59) can be integrated leading to

$$I_\nu(s) = I_\nu(0)\exp(-\tau(s, 0)) + \int_0^s S_\nu(s')\exp(-\tau(s, s'))\kappa_\nu \varrho ds' \tag{62}$$

with the optical thickness

$$\tau(s, s') = \int_{s'}^s \kappa_\nu \varrho ds'' \,. \tag{63}$$

The integrations for the separate directions are independent of one another. In particular, the ones up have nothing to do with the ones down. It cannot be overemphasized, that differential equations only allow the calculation of changes on the basis of known parameters. The initial values (or boundary conditions) cannot be derived from the differential equations to be solved. In particular, this even holds for this simple integral.

If one assumes that the temperature of a volume element should be constant, one cannot calculate a rising temperature.

3.6. *The hypotheses of Fourier, Tyndall, and Arrhenius*

3.6.1. *The traditional works*

In their research and review papers the climatologists refer to legendary publications of Svante August Arrhenius (19 Feb. 1859–2 Oct. 1927), a Nobel Prize winner for chemistry. Arrhenius published one of the earliest, extremely simple calculations in 1896, which were immediately — and correctly — doubted and have been forgotten for many decades.[44–46] It is a paper about the influence of carbonic acid in the air on the Earth's ground temperature. In this quite long paper, Arrhenius put the hypothesis up for discussion, that the occurrences of warm and ice ages are supposed to be explainable by certain gases in the atmosphere, which absorb thermal radiation.

In this context Arrhenius cited a 1824 publication by Fourier[r] entitled "Mémoire sur les températures du globe terrestre et des espaces planétaires."[37,38]

Arrhenius states incorrectly that Fourier was the first, who claimed that the atmosphere works like a glass of a greenhouse as it lets the rays of the Sun through but keeps the so-called dark heat from the ground inside.

The English translation of the relevant passage (p. 585) reads:

> "We owe to the celebrated voyager M. de Saussure an experiment which appears very important in illuminating this question. It consists of exposing to the rays of the Sun a vase covered by one or more layers of well transparent glass, spaced at a certain distance. The interior of the vase is lined with a thick envelope of blackened cork, to receive and conserve heat. The heated air is sealed in all parts, either in the box or in each interval between plates. Thermometers placed in the vase and the intervals mark the degree of heat acquired in each place. This instrument has been exposed to the Sun near midday, and one saw, in diverse experiments, the thermometer of the vase reach 70, 80, 100, 110 degrees and beyond (octogesimal division). Thermometers placed in the intervals acquired a lesser degree of heat, and which decreased from the depth of the box towards the outside."

Arrhenius's work was also preceded by the work of Tyndall who discovered that some gases absorb infrared radiation. He also suggested that changes in the concentration of the gases could bring climate change.[39–43] A facsimile of the front pages of Fourier's and Arrhenius's often cited but apparently not really known papers are shown in Figs. 18 and 19, respectively.

In which fantastic way Arrhenius uses Stefan–Boltzmann's law to calculate this "effect," can be seen better in another publication, in which he defends his ice age-hypothesis,[46] see Figs. 20, 21, and 22. First, Arrhenius estimates that 18.7% of the Earth's infrared radiation would not be emitted into space because of its absorption by carbonic acid. This could be taken into account by reducing the Earth's effective radiation temperature T_{eff} to a reduced temperature T_{reduced}. Arrhenius assumed

$$T_{\text{eff}} = 15^\circ\text{C} = 288 \text{ K} \tag{64}$$

and, assuming the validity of the Stefan–Boltzmann law, made the ansatz

$$\frac{\sigma \cdot T_{\text{reduced}}^4}{\sigma \cdot T_{\text{eff}}^4} = \frac{(1 - 0.187) \cdot I_0}{I_0} \tag{65}$$

[r] There is a misprint in Arrhenius's work. The year of publication of Fourier's paper is 1824, not 1827 as stated in many current papers, whose authors apparently did not read the original work of Fourier. It is questionable whether Arrhenius read the original paper.

yielding

$$T_{\text{reduced}} = T_{\text{eff}} \cdot \sqrt[4]{1 - 0.187} \tag{66}$$

and

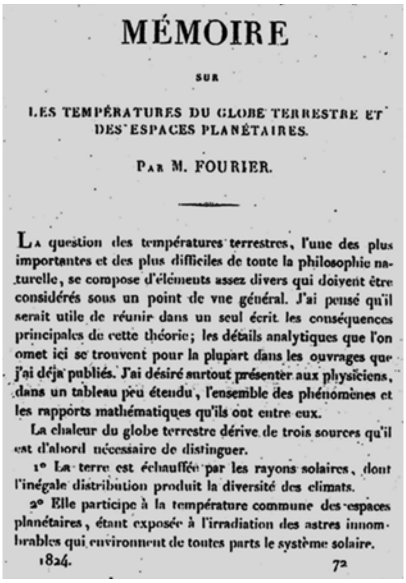
$$T_{\text{reduced}} = \sqrt[4]{0.813} \cdot 288 = 273.47 \tag{67}$$

which corresponds to a lowering of the Earth's temperature of 14.5°C.

As one would probably not think that such an absurd claim is possible, a scan of this passage is displayed in Figs. 21 and 22.

The English translation reads:

> "This statement could lead to the impression, that I had claimed that a reduction of the concentration of carbonic acid in the atmosphere of 20% would be sufficient to cause ice-age temperatures, i.e., to lower the Europe's average temperature about four to five degrees C. To keep such an idea from spreading, I would like to point out that according to the old calculation a reduction of carbonic acid of 50% would cause the temperature to fall for 4 (1897) or, respectively, 3.2 (1901) degrees. **The opinion that a decrease of carbonic acid in the air can explain ice-age temperatures is not proved wrong until it is shown, that the total disappearance of carbonic acid from the atmosphere would not be sufficient to cause a lowering of temperatures about four to five degrees.** It is now easy to estimate how low the temperature would fall, if the Earth's radiation rose in the ratio of 1 to 0.775, i.e., for 29%, which matches the



MÉMOIRE

SUR

LES TEMPÉRATURES DU GLOBE TERRESTRE ET DES ESPACES PLANÉTAIRES.

PAR M. FOURIER.

LA question des températures terrestres, l'une des plus importantes et des plus difficiles de toute la philosophie naturelle, se compose d'éléments assez divers qui doivent être considérés sous un point de vue général. J'ai pensé qu'il serait utile de réunir dans un seul écrit les conséquences principales de cette théorie; les détails analytiques que l'on omet ici se trouvent pour la plupart dans les ouvrages que j'ai déjà publiés. J'ai désiré surtout présenter aux physiciens, dans un tableau peu étendu, l'ensemble des phénomènes et les rapports mathématiques qu'ils ont entre eux.

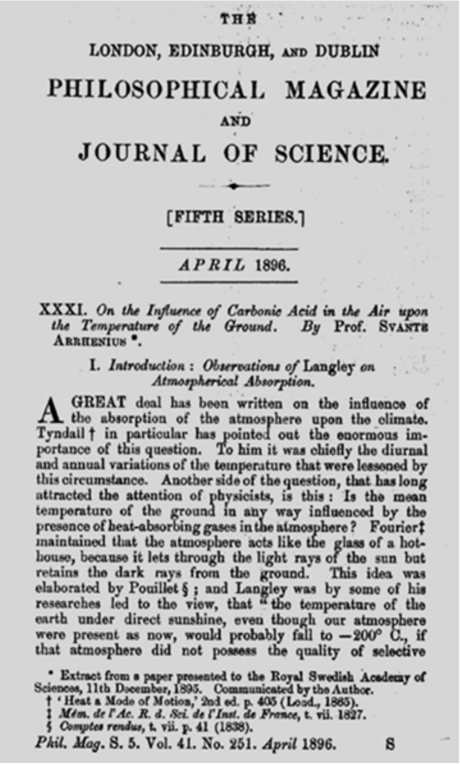
La chaleur du globe terrestre dérive de trois sources qu'il est d'abord nécessaire de distinguer.

1° La terre est échauffée par les rayons solaires, dont l'inégale distribution produit la diversité des climats.

2° Elle participe à la température commune des espaces planétaires, étant exposée à l'irradiation des astres innombrables qui environnent de toutes parts le système solaire.

1824. 72

Fig. 18. The front page of Fourier's 1824 paper.



THE

LONDON, EDINBURGH, AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.

XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS *.

I. *Introduction: Observations of* Langley *on Atmospherical Absorption.*

A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall † in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of the temperature that were lessened by this circumstance. Another side of the question, that has long attracted the attention of physicists, is this: Is the mean temperature of the ground in any way influenced by the presence of heat-absorbing gases in the atmosphere? Fourier ‡ maintained that the atmosphere acts like the glass of a hot-house, because it lets through the light rays of the sun but retains the dark rays from the ground. This idea was elaborated by Pouillet §; and Langley was by some of his researches led to the view, that "the temperature of the earth under direct sunshine, even though our atmosphere were present as now, would probably fall to −200° C., if that atmosphere did not possess the quality of selective

* Extract from a paper presented to the Royal Swedish Academy of Sciences, 11th December, 1895. Communicated by the Author.
† 'Heat a Mode of Motion,' 2nd ed. p. 405 (Lond., 1865).
‡ *Mém. de l'Ac. R. d. Sci. de l'Inst. de France*, t. vii. 1827.
§ *Comptes rendus*, t. vii. p. 41 (1838).

Phil. Mag. S. 5. Vol. 41. No. 251. *April* 1896. S

Fig. 19. The front page of Arrhenius's 1896 paper.

data of Messrs. Rubens and Ladenburg. An increase of emissions of 1% would be equivalent to a decrease of temperatures of 0.72°C, as the average absolute temperature of the Earth is taken to be 15°C = 288°C. Therefore, one could estimate a lowering of the temperatures about 20,9°C as a result of the disappearance of carbonic acid from the atmosphere. A more exact calculation, which takes into account the small amount of radiation of the carbonic acid and of which I have given details in my paper of 1901, leads to slightly lower numbers. According to this calculation, 3.8% out of the 22.5% of terrestrial radiation, which are being absorbed by the carbonic acid in the atmosphere at its current state, are emitted into space by the carbonic acid, so the real decrease of terrestrial radiation would be 18.7%. After the disappearance of the carbonic acid, instead of the current temperature of 15°C = 288 K, there would be an absolute temperature T, which is:

$$T^4 : 288^4 = (1 - 0,187) : 1 \tag{68}$$

being

$$T = 273{,}4 \text{ K} = 0{,}4°\text{C}\,. \tag{69}$$

MEDDELANDEN

FRÅN

K. VETENSKAPSAKADEMIENS NOBELINSTITUT

BAND 1. N:o 2.

Die vermutliche Ursache der Klimaschwankungen

von

SVANTE ARRHENIUS.

In seiner Bakerian Lecture vom 7. Febr. 1861[1] gab Tyndall die Resultate einiger Untersuchungen über die relativ kräftige Absorption von Wärmestrahlen durch Wasserdampf und Kohlensäure. Auf Grund dieser Untersuchungen sprach er die Ansicht aus, dass Veränderungen im Gehalt der Atmosphäre an Kohlensäure und Wasserdampf »alle die Klimaschwankungen, welche durch die Untersuchungen der Geologen konstatiert sind, erklären könnten.»

Später habe ich versucht diese Idée über den thermischen Einfluss der atmosphärischen Absorption, welche von De Saussure, Fourier und Pouillet vor etwa hundert Jahren entwickelt wurde, weiter quantitativ zu entwickeln, indem ich zu berechnen versuchte, wie viele Grade Temperatursteigerung der Erdoberfläche einer bestimmten Schwankung des Kohlensäuregehalts der Atmosphäre entsprechen. Seitdem ich meine letzte Berechnung ausführte, sind einige Untersuchungen erschienen, welche diese interessante Frage berühren und welche ich nicht unerwähnt lassen möchte, da sie teilweise zu unrichtigen Schlussfolgerungen veranlassen könnten.

Die erste dieser Untersuchungen stammt von Hrn Koch.[3] Er beobachtete die Strahlung von einer 100° warmen Quelle,

[1] Neugedruckt in John Tyndall: Contributions to molecular physics London 1872. Die citierte Stelle findet sich auf S. 40.

[2] S. Arrhenius: Phil. Mag. (5) 41. 237, April 1896. Bihang der Stockh. Ak. d. Wiss. Bd. 22, Abth. 1 N:o 1, 1896, Drudes Annalen d. Phys. Bd. 4, 690, 1901, Öfversigt d. Stockh. Ak. 1901, N:o 1. p. 55 und 56.

[3] J. Koch: Öfversigt der Stockh. Ak. 1901. 475.

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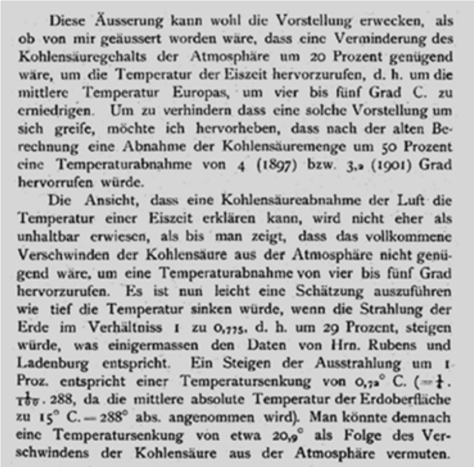
Fig. 20. Excerpt (a) of Arrhenius's 1906 paper.



Diese Äusserung kann wohl die Vorstellung erwecken, als ob von mir geäussert worden wäre, dass eine Verminderung des Kohlensäuregehalts der Atmosphäre um 20 Prozent genügend wäre, um die Temperatur der Eiszeit hervorzurufen, d. h. um die mittlere Temperatur Europas, um vier bis fünf Grad C. zu erniedrigen. Um zu verhindern dass eine solche Vorstellung um sich greife, möchte ich hervorheben, dass nach der alten Berechnung eine Abnahme der Kohlensäuremenge um 50 Prozent eine Temperaturabnahme von 4 (1897) bzw. 3,2 (1901) Grad hervorrufen würde.

Die Ansicht, dass eine Kohlensäureabnahme der Luft die Temperatur einer Eiszeit erklären kann, wird nicht eher als unhaltbar erwiesen, als bis man zeigt, dass das vollkommene Verschwinden der Kohlensäure aus der Atmosphäre nicht genügend wäre, um eine Temperaturabnahme von vier bis fünf Grad hervorzurufen. Es ist nun leicht eine Schätzung auszuführen wie tief die Temperatur sinken würde, wenn die Strahlung der Erde im Verhältniss 1 zu 0,775, d. h. um 29 Prozent, steigen würde, was einigermassen den Daten von Hrn. Rubens und Ladenburg entspricht. Ein Steigen der Ausstrahlung um 1 Proz. entspricht einer Temperatursenkung von 0,72° C. ($=\frac{1}{4}\cdot\frac{1}{100}\cdot 288$, da die mittlere absolute Temperatur der Erdoberfläche zu 15° C. = 288° abs. angenommen wird). Man könnte demnach eine Temperatursenkung von etwa 20,9° als Folge des Verschwindens der Kohlensäure aus der Atmosphäre vermuten.

Fig. 21. Excerpt (b) of Arrhenius's 1906 paper.

Eine genauere Rechnung, wobei die geringe Strahlung der Kohlensäure berücksichtigt wird, und wovon ich die Details in meiner Untersuchung von 1901 gegeben habe,[1] führt zu etwas niedrigeren Zahlen. Nach derselben würde von den 22,5 Prozent der Erdstrahlung, welche durch die Kohlensäure der Atmosphäre in ihrem jetzigen Zustand absorbiert werden, 3,8 Prozent wieder von der Kohlensäure in den Weltraum ausgestrahlt werden, so dass die wirkliche Verminderung der Erdstrahlung 18,7 Prozent betragen würde. Anstatt der jetzigen Temperatur von 15° C. = 288° abs. hätte man also nach Verschwinden der Kohlensäure eine absolute Temperatur T, für welche gilt:

$$T^4 : 288^4 = (1-0{,}187) : 1$$

woraus T = 273,4 abs. = 0,4° C.

Die jetzige Kohlensäuremenge würde demnach die Temperatur der Erdoberfläche um 14,6° C. erhöhen; ihr Verschwinden aus der Atmosphäre würde infolgedessen eine etwa drei mal so starke Temperaturerniedrigung als diejenige, welche für die Eiszeit charakteristisch war, hervorrufen.

In ähnlicher Weise berechne ich, dass eine Verminderung des Kohlensäuregehalts zur Hälfte oder eine Zunahme desselben auf den doppelten Betrag Temperaturänderungen von —1,5° C. bzw. +1,6° C. entsprechen würde.

Fig. 22. Excerpt (c) of Arrhenius's 1906 paper.

> The current amount of carbonic acid would therefore raise the temperature of the Earth's surface for 14,6°C its disappearance from the atmosphere would result in a lowering of temperatures about three times as strong as the one, which caused the ice ages. I calculate in a similar way, that a decrease in the concentration of carbonic acid by half or a doubling would be equivalent to changes of temperature of −1,5°C or +1,6°C respectively."

It is an interesting point that there is an **inversion of the burden of proof** in Arrhenius's paper, which is typeset in boldface here, because it winds its way as a red thread through almost all contemporary papers on the influence of CO_2 of the so-called global climate.

3.6.2. *Modern works of climatology*

Callendar[47–53] and Keeling,[54–60] the founders of the modern greenhouse hypothesis, recycled Arrhenius's "discussion of yesterday and the day before yesterday"[s] by perpetuating the errors of the past and adding lots of new ones.

In the 70s and 80s, two developments coincided: An accelerating progress in computer technology and an emergence of two contrary policy preferences, one supporting the development of civil nuclear technology, the other supporting Green Political movements. Suddenly, the CO_2 issue became on-topic, and so did computer simulations of the climate. The research results have been vague ever since:

- In the 70s, computer simulations of the "global climate" predicted for a doubling of the CO_2 concentration a global temperature rise of about 0.7–9.6 K.[152]

[s]a phrase used by von Storch in Ref. 1.

- Later, computer simulations pointed towards a null effect[t]:
  - In the IPCC 1992 report, computer simulations of the "global climate" predicted a global temperature rise of about 0.27–0.82 K per decade.[25]
  - In the IPCC 1995 report, computer simulations of the "global climate" predicted a global temperature rise of about 0.08–0.33 K per decade.[28]

- Two years ago (2005), computer simulations of the "global climate" predicted for a doubling of the CO_2 concentration a global temperature rise of about 2–12 K, whereby six so-called scenarios have been omitted that yield a *global cooling*.[154]

The state-of-the-art in climate modeling 1995 is described in detail in Ref. 155. Today every home server is larger than a mainframe at that time and every amateur can test and modify the vintage code.[156] Of course, there exist no realistic solvable equations for the weather parameters. Meanwhile, "computer models" have been developed which run on almost every PC[154,156] or even on the internet.[157]

To derive a climate catastrophe from these computer games and scare mankind to death is a crime.

3.7. *The assumption of radiative balance*

3.7.1. *Introduction*

Like the physical mechanism in glass houses, the CO_2-greenhouse effect is about a comparison of two different physical situations. Unfortunately, the exact definition of the atmospheric greenhouse effect changes from audience to audience, that is, there are many variations of the theme. Nevertheless, one common aspect lies in the methodology that a fictitious model computation for a celestial body *without* an atmosphere is compared to another fictitious model computation for a celestial body *with* an atmosphere. For instance, "average" temperatures are calculated for an Earth *without* an atmosphere and for an Earth *with* an atmosphere. Amusingly, there seem to exist no calculations for an Earth *without* oceans opposed to calculations for an Earth *with* oceans. However, in many studies, models for oceanic currents are included in the frameworks considered, and radiative "transport" calculations are incorporated too. Not all of these refinements can be discussed here in detail. The reader is referred to Ref. 156 and further references therein. Though there exists a huge family of generalizations, one common aspect is the assumption of a radiative balance, which plays a central role in the publications of the IPCC and, hence, in the public propaganda. In the following it is proved that this assumption is physically wrong.

[t] G.G. is indebted to the late science journalist Holger Heuseler for this valuable information.[153]

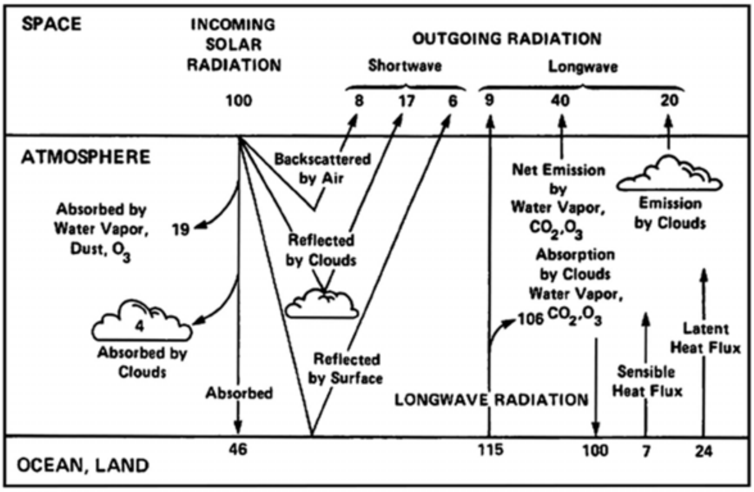


Fig. 23. A schematic diagram supposed to describe the global average components of the Earth's energy balance. Diagrams of this kind **contradict physics.**

3.7.2. *A note on "radiation balance" diagrams*

From the definition given in Sec. 2.1.2 it is immediately evident that a radiation intensity I_ν is *not* a current density that can be described by a vector field $\mathbf{j}(\mathbf{x}, t)$. That means that conservation laws (continuity equations, balance equations, budget equations) cannot be written down for intensities. Unfortunately, this is done in most climatologic papers, **the cardinal error of global climatology**, that may have been overlooked so long due to the oversimplification of the real world problem towards a quasi one-dimensional problem. Hence the popular climatologic "radiation balance" diagrams describing quasi-one-dimensional situations (cf. Fig. 23) are scientific misconduct since they do not properly represent the mathematical and physical fundamentals.

Diagrams of the type of Fig. 23 are the cornerstones of "climatologic proofs" of the supposed greenhouse effect in the atmosphere.[142] They are highly suggestive, because they bear some similarity to Kirchhoff rules of electrotechnics, in particular, to the node rule describing the conservation of charge.[158] Unfortunately, in the literature on global climatology it is not explained, what the arrows in "radiation balance" diagrams mean physically. It is easily verified that within the frame of physics they cannot mean anything.

Climatologic radiation balance diagrams are nonsense, since they

(1) cannot represent radiation intensities, the most natural interpretation of the arrows depicted in Fig. 23, as already explained in Secs. 2.1.2 and 2.1.5;
(2) cannot represent sourceless fluxes, i.e., a divergence free vector fields in three dimensions, since a vanishing three-dimensional divergence still allows that a portion of the field goes sidewards;

(3) do not fit in the framework of Feynman diagrams, which represent mathematical expressions clearly defined in quantum field theory.[159]
(4) do not fit in the standard language of system theory or system engineering.[160]

Kirchhoff-type node rules only hold in cases, where there is a conserved quantity and the underlying space may be described by a topological space that is a one-dimensional manifold almost everywhere, the singularities being the network nodes, i.e., in conventional electric circuitry,[158] in mesoscopic networks,[161] and, for electromagnetic waves, in waveguide networks[u].[163,164] However, although Kirchhoff's mesh analysis may be successfully applied to microwave networks, the details are highly involved and will break down if dissipation is allowed.[163,164]

Clearly, neither the cryptoclimate of a glass house nor the atmosphere of the Earth does compare to a waveguide network e.g., feeding the acceleration cavities of a particle accelerator. Therefore, the climatologic radiation balance diagrams are inappropriate and misleading, even when they are supposed to describe averaged quantities.

3.7.3. *The case of purely radiative balance*

If only thermal radiation was possible for the heat transfer of a radiation-exposed body one would use Stefan–Boltzmann's law

$$S(T) = \sigma T^4 \tag{70}$$

to calculate the ground temperature determined by this balance. The irradiance S has dimensions of a power density and σ is the Stefan–Boltzmann constant given by

$$\sigma = \frac{2\pi^5 k^4}{15 c^2 h^3} = 5.67040ß0 \cdot 10^{-8} \frac{\mathrm{W}}{\mathrm{m}^2\mathrm{K}^4} \,. \tag{71}$$

For example, the energy flux density of a black body at room temperature 300 K is approximately

$$S(T = 300\ \mathrm{K}) = 459\ \mathrm{W/m}^2 \,. \tag{72}$$

One word of caution is needed here: As already emphasized in Sec. 2.1.5 the constant σ appearing in the T^4 law is *not* a universal constant of physics. Furthermore, a gray radiator must be described by a temperature dependent $\sigma(T)$ spoiling the T^4 law. Rigorously speaking, for real objects Eq. (70) is invalid. Therefore, all crude approximations relying on T^4 expressions need to be taken with great care. In fact, though popular in global climatology, they prove nothing!

[u] The second and the third type are beautifully related by the correspondence of the v. Klitzing resistance $R_{vK} \approx 25,813\ \mathrm{k}\Omega$ with the characteristic impedance $Z_0 \approx 376,73\ \Omega$ via the Sommerfeld fine structure constant $\alpha = Z_0/2R_{vK} \approx 1/137,036$.[162]

Table 10. Effective temperatures T_{ground} in dependence of the parameter ϵ.

ϵ	T_{ground} [K]	T_{ground} [°C]
1.00	394.2	121.2
0.70	360.6	87.6
0.62	349.8	76.8

In the balance equation

$$\sigma \cdot T^4_{\text{Earth's ground}} = \sigma \cdot T^4_{\text{Sun}} \cdot \frac{R^2_{\text{Sun}}}{R^2_{\text{Earth's orbit}}} \tag{73}$$

one may insert a general phenomenological normalization factor ϵ at the right side, leaving room for a fine tuning and inclusion of geometric factors.[v] Thus, one may write

$$\sigma \cdot T^4_{\text{Earth's ground}} = \epsilon \cdot \sigma \cdot 5780^4 \cdot \frac{1}{46225} = \epsilon \cdot 1368 \text{ W/m}^2 = \epsilon \cdot \text{s} \tag{74}$$

which yields

$$T_{\text{Earth's ground}} = \sqrt[4]{\epsilon} \cdot \frac{5780}{\sqrt{215}} \text{ K} = \sqrt[4]{\epsilon} \cdot 394.2 \text{ K} \tag{75}$$

s is the solar constant. With the aid of Eq. (75) one calculates the values displayed in Table 10.

Only the temperature measured in the Sun inside the car bears some similarity with the three ones calculated here. Therefore, the radiation balance does not determine the temperature outside the car! In contrast to this, Table 11 displays the "average effective" temperatures of the ground, which according to climatological consensus are used to "explain" the atmospheric greenhouse effect. The factor of a quarter is introduced by "distributing" the incoming solar radiation seeing a cross section σ_{Earth} over the global surface Ω_{Earth}

$$\frac{\sigma_{\text{Earth}}}{\Omega_{\text{Earth}}} = \frac{\pi \cdot R^2_{\text{Earth}}}{4\pi \cdot R^2_{\text{Earth}}} = \frac{1}{4}\,. \tag{76}$$

The fictitious natural greenhouse effect is the difference between the "average effective" temperature of −18°C and the Earth's "observed" average temperature of +15°C.

In summary, the factor 0.7 will enter the equations if one assumes that a gray body absorber is a black body radiator, contrary to the laws of physics. Other choices are possible; the result is arbitrary. Evidently, such an average value has no physical meaning at all. This will be elucidated in the following subsection.

[v]The factor ε is related to the albedo A of the Earth describing her reflectivity: $A = 1 - \varepsilon$. In the earlier literature one often finds $A = 0.5$ for the Earth, in current publications $A = 0.3$. The latter value is used here.

Table 11. Effective "average" temperatures T_{ground} in dependence of the parameter ϵ.

ϵ	T_{ground} [K]	T_{ground} [°C]
$0.25 \cdot 1.00$	278.7	5.7
$0.25 \cdot 0.70$	255.0	−18.0
$0.25 \cdot 0.62$	247.4	−25.6

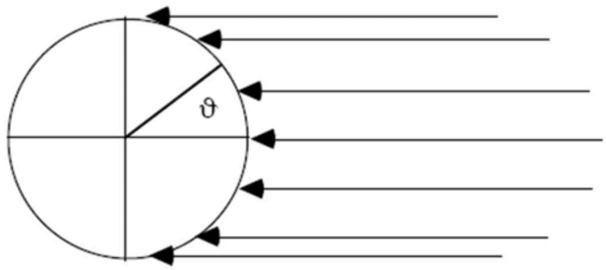


Fig. 24. A radiation-exposed static globe.

3.7.4. *The average temperature of a radiation-exposed globe*

For a radiation-exposed static globe (cf. Fig. 24) the corresponding balance equation must contain a geometric factor and reads therefore

$$\sigma \cdot T^4 = \begin{cases} \epsilon \cdot S \cdot \cos\vartheta = \epsilon \cdot \sigma \cdot 5780^4/215^2 \cdot \cos\vartheta & \text{if } 0 \le \vartheta \le \pi/2 \\ 0 & \text{if } \pi/2 \le \vartheta \le \pi\,. \end{cases} \tag{77}$$

It is obvious that one gets the effective temperatures if the right side is divided by σ.

This in turn will determine the formerly mentioned "average" effective temperatures over the global surface.

$$\begin{aligned} T_{\text{eff}}^4 &= \frac{1}{4\pi}\iint_{\text{surface}} T^4\, d\Omega \\ &= \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} T^4 \sin\vartheta\, d\vartheta\, d\varphi \\ &= \frac{1}{4\pi}\int_0^{2\pi}\int_1^{-1} T^4 d(-\cos\vartheta) d\varphi \\ &= \frac{1}{4\pi}\int_0^{2\pi}\int_{-1}^{1} T^4 d(\cos\vartheta) d\varphi\,. \end{aligned} \tag{78}$$

Defining

$$\mu = \cos\vartheta \tag{79}$$

one gets

$$\begin{aligned}
T_{\mathrm{eff}}^4 &= \frac{1}{4\pi}\int_0^{2\pi}\int_{-1}^{1} T^4 d\mu d\varphi \\
&= \frac{1}{4\pi}\int_0^{2\pi}\int_0^{1} \epsilon\cdot\frac{\mathrm{S}}{\sigma}\cdot\mu d\mu d\varphi \\
&= \frac{1}{2}\cdot\epsilon\cdot\frac{\mathrm{S}}{\sigma}\cdot\int_0^1 \mu d\mu \\
&= \frac{1}{2}\cdot\epsilon\cdot\frac{S}{\sigma}\cdot\left(\frac{\mu^2}{2}\bigg|_0^1\right) \\
&= \frac{1}{4}\cdot\epsilon\cdot\frac{S}{\sigma} \\
&= \frac{1}{4}\cdot\epsilon\cdot(394.2)^4\ \mathrm{K}^4\,.
\end{aligned} \tag{80}$$

This is the correct derivation of the factor quarter appearing in Eq. (76). Drawing the fourth root out of the resulting expression

$$\begin{aligned}
T_{\mathrm{eff}} &= \sqrt[4]{\frac{\epsilon}{4}\cdot\frac{S}{\sigma}} \\
&= \sqrt[4]{\frac{\epsilon}{4}}\cdot 394.2\ \mathrm{K} \\
&= (1/\sqrt{2})\cdot\sqrt[4]{\epsilon}\cdot 394.2\ \mathrm{K} \\
&= 0.707\cdot\sqrt[4]{\epsilon}\cdot 394.2\ \mathrm{K}\,.
\end{aligned} \tag{81}$$

Such a calculation, though standard in global climatology, is plainly wrong. Namely, if one wants to calculate the average temperature, one has to draw the fourth root first and then determine the average, though:

$$\begin{aligned}
T_{\mathrm{phys}} &= \frac{1}{4\pi}\int_0^{2\pi}\int_{-1}^{1} T d\mu d\varphi \\
&= \frac{1}{4\pi}\int_0^{2\pi}\int_0^{1} \sqrt[4]{\epsilon\cdot\frac{S}{\sigma}\cdot\mu}\, d\mu d\varphi \\
&= \frac{1}{2}\cdot\sqrt[4]{\epsilon\cdot\frac{S}{\sigma}}\cdot\int_0^1 \sqrt[4]{\mu}\, d\mu \\
&= \frac{1}{2}\cdot\sqrt[4]{\epsilon\cdot\frac{S}{\sigma}}\cdot\left(\frac{\mu^{5/4}}{5/4}\bigg|_0^1\right) \\
&= \frac{1}{2}\cdot\sqrt[4]{\epsilon\cdot\frac{S}{\sigma}}\cdot\frac{4}{5}
\end{aligned}$$

Table 12. Two kinds of "average" temperatures T_{eff} and T_{phys} in dependence of the parameter ϵ compared.

ϵ	T_{eff} [°C]	T_{phys} [°C]
1.00	5.7	−115
0.70	−18.0	−129
0.62	−25.6	−133

$$= \frac{2}{5} \cdot \sqrt[4]{\epsilon \cdot \frac{S}{\sigma}} \tag{82}$$

finally yielding

$$T_{\mathrm{phys}} = \frac{2}{5} \cdot \sqrt[4]{\epsilon} \cdot 394.2\ \mathrm{K} = 0.4 \cdot \sqrt[4]{\epsilon} \cdot 394.2\ \mathrm{K}\,. \tag{83}$$

Now the averaged temperatures T_{phys} are considerably lower than the absolute temperature's fourth root of the averaged fourth power (cf. Table 12).

This is no accident but a general inequality

$$\langle T \rangle = \int_X T dW \leq \sqrt[4]{\int_X T^4 dW} = \sqrt[4]{\langle T^4 \rangle} \tag{84}$$

for a nonnegative measurable function T and a probability measure W. It is a consequence of Hölder's inequality[165–168]

$$\int_X fg dW \leq \left\{ \int_X f^p dW \right\}^{1/p} \cdot \left\{ \int_X g^q dW \right\}^{1/q} \tag{85}$$

for a probability measure W and for two nonnegative measurable functions f, g and nonnegative integers p, q obeying

$$\frac{1}{p} + \frac{1}{q} = 1\,. \tag{86}$$

In the case discussed here, one has

$$p = 4\,, \quad q = 4/3\,, \quad g(x) \equiv 1 \tag{87}$$

and

$$f = T\,. \tag{88}$$

3.7.5. *Nonexistence of the natural greenhouse effect*

According to the consensus among global climatologists, one takes the −18°C computed from the T^4 average and compares it to the fictitious Earth's average temperature of +15°C. The difference of 33°C is attributed to the *natural greenhouse effect*. As seen in Eq. (83) a correct averaging yields a temperature of −129°C. Evidently, something must be fundamentally wrong here.

In global climatology, temperatures are computed from given radiation intensities, and this exchanges cause and effect. The current *local* temperatures determine the radiation intensities and not *vice versa*. If the soil is warmed up by the solar radiation many different local processes are triggered, which depend on the local movement of the air, rain, evaporation, moistness, and on the local ground conditions as water, ice, rock, sand, forests, meadows, etc. One square meter of a meadow does not know anything of the rest of the Earth's surface, which determine the global mean value. Thus, the radiation is *locally* determined by the *local* temperature. Neither is there a global radiation balance, nor a global radiation budget, even in the mean-field limit.

While it is incorrect to determine a temperature from a given radiation intensity, one is allowed to compute an effective radiation temperature $T_{\text{eff rad}}$ from T^4 averages representing a mean radiation emitted from the Earth and to compare it with an assumed Earth's average temperature T_{mean} Hölder's inequality says that the former is always larger than the latter

$$T_{\text{eff rad}} > T_{\text{mean}} \tag{89}$$

provided sample selection and averaging (probability space) remain the same.

For example, if n weather stations distributed around the globe measure n temperature values $T_1, \ldots T_n$, an *empirical* mean temperature will be defined as

$$T_{\text{mean}} = \frac{1}{n}\sum_{i=1}^{n} T_i \,. \tag{90}$$

For the corresponding black body radiation intensity, one can approximately set

$$S_{\text{mean}} = \frac{1}{n}\sum_{i=1}^{n} \sigma T_i^4 =: \sigma T_{\text{eff rad}}^4 \tag{91}$$

defining an *effective* radiation temperature

$$T_{\text{eff rad}} = \sqrt{\frac{1}{\sigma} S_{\text{mean}}} \,. \tag{92}$$

One immediately gets

$$T_{\text{eff rad}} = \sqrt[4]{\frac{1}{n}\sum_{i=1}^{n} T_i^4} \,. \tag{93}$$

Hölder's inequality shows that one always has

$$T_{\text{eff rad}} > T_{\text{mean}} \,. \tag{94}$$

3.7.6. *A numerical example*

From Eq. (93) one can construct numerical examples where e.g., a few high local temperatures spoil an average built from a large collection of low temperatures. A more realistic distribution is listed in Table 13. The effective radiation temperature

Table 13. An example for a measured temperature distribution from which its associated effective radiation temperature is computed. The latter one corresponds to the fourth root of the fourth power mean.

Weather Station	Instruments Reading T_i [°C]	Absolute Temperature T_i [K]	4th Power T_i^4	4th Root of 4th Power Mean $T_{\mathrm{eff\ rad}}$ [K]	4th Root of 4th Power Mean $T_{\mathrm{eff\ rad}}$ [°C]
1	0.00	273.15	5566789756		
2	10.00	283.15	6427857849		
3	10.00	283.15	6427857849		
4	20.00	293.15	7385154648		
5	20.00	293.15	7385154648		
6	30.00	303.15	8445595755		
Average	15.00	288.15	6939901750	288,63	15.48

$T_{\mathrm{eff\ rad}}$ is slightly higher than the average T_{mean} of the measured temperatures. According to Hölder's inequality this will always be the case.

Thus there is no longer any room for a *natural greenhouse effect*, both mathematically and physically:

- Departing from the *physically incorrect* assumption of radiative balance, a *mathematically correct* calculation of the average temperature lets the difference temperature that defines the natural greenhouse effect explode.
- Departing from the *mathematically correct* averages of *physically correct* temperatures (i.e., measured temperatures), the corresponding effective radiation temperature will be *always higher* than the average of the measured temperatures.

3.7.7. *Nonexistence of a global temperature*

In the preceding sections mathematical and physical arguments have been presented that the notion of a global temperature is meaningless. Recently, Essex, McKitrick, and Andresen showed[169]:

> "that there is no physically meaningful global temperature for the Earth in the context of the issue of global warming. While it is always possible to construct statistics for any given set of local temperature data, an infinite range of such statistics is mathematically permissible if physical principles provide no explicit basis for choosing among them. Distinct and equally valid statistical rules can and do show opposite trends when applied to the results of computations from physical models and real data in the atmosphere. A given temperature field can be interpreted as both 'warming' and 'cooling' simultaneously, making the concept of warming in the context of the issue of global warming physically ill-posed."

Regardless of any ambiguities, a global mean temperature could only emerge out of many local temperatures. Without knowledge of any science everybody can see, how such a changing average near-ground temperature is constructed: There is more

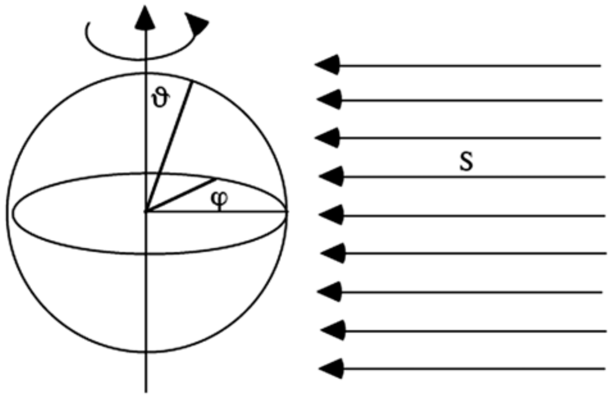


Fig. 25. The rotating globe.

or less sunshine on the ground due to the distribution of clouds. This determines a field of local near-ground temperatures, which in turn determines the change of the distribution of clouds and, hence, the change of the temperature average, which is evidently independent of the carbon dioxide concentration. Mathematically, an evolution of a temperature distribution may be phenomenologically described by a differential equation. The averages are computed afterwards from the solution of this equation. However, one cannot write down a differential equation directly for averages.

3.7.8. *The rotating globe*

Since the time when Fourier formulated the heat conduction equation, a nonlinear boundary condition describing radiative transfer of a globe with a Sun-side and a dark side has never belonged to the family of solvable heat conduction problems, even in the case of a nonrotating globe.

Regardless of solvability, one can write down the corresponding equations as well as their boundary conditions. If a rotating globe (Fig. 25) was exposed to radiation and only radiative heat transfer to its environment was possible, the initial problem of the heat conduction equation would have to be solved with the following boundary condition

$$-\lambda\frac{\partial T}{\partial \mathbf{n}} = \begin{cases} \sigma T^4 - S\cdot\sin\vartheta\cos(\varphi-\omega_d t) & \text{if } -\pi/2 \le \varphi-\omega_d t \le \pi/2 \\ \sigma T^4 & \text{if } \pi/2 \le \varphi-\omega_d t \le 3\pi/2 \end{cases} \tag{95}$$

where

$$\frac{\partial}{\partial \mathbf{n}} = \mathbf{n}\cdot\boldsymbol{\nabla} \tag{96}$$

denotes the usual normal derivative at the surface of the sphere and ω_d the angular frequency associated with the day-night cycle. By defining an appropriate geometry

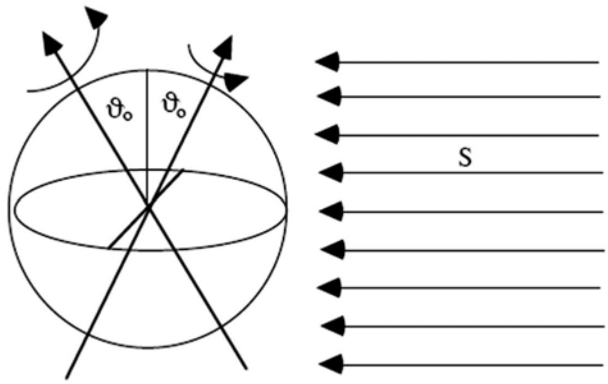


Fig. 26. An obliquely rotating globe.

factor

$$\zeta(\vartheta, \varphi, \omega_d, t) = \sin\vartheta \cos(\varphi - \omega_d t) \tag{97}$$

and the corresponding Sun-side area

$$A = \{(\varphi, \vartheta) | \zeta(\vartheta, \varphi, \omega_d, t) \geq 0\} \tag{98}$$

one can rewrite the expression as

$$-\lambda \frac{\partial T}{\partial \mathbf{n}} = \begin{cases} \sigma T^4 - S \cdot \zeta(\vartheta, \varphi, \omega_d, t) & \text{if } (\varphi, \vartheta) \in A \\ \sigma T^4 & \text{if } (\varphi, \vartheta) \notin A\,. \end{cases} \tag{99}$$

3.7.9. *The obliquely rotating globe*

The result obtained above may be generalized to the case of an obliquely rotating globe. For an obliquely rotating globe (Fig. 26), one has

$$-\lambda \frac{\partial T}{\partial \mathbf{n}} = \begin{cases} \sigma T^4 - S \cdot \xi(\vartheta_0, \vartheta, \varphi, \omega_y, \omega_d, t) & \text{if } (\varphi, \vartheta) \in A \\ \sigma T^4 & \text{if } (\varphi, \vartheta) \notin A \end{cases} \tag{100}$$

where $\partial/\partial\mathbf{n}$ denotes the usual normal derivative on the surface of the sphere and ω_y, ω_d the angular frequencies with the year cycle and the day-night cycle, respectively.[w] The geometry factor now reads

$$\begin{aligned} \xi(\vartheta_0, \vartheta, \varphi, \omega_y, \omega_d, t) = {} & [\sin(\omega_y t)\cos(\omega_d t) + \cos(\omega_y t)\sin(\omega_d t)\cos\vartheta_0]\sin\vartheta\cos\varphi \\ & + [-\sin(\omega_y t)\sin(\omega_d t) + \cos(\omega_y t)\cos(\omega_d t)\cos\vartheta_0]\sin\vartheta\sin\varphi \\ & - [\cos(\omega_y t)\sin\vartheta_0]\cos\vartheta \end{aligned} \tag{101}$$

[w] Here, sidereal time is used.[138,139]

and the expression for the Sun-side surface is given by

$$A = \{(\varphi, \vartheta) | \xi(\vartheta_0, \vartheta, \varphi, \omega_y, \omega_d, t) \geq 0\} . \tag{102}$$

Already the first unrealistic problem will be too much for any computer. The latter more realistic model cannot be tackled at all. The reasons for this is not only the extremely different frequencies ω_y and ω_d but also a very nonphysical feature which affects the numeric as well: According to a famous law formulated by Wiener, almost all particles in this mathematical model which cause the diffusion, move on paths at infinitely high speeds.[170,171]

Rough estimates indicate that even these oversimplified problems cannot be tackled with any computer. Taking a sphere with dimensions of the Earth it will be impossible to solve this problem numerically even in the far future. Not only the computer would work ages, before a "balanced" temperature distribution would be reached, but also the correct initial temperature distributions could not be determined at all.

3.7.10. *The radiating bulk*

The physical situation of a radiating volume where the radiation density

$$S(T) = \sigma T^4 \tag{103}$$

emitted through the surface shell originates from the volume's heat content, cannot be realized easily, if at all. However, it is interesting to study such a toy model in order to get a feeling about radiative equilibration processes which are assumed to take place within a reasonable time interval.

With disregard to the balancing processes inside, one gets the differential equation

$$V \varrho c_v \frac{dT}{dt} = \Omega \sigma T^4 \tag{104}$$

with V denoting the volume, ϱ the density, c_v the isochoric specific heat, Ω the surface of the body. By defining

$$\eta = \frac{\Omega}{V} \tag{105}$$

the above equation can be rewritten as

$$\frac{dT}{dt} = -\frac{\eta \sigma}{\varrho c_v} \cdot T^4 . \tag{106}$$

For a cube with an edge length of a, one has $\eta = 6/a$; for a globe with radius r, one has $\eta = 3/r$ instead. For bodies with unit volumes $\eta = 6$ or $\eta = 4.8$, respectively.

The differential equation is easily solvable. The solution reads

$$T(t) = T_0 / \sqrt[3]{1 + \frac{3\eta\sigma T_0^3}{\varrho c_v}\, t} . \tag{107}$$

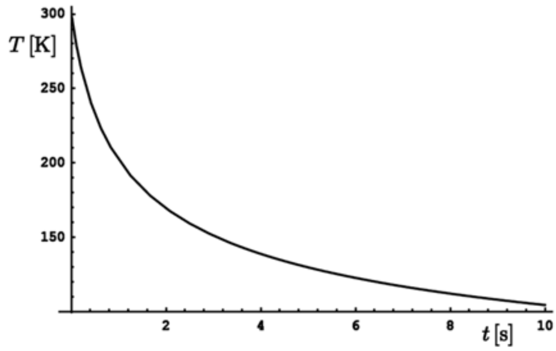


Fig. 27. The cooling curve for a radiating standard cube.

At an initial temperature of 300 K with the values of ϱ and c_v for air, one gets one-half of the temperature value within three seconds for the standard cube (cf. Fig. 27) For iron the isochoric thermal diffusivity

$$a_v = \varrho\, c_v \tag{108}$$

is about 3000 times higher than for air; the half time for the temperature decrease is approximately three hours. For air, even if only one of the cube's planes were allowed to radiate, one would get a fall in temperatures of 70 degrees within the first three seconds, and almost 290 degrees within 10 hours — a totally unrealistic cooling process.

Hence, this simple assessment will prove that one has to be extremely careful, if the radiation laws for black-body radiation, where the energy comes from the heated walls of the cavity, are to be used for gases, where the emitted electromagnetic radiation should originate from the movements of the gas molecules (cf. Sec. 3.5).

3.7.11. *The comprehensive work of Schack*

Professor Alfred Schack, the author of a standard textbook on industrial heat transfer,[95] was the first scientist who pointed out in the 20s of the past century that the infrared light absorbing fire gas components *carbon dioxide* (CO_2) and *water vapor* (H_2O) may be responsible for a higher heat transfer in the combustion chamber *at high burning temperatures* through *an increased emission in the infrared*. He estimated the emissions by measuring the spectral absorption capacity of carbon dioxide and water vapor.

In the year 1972, Schack published a paper in *Physikalische Blätter* entitled "The influence of the carbon dioxide content of the air on the world's climate." With his article he got involved in the climate discussion and emphasized the important role of water vapor.[98]

Firstly, Schack estimated the mass of the consumed fossil fuels up

$$m_{\text{burned}} = 5 \cdot 10^{12}\ \text{kg} = 5\ \text{GtC} \tag{109}$$

per anno. Since 1 kg produces 10 m^3 waste gas with 15% CO_2, a volume of

$$V_{CO_2} = 7.5 \cdot 10^{12}\ m^3 \tag{110}$$

is blown into the Earth's atmosphere, whose total volume under normal conditions (0°C and 760 mm Hg) is

$$V_{atmosphere} = 4 \cdot 10^{18}\ m^3\,. \tag{111}$$

It follows immediately that the increase of the CO_2 concentration is approximately $1.9 \cdot 10^{-6}$ *per anno*. About one-half is absorbed by the oceans, such that the increase of CO_2 is reduced to

$$\frac{\Delta V_{CO_2}}{V_{CO_2}} = 0.95 \cdot 10^{-6} \tag{112}$$

per anno.

With the "current" (1972) atmospheric CO_2 volume concentration of

$$0.03\% = 300 \cdot 10^{-6} \tag{113}$$

and a relative annual increase of

$$0.32\% = \frac{0.95 \cdot 10^{-6}}{300 \cdot 10^{-6}} \tag{114}$$

the CO_2 concentration in the atmosphere would rise by one-third of current concentration within 100 years, supposed the fossil fuel consumption will remain constant.

Schack then shows that CO_2 would absorb only one-seventh of the ground's heat radiation at most, if the water vapor had not already absorbed the infrared light in most situations. Furthermore, a doubling of the CO_2-content in the air would only halve the radiation's characteristic absorption length, that is, the radiation would be absorbed at a length of 5 km instead of at a length of 10 km, for example.

Schack discussed the CO_2 contribution only under the aspect that CO_2 acts as an absorbent medium. He did not get the absurd idea to heat the radiating warmer ground with the radiation absorbed and re-radiated by the gas.

In a comment on an article by the science journalist Rudzinski[172] the climatologist Oeschger objected against Schack's analysis of the influence of the CO_2 concentration on the climate that Schack had not calculated thoroughly enough.[173] In particular, he referred to radiation transport calculations. However, such calculations have formerly been performed only for the atmospheres of stars, because the processes in planetary atmospheres are far too complicated for such simple models. The goal of astrophysical radiation transport calculations is to calculate as many absorption lines as possible with one boundary density distribution and one temperature dependency with respect to the height with Saha's equation and many other additional hypotheses.[174] However, the boundary density of the radiation intensity cannot be derived from these calculations.

One should emphasize that Schack was the first scientist to take into account the selective emission by the infrared light absorbing fire-gases for combustion chambers. Therefore, one is driven to the verge of irritation when global climatologists

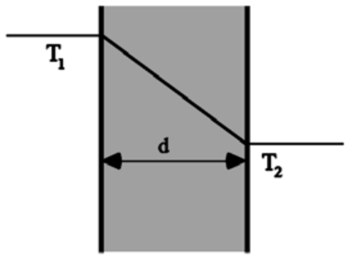


Fig. 28. A simple heat transport problem.

blame him for not calculating complicatedly enough, simply because he saw the primitive physical concepts behind the equations for the radiation transfer.

3.8. *Thermal conductivity versus radiative transfer*

3.8.1. *The heat equation*

In many climatological texts it seems to be implicated that thermal radiation does not need to be taken into account when dealing with heat conduction, which is incorrect.[175] Rather, always the entire heat flow density **q** must be taken into account. This is given by the equation

$$\mathbf{q} = -\lambda \cdot \mathbf{grad}\, T \tag{115}$$

in terms of the gradient of the temperature T. It is inadmissible to separate the radiation transfer from the heat conduction, when balances are computed.

In the following, a quasi one-dimensional experimental situation for the determination of the thermal conductivity is considered (Fig. 28). With F being the cross section, d the distance between the two walls, and Q being the heat per time transported from 1 to 2, such that,

$$q_x = \frac{Q}{F} \tag{116}$$

we have

$$Q = F \cdot q_x = -\lambda \cdot F \cdot \frac{\partial T}{\partial x} = -\lambda \cdot F \cdot \frac{T_2 - T_1}{d} = \lambda \cdot F \cdot \frac{T_1 - T_2}{d} \tag{117}$$

in the case of a stationary temperature distribution.

Q is produced and measured for the stationary situation by Joule heat (i.e., electric heat) at the higher temperature. The heat transfer by radiation cannot be separated from the heat transfer of kinetic energy. Of course, one tries to avoid the heat convection by the experimental arrangement. Hence, any effects of the thermal radiation (long wave atmospheric radiation to Earth) are simply contained in the stationary temperatures and the measured Joule heat.

In the nonstationary case the divergence of the heat flow no longer vanishes, and we have for constant thermal conductivity

$$\operatorname{div}\mathbf{q} = \lambda \cdot \mathbf{div}\,\mathbf{grad}\,T = -\lambda \cdot \Delta T = -\varrho c_v \cdot \frac{\partial T}{\partial t} \tag{118}$$

where ΔT is the Laplacian of the temperature and ϱc_v is the specific heat of unit volume. We finally obtain

$$\frac{\partial T}{\partial t} = \frac{\lambda}{\varrho c_v}\Delta T\,. \tag{119}$$

It is important to note that the thermal conductivity is divided by ϱc_v, which means that the isochoric thermal diffusivity

$$a_v = \frac{\lambda}{\varrho c_v} \tag{120}$$

of gases and metals can be of the the same order of magnitude, even if the thermal conductivities λ are completely different.

Unfortunately, the work on even the simplest examples of heat conduction problems needs techniques of mathematical physics, which are far beyond the undergraduate level. Because a concise treatment of the partial differential equations lies even outside the scope of this paper, the following statements should suffice: Under certain circumstances it is possible to calculate the space-time dependent temperature distribution with given initial values and boundary conditions. If the temperature changes have the characteristic length L_{char}, the characteristic time for the heat compensation process is

$$\frac{1}{t_{\text{char}}} = \frac{\lambda}{\varrho c_v} \cdot \frac{1}{L_{\text{char}}^2}\,. \tag{121}$$

If the radius of the Moon were used as the characteristic length and typical values for the other variables, the relaxation time would be equivalent *to many times the age of the universe*. Therefore, an average ground temperature (over hundreds of years) is **no indicator at all** that the total irradiated solar energy is emitted. If there were a difference, it would be impossible to measure it, due to the large relaxation times. At long relaxation times, the heat flow from the Earth's core is an important factor for the long term reactions of the average ground temperature; after all, according to certain hypotheses, the surfaces of the planetary bodies are supposed to have been very hot and to have cooled down. These temperature changes can never be separated experimentally from those which were caused by solar radiation.

3.8.2. *Heat transfer across and near interfaces*

In the real world, things become even more complex through the existence of interfaces, namely

- solid-gas interfaces
- solid-liquid interfaces

- liquid-gas interfaces

for which a general theory of heat transport does not exist yet. The mechanisms of air cooling and water cooling and the influence of radiation have been studied in engineering thermodynamics[95–97] and are of practical interest e.g., in solar collectors, fire research, chemistry, nuclear engineering, electronic cooling, and in constructing reliable computer hardware.[176,177] Obviously, they are of utmost importance in geophysics and atmospheric physics as well. Since they add an additional degree of complexity to the problem discussed here, they are not discussed further in this context.

3.8.3. *In the kitchen: Physics-obsessed housewife versus IPCC*

In Sec. 3.3.5, it was indicated how simple it is to falsify the atmospheric greenhouse hypotheses, namely by observing a water pot on the stove: Without water filled in, the bottom of the pot will soon become glowing red. However, with water filled in, the bottom of the pot will be substantially colder.

In particular, such an experiment can be performed on a glass-ceramic stove. The role of the Sun is played by the electrical heating coils or by infrared halogen lamps that are used as heating elements. Glass-ceramic has a very low heat conduction coefficient, but lets infrared radiation pass very well. The dihydrogen monoxide in the pot, which not only plays the role of the "greenhouse gas" but also realizes a very dense phase of such a magic substance, absorbs the infrared extremely well. Nevertheless, there is no additional "backwarming" effect of the bottom of the pot. In the opposite, the ground becomes colder.

There are countless similar experiments that immediately show that the atmospheric greenhouse picture is absolutely ridiculous from an educated physicist's point of view or from the perspective of a well-trained salesman offering high performance tinted glass that reduces solar heat gain mainly in the infrared[100]:

> "Daylight and view are two of the fundamental attributes of a window. Unfortunately, windows are also the source of significant solar heat gain during times when it is unwanted. Traditional solutions to reducing solar heat gain such as tinted glazing or shades mean that the amount of light is reduced as well. New glazings with low-solar-gain Low-E (spectrally selective) coatings can provide better solar heat gain reduction than tinted glass, with a minimal loss of visible light. This also means that views can be clearer and unobstructed."

Ironically, this works already in the case of dihydrogen monoxide. Such experiments can be performed easily on every overhead projector, showing that the absorption of the infrared portion of the incoming radiation by water is a nonneglible and leads to a drop of the temperature of the illuminated surface dressed by an infrared absorbing layer that is transparent to visible light.

3.9. *The laws of thermodynamics*

3.9.1. *Introduction*

At the time of Fourier's publication[37,38] the two fundamental laws of classical thermodynamics were not known. For each law two equivalent versions as formulated by Rudolf Clausius (2 January, 1822 – 24 August, 1888), the founder of axiomatic thermodynamics, are given by[178,179]:

- ***First law of thermodynamics:***
  - *In all cases, when work is transformed into heat, an amount of heat in proportion to the produced work is used up, and vice versa, the same amount of heat can be produced by the consumption of an equal amount of work.*
  - *Work can be transformed into heat and vice versa, where the amount of one is in proportion to the amount of the other.*

  This is a definition of the *mechanical heat equivalent.*

- ***Second law of thermodynamics:***
  - *Heat cannot move itself from a cooler body into a warmer one.*
  - *A heat transfer from a cooler body into a warmer one cannot happen without compensation.*

  A fictitious heat engine which works in this way is called a *perpetuum mobile of the second kind.*

Clausius examines thoroughly, that the second law is relevant for radiation as well, even if image formations with mirrors and lenses are taken into account.[178,179]

3.9.2. *Diagrams*

It is quite useful to clarify the second law of thermodynamics with (self-explaining) diagrams.

- A steam engine works transforming heat into mechanical energy, whereby heat is transferred from the warmth to the cold (see Fig. 29).
- A heat pump (e.g., a refrigerator) works, because an external work is applied, whereby heat is transferred from the cold to the warmth (see Fig. 30).
- In a perpetuum mobile of the second kind heat is transferred from the cold to the warmth without external work applied (see Fig. 31).

3.9.3. *A paradox*

The use of *a perpetuum mobile of the second kind* can be found in many modern pseudo-explanations of the CO_2-greenhouse effect (see Fig. 32). Even prominent physicists have relied on this argumentation. One example was the hypothesis of Stichel already discussed in Sec. 3.3.4.[134]

The renowned German climatologist Rahmstorf has claimed that the greenhouse effect does not contradict the second law of thermodynamics[141]:

> "Some 'sceptics' state that the greenhouse effect cannot work since (according to the second law of thermodynamics) no radiative energy can be transferred from a colder body (the atmosphere) to a warmer one (the surface). However, the second law is not violated by the greenhouse effect, of course, since, during the radiative exchange, in both directions the net energy flows from the warmth to the cold."

Rahmstorf's reference to the second law of thermodynamics is plainly wrong. The second law is a statement about heat, not about energy. Furthermore, the author introduces an obscure notion of "net energy flow." The relevant quantity is the "net heat flow," which, of course, is the sum of the upward and the downward heat flow within a fixed system, here the atmospheric system. It is inadmissible to apply the second law for the upward and downward heat separately redefining the thermodynamic system on the fly.

A similar confusion is currently seen in the German version of Wikipedia[180]:

> "Some have problems with the energy that is radiated by the greenhouse gases towards the surface of the Earth (150 W/m^2 — as shown above) because this energy flows from a colder body (approx. $-40°$C) to a warmer

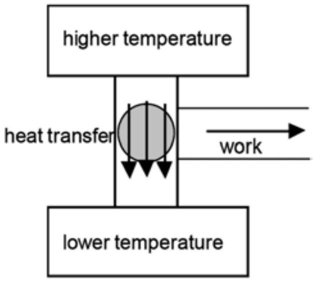


Fig. 29. A steam engine works transforming heat into mechanical energy.

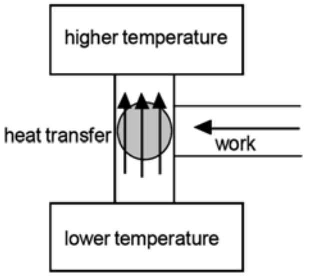


Fig. 30. A heat pump (e.g., a refrigerator) works because an external work is applied.

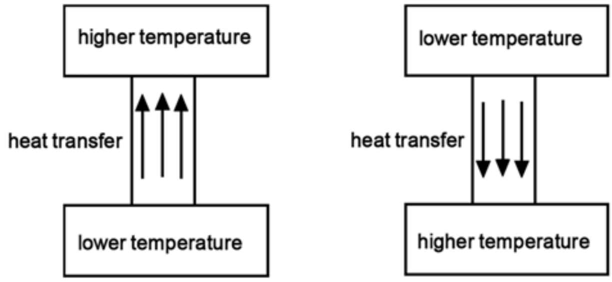


Fig. 31. Any machine which transfers heat from a low temperature reservoir to a high temperature reservoir without external work applied cannot exist: A *perpetuum mobile of the second kind* is impossible.

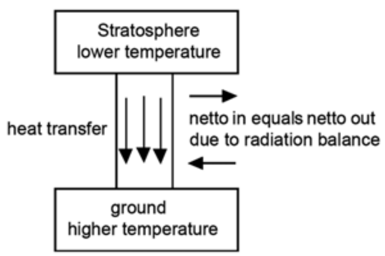


Fig. 32. A machine which transfers heat from a low temperature reservoir (e.g., stratosphere) to a high temperature reservoir (e.g., atmosphere) without external work applied, cannot exist — even if it is radiatively coupled to an environment, to which it is radiatively balanced. A modern climate model is supposed to be such a variant of a perpetuum mobile of the second kind.

> one (Earth's ground approx. +15°C) apparently violating the second law of thermodynamics. This is a wrong interpretation, since it ignores the radiation of the Sun (even 6000 K). With respect to the total balance the second law is obeyed indeed."

Obviously, the authors are confusing energy with heat. Furthermore, the system in question here is the atmospheric system of the Earth including the Earth's ground. Since this system is **assumed to be in radiative balance** with its environment, and any other forms of energy and mass exchange with its environment are strictly prohibited, it defines a system in the sense of thermodynamics for which the second law holds strictly.

The difference among heat, energy, and work is crucial for the understanding of thermodynamics. The second law is a statement about this difference.

3.9.4. *Possible resolution of the paradox*

It may be due to the following approximation that something is possible in climate models, which contradicts the second law of thermodynamics. In the field theoretical description of irreversible thermodynamics, the second law is found in the statement, that the heat flow density and the gradient of the temperature point into opposite directions

$$\mathbf{q} = \boldsymbol{\lambda} \cdot \operatorname{grad} T\,. \tag{122}$$

In this formula, the heat conduction necessarily is a positive definite tensor. In climate models it is customary to neglect the thermal conductivity of the atmosphere, which means to set it to zero[181]

$$\boldsymbol{\lambda} = 0\,. \tag{123}$$

This could explain why the numerical simulations could produce small effects in contradiction to the second law of thermodynamics. To set the heat conduction to zero would not be a real violation of the second law of thermodynamics, as it corresponds to an approximation of an ideal system: In spite of the temperature differences, no heat flow could move from a warmer area to a colder one. It would be in accordance with the second law, if there were no temperature rise. In the past, the "predictions" of the climate models were pointing sometimes in this direction, as was shown in detail in Sec. 3.6.2.

4. Physical Foundations of Climate Science

4.1. *Introduction*

A fundamental theory of the weather and its local averages, the climates, must be founded on a reasonable physical theory. Under the premise that such a theory has already been formulated there are still two basic problems left unresolved, namely

- the embedding of the purely physical theory in a much more wider framework including the chemical and biological interactions within the geophysical realm;
- the correct physical account of a possible nontrivial radiative effect, which must go far beyond the famous black body approach, which is suggestive but does not apply to gases.

A review of the issues of chemistry and biology such as the carbon cycle lies outside the perspective of this paper, but it must not be neglected. In his criticism of global warming studies by means of computer models, the eminent theoretical physicist Freeman J. Dyson stated[182]:

> "The models solve the equations of fluid dynamics, and they do a very good job of describing the fluid motions of the atmosphere and the oceans. They do a very poor job of describing the clouds, the dust, the chemistry and the biology of fields and farms and forests. They do not begin to describe the real world that we live in. The real world is muddy and messy and full of things that we do not yet understand. It is much easier for a scientist to sit in an air-conditioned building and run computer models, than to put on winter clothes and measure what is really happening outside in the swamps

and the clouds. That is why the climate model experts end up believing in their own models."

However, it can be shown that even within the borders of theoretical physics with or without radiation things are extremely complex so that one very quickly arrives at a point where verifiable predictions no longer can be made. Making such predictions nevertheless may be interpreted as an escape out of the department of sciences, not to say as a scientific fraud.

In the following the conservation laws of magnetohydrodynamics are reviewed. It is generally accepted that a Navier–Stokes-type approach or a simplified magnetohydrodynamics provides the backbone to climatological computer simulations.[156,183,184] In these frameworks neither the radiative budget equations can be derived, nor is it possible to integrate radiative interactions in a consistent way. Therefore, it would conceptually be necessary to go into the microscopic regime, which is described by nonequilibrium multi-species quantum electrodynamics of particles incorporating bound states with internal degrees of freedom, whereby the rich structure and coexistence of phases have to be taken into account in the discussion of natural situations. From these only formally sketchable microscopic *ab initio* approaches there is no path known that leads to a family of more realistic phenomenological climate models.[185]

4.2. *The conservation laws of magnetohydrodynamics*

4.2.1. *Overview*

The core of a climate model must be a set of equations describing the equations of fluid flow, namely the Navier–Stokes equations.[183,184] The Navier–Stokes equations are nonlinear partial differential equations, which, in general, are impossible to solve analytically. In very special cases numerical methods lead to useful results, but there is no systematics for the general case. In addition, the Navier–Stokes approach has to be extended to multi-component problems, which does not simplify the analysis.

Climate modelers often do not accept that "climate models are too complex and uncertain to provide useful projections of climate change".[186] Rather, they claim that "current models enable [them] to attribute the causes of past climate change and predict the main features of the future climate with a high degree of confidence."[186] Evidently, this claim (not specifying the observables subject to the prediction) contradicts to what is well-known from theoretical meteorology, namely that the predictability of the weather forecast models is (and must be) rather limited (i.e., limited to a few days).[187]

The nonsolvability of Navier–Stokes-type equations is related (but not restricted) to the chaotic character of turbulence. But this is not the only reason why the climate modeling cannot be built on a solid ground. Equally importantly, even the full set of equations providing a proper model of the atmospheric system (not to say atmospheric-oceanographic system) are not known (and never will) to a full extent. All models used for "simulation" are (and have to be) oversimplified.

However, in general, a set of oversimplified nonlinear partial differential equations exhibits a totally different behavior than a more realistic, more complex system. Because there exists no strategy for a stepwise refinement within the spirit of the renormalization (semi-)group, one cannot make any useful predictions. The real world is too complex to be represented properly by a feasable system of equations ready for processing.[185] The only safe statement that can be made is that the dynamics of the weather is probably governed by a generalized Navier–Stokes-type dynamics.

Evidently, the electromagnetic interactions have to be included, leading straightly to the discipline of magnetohydrodynamics (MHD).[188–191] This may be regarded as a set of equations expressing all the essential physics of a fluid, gas, and/or plasma.

In the following these essential equations are reviewed. The purpose is twofold:

- Firstly, it should be made a survey of what budget relations really exist in the case of atmospheric physical systems.
- Secondly, the question should be discussed at what point the supposed greenhouse mechanism does enter the equations and where the carbon dioxide concentration appears.

Unfortunately, the latter aspect seems to be obfuscated in the mainstream approaches of climatology.

4.2.2. *Electric charge conservation*

As usual, electric charge conservation is described by the continuity equation

$$\frac{\partial \varrho_e}{\partial t} + \boldsymbol{\nabla} \cdot \mathbf{j} = 0 \tag{124}$$

where ϱ_e is the electrical (excess) charge density and $\mathbf{j}$ is the electrical (external) current density.

4.2.3. *Mass conservation*

The conservation of mass is described by another sort of continuity equation

$$\frac{\partial \varrho}{\partial t} + \boldsymbol{\nabla} \cdot (\varrho \mathbf{v}) = 0 \tag{125}$$

where ϱ is the mass density and $\varrho\mathbf{v}$ is the density of the mass current.

4.2.4. *Maxwell's equations*

The electromagnetic fields are described by Maxwell's field equations that read

$$\boldsymbol{\nabla} \cdot \mathbf{D} = \varrho_e \tag{126}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \tag{127}$$

$$\nabla \cdot \mathbf{B} = 0 \tag{128}$$

$$\nabla \times \mathbf{H} = \mathbf{j} + \frac{\partial \mathbf{D}}{\partial t} \tag{129}$$

where the standard notation is used. They have to be supplemented by the material equations

$$\mathbf{D} = \varepsilon\varepsilon_0 \mathbf{E} \tag{130}$$

$$\mathbf{B} = \mu\mu_0 \mathbf{H} \tag{131}$$

where ε and μ are assumed to be constant in space and time, an assumption that was already made by Maxwell.

4.2.5. *Ohm's law for moving media*

Electric transport is described by Ohm's law for moving media

$$\mathbf{j} - \varrho_e \mathbf{v} = \boldsymbol{\sigma}\,(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \tag{132}$$

with $\boldsymbol{\sigma}$ being the electrical conductivity tensor. Expressed in terms of the resistivity tensor $\boldsymbol{\rho}$, this reads

$$\boldsymbol{\rho}(\mathbf{j} - \varrho_e \mathbf{v}) = \mathbf{E} + \mathbf{v} \times \mathbf{B}\,. \tag{133}$$

4.2.6. *Momentum balance equation*

Conservation of momentum is described by a momentum balance equation, also known as Navier–Stokes equation,

$$\frac{\partial}{\partial t}(\varrho\,\mathbf{v}) + \nabla \cdot (\varrho\mathbf{v} \otimes \mathbf{v}) = -\nabla p - \varrho\nabla\Phi + \varrho_e\mathbf{E} + \mathbf{j} \times \mathbf{B} + \nabla \cdot \mathbf{R} + \mathbf{F}_{\mathrm{ext}} \tag{134}$$

where $\mathbf{v}$ is the velocity vector field, p is the pressure field, Φ is the gravitational potential, $\mathbf{R}$ is the friction tensor, and $\mathbf{F}_{\mathrm{ext}}$ are the external force densities, which could describe the Coriolis and centrifugal accelerations.

4.2.7. *Total energy balance equation*

The conservation of energy is described by

$$\begin{aligned}\frac{\partial}{\partial t}&\left(\frac{\varrho}{2}|\mathbf{v}|^2 + \frac{1}{2}\mathbf{H}\cdot\mathbf{B} + \frac{1}{2}\mathbf{E}\cdot\mathbf{D} + \varrho\Phi + \varrho u\right)\\ &\quad + \nabla \cdot \left(\frac{\varrho}{2}|\mathbf{v}|^2\mathbf{v} + \mathbf{E}\times\mathbf{H} + \varrho\Phi\mathbf{v} + \varrho u\mathbf{v} + p\mathbf{v} - \mathbf{v}\cdot\mathbf{R} + \boldsymbol{\lambda}\cdot\nabla T\right)\\ &= \varrho\frac{\partial\Phi}{\partial t} + \mathbf{F}_{\mathrm{ext}}\cdot\mathbf{v} + \mathbf{Q}\end{aligned} \tag{135}$$

where u is the density of the internal energy, T is the temperature field, and $\boldsymbol{\lambda}$ is the thermal conductivity tensor, respectively. Furthermore, a term $\mathbf{Q}$ has been added which could describe a heat density source or sink distribution.

4.2.8. *Poynting's theorem*

From Maxwell's equation with space-time independent ε and μ, one obtains the relation

$$\frac{\partial}{\partial t}\left(\frac{1}{2}\mathbf{H}\cdot\mathbf{B}+\frac{1}{2}\mathbf{E}\cdot\mathbf{D}\right)+\boldsymbol{\nabla}\cdot(\mathbf{E}\times\mathbf{H})=-\mathbf{j}\cdot\mathbf{E}\,. \tag{136}$$

This relation is a balance equation. The Pointing vector field $\mathbf{E}\times\mathbf{H}$ may be interpreted as an energy current density of the electromagnetic field.

4.2.9. *Consequences of the conservation laws*

Multiplying Ohm's law for moving media [Eq. (133)] with $(\mathbf{j}-\varrho_e\mathbf{v})$, one gets

$$\begin{aligned}(\mathbf{j}-\varrho_e\mathbf{v})\boldsymbol{\rho}(\mathbf{j}-\varrho_e\mathbf{v})&=\mathbf{j}\cdot\mathbf{E}+\mathbf{j}\cdot(\mathbf{v}\times\mathbf{B})-\varrho_e\mathbf{v}\cdot\mathbf{E}\\&=\mathbf{j}\cdot\mathbf{E}-\mathbf{v}\cdot(\mathbf{j}\times\mathbf{B})-\varrho_e\mathbf{v}\cdot\mathbf{E}\end{aligned} \tag{137}$$

which may be rewritten as

$$\mathbf{j}\cdot\mathbf{E}=(\mathbf{j}-\varrho_e\mathbf{v})\boldsymbol{\rho}(\mathbf{j}-\varrho_e\mathbf{v})+\mathbf{v}\cdot(\mathbf{j}\times\mathbf{B})+_e\mathbf{v}\cdot\mathbf{E}\,. \tag{138}$$

Inserting this into Poynting's theorem (Eq. 136) one obtains

$$\begin{aligned}&\frac{\partial}{\partial t}\left(\frac{1}{2}\mathbf{H}\cdot\mathbf{B}+\frac{1}{2}\mathbf{E}\cdot\mathbf{D}\right)+\boldsymbol{\nabla}\cdot(\mathbf{E}\times\mathbf{H})\\&\quad=-(\mathbf{j}-\varrho_e\mathbf{v})\boldsymbol{\rho}(\mathbf{j}-\varrho_e\mathbf{v})-\mathbf{v}\cdot(\varrho_e\mathbf{E}+\mathbf{j}\times\mathbf{B})\,.\end{aligned} \tag{139}$$

On the other hand, if one applies the scalar product with $\mathbf{v}$ on the momentum balance Eq. (134), one gets

$$\begin{aligned}\frac{\partial}{\partial t}\left(\frac{\varrho}{2}|\mathbf{v}|^2\right)+\boldsymbol{\nabla}\cdot\left(\frac{\varrho}{2}|\mathbf{v}|^2\mathbf{v}\right)&=\mathbf{v}\cdot\boldsymbol{\nabla}p-\varrho\mathbf{v}\cdot\boldsymbol{\nabla}\Phi+\mathbf{v}\cdot(\varrho_e\mathbf{E}+\mathbf{j}\times\mathbf{B})\\&\quad+\mathbf{v}\cdot(\boldsymbol{\nabla}\cdot\mathbf{R})+\mathbf{v}\cdot\mathbf{F}_{\text{ext}}\end{aligned} \tag{140}$$

Replacing $\mathbf{v}\cdot(\varrho_e\mathbf{E}+\mathbf{j}\times\mathbf{B})$ with Eq. (139) and doing some elementary manipulations, one finally obtains

$$\begin{aligned}&\frac{\partial}{\partial t}\left(\frac{\varrho}{2}|\mathbf{v}|^2+\frac{1}{2}\mathbf{H}\cdot\mathbf{B}+\frac{1}{2}\mathbf{E}\cdot\mathbf{D}+\varrho\Phi\right)\\&\quad+\boldsymbol{\nabla}\cdot\left(\frac{\varrho}{2}|\mathbf{v}|^2\mathbf{v}+\mathbf{E}\times\mathbf{H}-\mathbf{v}\cdot\mathbf{R}+p\mathbf{v}+\varrho\Phi\mathbf{v}\right)\\&=p\boldsymbol{\nabla}\cdot\mathbf{v}+\varrho\frac{\partial\Phi}{\partial t}-\mathrm{Tr}((\boldsymbol{\nabla}\otimes\mathbf{v})\cdot\mathbf{R})-(\mathbf{j}-\varrho_e\mathbf{v})\boldsymbol{\rho}(\mathbf{j}-\varrho_e\mathbf{v})+\mathbf{F}_{\text{ext}}\cdot\mathbf{v}\,.\end{aligned} \tag{141}$$

Hence, this relation is a consequence of the fundamental equations of magnetohydrodynamics. The heat density source term $\mathbf{Q}$, the internal energy density u, and the divergence of the heat current density $\mathbf{q}$ are missing here.

4.2.10. *General heat equation*

With

$$du = \frac{p}{\varrho^2} d\varrho + T ds \tag{142}$$

for reversible processes, one can substitute the density of the internal energy u by the density of the entropy s.

With the aid of Eqs. (135) and (141) one derives a differential equation for the entropy density s:

$$\frac{\partial(\varrho s)}{\partial t} + \nabla \cdot (\varrho s \mathbf{v}) = \frac{1}{T} \mathrm{Tr}((\nabla \otimes \mathbf{v}) \cdot \mathbf{R}) + \frac{1}{T}(\mathbf{j} - \varrho_e \mathbf{v}) \boldsymbol{\rho} (\mathbf{j} - \varrho_e \mathbf{v}) - \frac{1}{T} \nabla \cdot (\boldsymbol{\lambda} \cdot \nabla T) + \frac{\mathbf{Q}}{T} \,. \tag{143}$$

This is the generalized form of the heat equation.

Only with artificial heat densities $\mathbf{Q}$ in Eqs. (143) and (135) one can incorporate a hypothetical warming by radiation. There is no term that depends on the carbon dioxide concentration.

4.2.11. *Discussion*

The equations discussed above comprise a system of one-fluid equations only. One can (and must) write down many-fluid equations and, in addition, the averaged equations describing the turbulence. To get a realistic model of the real world, the above equations *must* be generalized to take into account

- the dependency of all relevant coefficients on space and time;
- the presence and coexistence of various species of fluids and gases;
- the inhomogenities of the media, the mixture, and separation of phases.

In principle such a generalization will be feasible, if one cuts the domains of definition into pieces and treats the equations by a method of patches. Thus, the final degree of complexity may be much larger than originally expected arriving at a system of thousands of phenomenological equations defining nonlinear three-dimensional dynamics and heat transfer.

It cannot be overemphasized that even if these equations are simplified considerably, one cannot determine numerical solutions, even for small space regions and even for small time intervals. This situation will not change in the next 1000 years regardless of the progress made in computer hardware. Therefore, global climatologists may continue to write updated research grant proposals demanding next-generation supercomputers *ad infinitum*. As the extremely simplified one-fluid equations are unsolvable, the many-fluid equations would be more unsolvable, the equations that include the averaged equations describing the turbulence would be still more unsolvable, if "unsolvable" had a comparative.

Regardless of the chosen level of complexity, these equations are supposed to be the backbone of climate simulations, or, in other words, the foundation of models of nature. But even this is not true: In computer simulations heat conduction and friction are compületely neglected, since they are mathematically described by second order partial derivatives that cannot be represented on grids with wide meshes. Hence, the computer simulations of global climatology **are not based on physical laws.**

The same holds for the speculations about the influence of carbon dioxide:

- Although the electromagnetic field is included in the MHD-type global climatologic equations, there are no terms that correspond to the absorption of electromagnetic radiation.
- It is hard if not impossible to find the point in the MHD-type global climatologic equations, where the concentration of carbon dioxide enters the game.
- It is impossible to include the radiative transfer equation (59) into the MHD-type climatologic equations.
- Apparently, there is no reference in the literature, where the carbon dioxide concentration is implemented in the MHD-type climatologic equations.

Hence, one is left with the possibility to include a hypothetical warming by radiation by hand in terms of artificial heat densities $\mathbf{Q}$ in Eq. (143). But this would be equivalent to imposing the "political correctly" requested anthropogenic rise of the temperature even from the beginning just saving an additional trivial calculation.

In case of partial differential equations more than the equations themselves the boundary conditions determine the solutions. There are so many different transfer phenomena, radiative transfer, heat transfer, momentum transfer, mass transfer, energy transfer, etc. and many types of interfaces, static or moving, between solids, fluids, gases, plasmas, etc. for which there does not exist an applicable theory, such that one even cannot write down the boundary conditions.[176,177]

In the "approximated" discretized equations, artificial unphysical boundary conditions are introduced, in order to prevent running the system into unphysical states. Such a "calculation," which yields an arbitrary result, is no calculation in the sense of physics, and hence, in the sense of science. There is no reason to believe that global climatologists do not know these fundamental scientific facts. Nevertheless, in their summaries for policymakers, global climatologists claim that they can compute the influence of carbon dioxide on the climates.

4.3. *Science and global climate modelling*

4.3.1. *Science and the problem of demarcation*

Science refers to any system of objective knowledge, in particular, knowledge based on the scientific method as well as an organized body of knowledge gained through research.[196,197]

There are essentially three categories of sciences, namely

- formal sciences (mathematics),
- natural sciences (physics, chemistry, biology),
- social sciences.

In natural sciences one has to distinguish between

- *a theory*: a logically self-consistent framework for describing the behavior of certain natural phenomena based on fundamental principles;
- *a model*: a similar but weaker concept than a theory, describing only certain aspects of natural phenomena typically based on some simplified working hypothesis;
- *a law of nature*: a scientific generalization based on a sufficiently large number of empirical observations that it is taken as fully verified;
- *a hypothesis*: a contention that has been neither proved nor yet ruled out by experiment or falsified by contradiction to established laws of nature.

A *consensus*, exactly speaking *a consensus about a hypothesis* is a notion which lies outside natural science, since it is completely irrelevant for objective truth of a physical law:

Scientific consens(us) is scientific nonsense.

The *problem of demarcation* is how and where to draw lines around science, i.e., to distinguish science from religion, from pseudoscience, i.e., fraudulent systems that are dressed up as science, and nonscience in general.[196,198]

In the philosophy of science several approaches to the definition of science are discussed[196,197]:

- *empirism*[x] (*Vienna Circle*): only statements of empirical observations are meaningful, i.e., if a theory is verifiable, then it will be scientific;
- *falsificationism* (*Popper*): if a theory is falsifiable, then it will be scientific;
- *paradigm shift* (*Kuhn*): within the process of normal science anomalies are created which lead eventually to a crisis finally creating a new paradigm; the acceptance of a new paradigm by the scientific community indicates a new demarcation between science and pseudoscience;
- *democratic and anarchist approach to science* (*Feyerabend*): science is not an autonomous form of reasoning but inseparable from the larger body of human thought and inquiry: "Anything goes."

Superficially, the last point provides a nice argument *for* computer modelers in the framework of global climatology. However, it is highly questionable whether this fits into the frame of physics. Svozil remarked that Feyerabend's understanding of physics was superficial.[199] Svozil emphasizes:

[x]also *logical positivism* or *verificationism*.

> "Quite generally, partly due to the complexity of the formalism and the new challenges of their findings, which left philosophy proper at a loss, physicists have attempted to develop their own meaning of their subject."

Physics provides a fundament for engineering and, hence, for production and modern economics. Thus, the citizen is left with the alternative (in the sense of a choice between two options):

(a) either to accept the derivation of political and economical decisions from an anarchic standpoint that eventually claims that there is a connection to experiment and observation, and, hence, the real world, when there is no such connection;
(b) or to call in the derivation of political and economical decisions from verifiable research results within the frame of physics, where there is a connection to experiment and observation, and hence, the real world.

Evidently, the option (b) defines a pragmatic approach to science, defining a minimum of common features, such that engineers, managers, and policymakers have something to rely on: Within the frame of exact sciences a theory should

(a) be logically consistent;
(b) be consistent with observations;
(c) have a grounding in empirical evidence;
(d) be economical in the number of assumptions;
(e) explain the phenomena;
(f) be able to make predictions;
(g) be falsifiable and testable;
(h) be reproducible, at least for the colleagues;
(i) be correctable;
(j) be refinable;
(k) be tentative;
(l) be understandable by other scientists.

Can these criteria ever be met by a computer model approach of global climatology?

4.3.2. *Evaluation of climatology and climate modeling*

In contrast to meteorology climatology, studies the averaged behavior of the local weather. There are several branches, such as paleoclimatology, historical climatology, and climatology involving statistical methods which more or less fit into the realm of sciences. The problem is, what climate modeling is about, especially if it does refer to chaotic dynamics on the one hand, and the greenhouse hypothesis on the other.

The equations discussed in Sec. 4.2 may give an idea what the final defining equations of the atmospheric and/or oceanic system may look like. It has been emphasized that in a more realistic albeit phenomenological description of nature the system of the relevant equations may be huge. But even by simplifying the structure of equations one cannot determine solutions numerically, and this will not change, if one does not restrict oneself on small space-time domains.

There are serious solvability questions in the theory of nonlinear partial differential equations and the shortage of numerical recipes leading to sufficient accurate results will remain in the nearer or further future — for fundamental mathematical reasons. The Navier–Stokes equations are something like the holy grail of theoretical physics, and a brute force discretization with the aid of lattices with very wide meshes leads to models, which have nothing to do with the original puzzle and thus have no predictability value.

In problems involving partial differential equations the boundary condition determine the solutions much more than the differential equations themselves. The introduction of a discretization is equivalent to an introduction of artificial boundary conditions, a procedure, that is characterized in von Storch's statement: "The discretization *is* the model."[200] In this context a correct statement of a mathematical or theoretical physicist would be: "A discretization is a model with unphysical boundary conditions." Discretizations of continua problems will be allowed if there is a strategy to compute stepwise refinements. Without such a renormalization group analysis a finite approximation does not lead to a physical conclusion. However, in Ref. 200, von Storch emphasized that this is by no means the strategy he follows, rather he takes the finite difference equations as they are. Evidently, this would be a grotesque standpoint, if one considered the heat conduction equation, being of utmost relevance to the problem and being a second order partial differential equation, that cannot be replaced by a finite difference model with a lattice constant in the range of kilometers.

Generally, it is *impossible* to derive differential equations for averaged functions and, hence, averaged nonlinear dynamics.[192–195]

Thus, there is simply no physical foundation of global climate computer models, for which still the chaos paradigma holds: Even in the case of a well-known deterministic dynamics nothing is predictable.[201] That discretization has neither a physical nor a mathematical basis in nonlinear systems is a lesson that has been taught in the discussion of the logistic differential equation, whose continuum solutions differ fundamentally from the discrete ones.[202,203]

Modern global climatology has confused and continues to confuse fact with fantasy by introducing the concept of a scenario replacing the concept of a model. In Ref. 29, a clear definition of what scenarios are is given:

> "Future greenhouse gas (GHG) emissions are the product of very complex dynamics systems, determined by driving forces such as demographic development, socio-economic development, and technological change. Their future evolution is highly uncertain. Scenarios are alternative images of how the future might unfold and are an appropriate tool with which to

analyze how driving forces may influence future emission outcomes and to access the associated uncertainties. They assist in climate change analysis, including climate modeling and the assessment of impacts, adaptation and mitigation. The possibility that any single emissions path will occur as described in scenarios is highly uncertain."

Evidently, this is a description of a pseudo-scientific (i.e., nonscientific) method by the experts at the IPCC. The next meta-plane beyond physics would be a questionnaire among scientists already performed by von Storch[204] or, finally, a democratic vote about the validity of a physical law. Exact science is going to be replaced by a sociological methodology involving a statistical field analysis and by "democratic" rules of order. This is in harmony with the definition of science advocated by the "scientific" website *RealClimate.org* that has integrated inflammatory statements, personal attacks and offenses against authors as a part of their "scientific" workflow.

4.3.3. *Conclusion*

A statistical analysis, no matter how sophisticated it is, heavily relies on underlying models and if the latter are plainly wrong then the analysis leads to nothing. One cannot detect and attribute something that does not exist for reason of principle like the CO_2 greenhouse effect. There are so many unsolved and unsolvable problems in nonlinearity and the climatologists believe to beat them all by working with crude approximations leading to unphysical results that have been corrected afterwards by mystic methods, flux control in the past, obscure ensemble averages over different climate institutes today, by excluding accidental global cooling results by hand,[154] continuing the greenhouse inspired global climatologic tradition of *physically meaningless* averages and *physically meaningless* applications of mathematical statistics.

In conclusion, the derivation of statements on the CO_2 induced anthropogenic global warming out of the computer simulations lies **outside any science**.

5. Physicist's Summary

A thorough discussion of the planetary heat transfer problem in the framework of theoretical physics and engineering thermodynamics leads to the following results:

(1) There are no common physical laws between the warming phenomenon in glass houses and the fictitious atmospheric greenhouse effect, which explains the relevant physical phenomena. The terms "greenhouse effect" and "greenhouse gases" are deliberate misnomers.

(2) There are no calculations to determinate an average surface temperature of a planet

   (a) with or without an atmosphere,
   (b) with or without rotation,

(c) with or without infrared light absorbing gases.

The frequently mentioned difference of 33°C for the fictitious greenhouse effect of the atmosphere is therefore a meaningless number.

(3) Any radiation balance for the average radiant flux is completely irrelevant for the determination of the ground level air temperatures and thus for the average value as well.
(4) Average temperature values cannot be identified with the fourth root of average values of the absolute temperature's fourth power.
(5) Radiation and heat flows do not determine the temperature distributions and their average values.
(6) Re-emission is not reflection and can, in no way, heat up the ground-level air against the actual heat flow without mechanical work.
(7) The temperature rises in the climate model computations are made plausible by a perpetuum mobile of the second kind. This is possible by setting the thermal conductivity in the atmospheric models to zero, an unphysical assumption. It would be no longer a perpetuum mobile of the second kind, if the "average" fictitious radiation balance, which has no physical justification anyway, was given up.
(8) After Schack (1972), water vapor is responsible for most of the absorption of the infrared radiation in the Earth's atmosphere. The wavelength of the part of radiation, which is absorbed by carbon dioxide is only a small part of the full infrared spectrum and does not change considerably by raising its partial pressure.
(9) Infrared absorption does not imply "backwarming." Rather, it may lead to a drop of the temperature of the illuminated surface.
(10) In radiation transport models with the assumption of local thermal equilibrium, it is assumed that the absorbed radiation is transformed into the thermal movement of all gas molecules. There is no increased selective re-emission of infrared radiation at the low temperatures of the Earth's atmosphere.
(11) In climate models, planetary or astrophysical mechanisms are not accounted for properly. The time dependency of the gravity acceleration by the Moon and the Sun (high tide and low tide) and the local geographic situation, which is important for the local climate, cannot be taken into account.
(12) Detection and attribution studies, predictions from computer models in chaotic systems, and the concept of scenario analysis lie outside the framework of exact sciences, in particular, theoretical physics.
(13) The choice of an appropriate discretization method and the definition of appropriate dynamical constraints (flux control) having become a part of computer modeling is nothing but another form of data curve fitting. The mathematical physicist v. Neumann once said to his young collaborators: "If you allow me four free parameters I can build a mathematical model that describes exactly everything that an elephant can do. If you allow me a fifth free parameter, the

model I build will forecast that the elephant will fly." (cf. Ref. 185.)

(14) Higher derivative operators (e.g., the Laplacian) can never be represented on grids with wide meshes. Therefore, a description of heat conduction in global computer models is impossible. The heat conduction equation is not and cannot properly be represented on grids with wide meshes.

(15) Computer models of higher dimensional chaotic systems, best described by nonlinear partial differential equations (i.e., Navier–Stokes equations), fundamentally differ from calculations where perturbation theory is applicable and successive improvements of the predictions — by raising the computing power — are possible. At best, these computer models may be regarded as a heuristic game.

(16) Climatology misinterprets unpredictability of chaos known as butterfly phenomenon as another threat to the health of the Earth.

In other words: Already the natural greenhouse effect is a myth beyond physical reality. The CO_2-greenhouse effect, however, is a "mirage."[205] The horror visions of a risen sea level, melting pole caps, and developing deserts in North America and in Europe are *fictitious consequences* of *fictitious physical mechanisms* as they cannot be seen even in the climate model computations. The emergence of hurricanes and tornados cannot be predicted by climate models because all of these deviations are ruled out. The main strategy of modern CO_2-greenhouse gas defenders seems to hide themselves behind more and more pseudo-explanations, which are not part of the academic education or even of the physics training. A good example are the radiation transport calculations, which are probably not known by many. Another example are the so-called feedback mechanisms, which are introduced to amplify an effect which is not marginal but does not exist at all. Evidently, the defenders of the CO_2-greenhouse thesis refuse to accept any reproducible calculation as an explanation and have resorted to unreproducible ones. A theoretical physicist must complain about a lack of transparency here, and he also has to complain about the style of the scientific discussion, where advocators of the greenhouse thesis claim that the discussion is closed, and others are discrediting justified arguments as a discussion of "questions of yesterday and the day before yesterday."[y] In exact sciences, in particular in theoretical physics, the discussion is never closed and is to be continued *ad infinitum*, even if there are proofs of theorems available. Regardless of the specific field of studies a minimal basic rule should be fulfilled in natural science, though, even if the scientific fields are methodically as far apart as physics and meteorology: At least among experts, the results and conclusions should be understandable or reproducible. And it should be strictly distinguished between a theory and a model on the one hand, and between a model and a scenario on the other hand, as clarified in the philosophy of science.

[y] a phrase used by von Storch in Ref. 1.

That means that if conclusions out of computer simulations are to be more than simple speculations, then in addition to the examination of the numerical stability and the estimation of the effects of the many vague input parameters, at least the simplifications of the physical original equations should be critically exposed. Not the critics have to estimate the effects of the approximation, but the scientists who do the computer simulations.

"Global warming is good ... The net effect of a modest global warming is positive" (Singer).[z] In any case, it is extremely interesting to understand the dynamics and causes of the long-term fluctuations of the climates. However, it was not the purpose of this paper to get into all aspects of the climate variability debate.

The point discussed here was to answer the question, whether the supposed atmospheric effect has a physical basis. This is not the case. In summary, there is no atmospheric greenhouse effect, in particular CO_2-greenhouse effect, in theoretical physics and engineering thermodynamics. Thus, it is illegitimate to deduce predictions which provide a consulting solution for economics and intergovernmental policy.

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[z]cf. Singer's summary at the Stockholm 2006 conference.[1]

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The authors express their hope that in the schools around the world the fundamentals of physics will be taught correctly and not by using award-winning "Al Gore" movies shocking every straight physicist by confusing absorption/emission with reflection, by confusing the tropopause with the ionosphere, and by confusing microwaves with shortwaves.

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