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REPLY TO "COMMENT ON 'FALSIFICATION OF THE ATMOSPHERIC CO_2 GREENHOUSE EFFECTS WITHIN THE FRAME OF PHYSICS' BY JOSHUA B. HALPERN, CHRISTOPHER M. COLOSE, CHRIS HO-STUART, JOEL D. SHORE, ARTHUR P. SMITH, JÖRG ZIMMERMANN"

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It is shown that the notorious claim by Halpern *et al.* recently repeated in their comment that the method, logic, and conclusions of our "Falsification Of The CO_2 Greenhouse Effects Within The Frame Of Physics" would be in error has no foundation. Since Halpern *et al.* communicate our arguments incorrectly, their comment is scientifically vacuous. In particular, it is not true that we are "trying to apply the Clausius statement of the Second Law of Thermodynamics to only one side of a heat transfer process rather than the entire process" and that we are "systematically ignoring most non-radiative heat flows applicable to Earth's surface and atmosphere". Rather, our falsification paper discusses the violation of fundamental physical and mathematical principles in 14 examples of common pseudo-derivations of fictitious greenhouse effects that are all based on simplistic pictures of radiative transfer and their obscure relation to thermodynamics, *including but not limited to* those descriptions (a) that define a "Perpetuum Mobile Of The 2nd Kind", (b) that rely on incorrectly calculated averages of global temperatures, (c) that refer to incorrectly normalized spectra of electromagnetic radiation. Halpern *et al.* completely missed an exceptional chance to formulate a scientifically well-founded antithesis. They do not even define a greenhouse effect that they wish to defend. We take the opportunity to clarify some misunderstandings, which are communicated in the current discussion on the non-measurable, i.e., physically non-existing influence of the trace gas CO_2 on the climates of the Earth.

Keywords: Greenhouse effect; Gibbs thermodynamics; radiation theory.

1. Introduction

1.1. *Prologue*

Any statement is subject to a simple question: "Is it true?"

Since Arrhenius (1896),[1] the so-called atmospheric greenhouse effect provides a reasoning for climate change, although his paper (1896) is *arbitrarily wrong.*[a] Neither is there any empirical evidence for the existence of an atmospheric CO_2 greenhouse effect, i.e., the influence of the concentration of the trace gas CO_2 on the Earth's climates, nor there is a definition of an atmospheric CO_2 greenhouse effect in terms of a physical effect.[3,4]

1.2. *What is a physical effect?*

A physical effect consists of three things:

(a) a reproducible experiment in the lab;
(b) an interesting or surprising outcome;
(c) an explanation in terms of a physical theory.

Examples:

(1) Hall Effect: The Hall effect[5] is the production of a potential difference (the Hall voltage) across an electrical conductor, transverse to an electric current in the conductor and a magnetic field perpendicular to the current. In the experimental setups, the strength of the magnetic and electric fields as well as the mobility of conduction electrons is varied. The effect is "explained" with the Lorentz force introduced already by Maxwell. In the meantime the quantum Hall effects have been discovered whose theoretical "explanations" may be regarded not completely convincing, although their importance was recognized by the awarding of several Nobel Prizes in physics (Some experts say, that the integral quantum Hall effect is less understood than the fractional quantum Hall effect).[6,7] Clearly, the criteria (a), (b), (c) are fulfilled.
(2) The warming process in a car parking in the sun.[3,4] Once the interior of the car is heated up the air cooling stops immediately. This obstruction to air cooling is also at work in case of fur coats, blankets, insulating layers etc.[b] This can be explained without any physical skills as it was already known by the Neanderthalian, which was formulated firstly by the popular German meteorologist Wolfgang Thüne. Evidently, a class of certain verifiable processes reproducible by measurements (a) are given. However, there is no non-trivial physical explanation, cf. (b) and (c). Therefore, it is justified to christen this (non-physical) effect "Neanderthalian effect".

[a] A formulation used by the theoretical meteorologist Gerhard Kramm.[2]
[b] "Every climatologist should ask himself/herself: Why is the sparrow on a cold morning not freezing to death?" (after Wolfgang Thüne).

(3) Sometimes one describes by the natural greenhouse effect the circumstances, that without the trace gases (carbon dioxide etc.) the global average temperatures of the atmosphere near the ground would be minus 18 degrees Celsius. Evidently, property (a) is not fulfilled, since there are no reproducible and comparable measurements. Therefore, the so-called natural greenhouse effect is not a physical effect. It was called a "meteorological effect"[c] by the first author in his Leipzig talk.[8]

Hence there are no greenhouse effects in physics.[3,4] Beyond this simple observation, there is a falsification of the atmospheric CO_2 greenhouse effects in the two senses of this homonymous word:

- it is a fake within the framework of so-called climate science,
- it is falsified in a Popperian sense within the frame of physics.

This is one main result of our paper.[3,4] The other main result is that the concentration of carbon dioxide has no measurable influence on the temperature field of the atmosphere of the Earth.[3,4]

1.3. *The comment by Halpern*

The results of our paper are not the results of (so-called) climate science or chemistry, but of theoretical and applied physics. Therefore, the submission of our article to an applied physics journal did make sense. In our honest opinion this is not true for the recent comment by the chemist Halpern and his co-authors.[9,d]

We do not agree at all that our

- "methods, logic, and conclusions are in error."

To our surprise Halpern *et al.* **did not even define a greenhouse effect**, such that their work is scientifically worthless, since, without a sharp definition of the concept in question, any scientific comment or any scientific refutation is impossible. The two core statements of Halpern *et al.*

(H1) that we are "trying to apply the Clausius statement of the Second Law of Thermodynamics to only one side of a heat transfer process rather than the entire process" and we are "systematically ignoring most non-radiative heat flows applicable to Earth's surface and atmosphere";

(H2) that we claim that "radiative heat transfer from a colder atmosphere to a warmer surface is forbidden, ignoring the larger transfer in the other direction which makes the complete process allowed by ignoring heat capacity and non-radiative heat flows they claim that radiative balance requires that the surface cool by 100 K or more at night";

[c]Not all meteorologists would agree.
[d]See also Refs. 10 and 11.

are incorrect.[e] Rather, we show[3,4]

- ($\overline{\text{H1}}$) that some pseudo-explanations of a fictitious atmospheric natural greenhouse effect or atmospheric CO_2 greenhouse effect describe a Perpetuum Mobile of the Second Kind and, thus, violate the Clausius law;
- ($\overline{\text{H2}}$) that many discussions which speculate on an influence of the concentration of the trace gas CO_2 on the climates only rely on a simplistic discussion of radiative transfer, while ignoring heat conductivity, convection, friction, interface physics.

In other words, we analyze the rationale and the inner contradiction of derivations of the atmospheric greenhouse effects communicated in the standard climate literature from the viewpoint of a physicist. In part, we are arguing within the context of the standard assumptions put forward by mainstream global climatologists. Nowhere we offer our own model, and we never will.

1.4. *This paper*

We have made time and have tried to trace back the origins of the objections raised against our paper. The rest of our response should clarify these misunderstandings. However, we cannot repeat our previous work here, to which the reader is referred.[3,4]

One should keep in mind that we are theoretical physicists with experimental experience and, additionally, a lot of experience in numerical computing. Joshua Halpern and Jörg Zimmermann, for example, are chemists. We are not willing to discuss whether they can be considered as laymen in physics, in particular laymen in thermodynamics.[f]

2. Some General Remarks on Statements Appearing in the Comment by Halpern *et al.*

2.1. *Basic facts*

The title of our paper reads: "Falsification Of The Atmospheric CO_2 Greenhouse Effects Within The Frame Of Physics". Until now, there are no papers that refute our work. The only attempt to try this so far is due to Arthur P. Smith (2008).[12] However, Kramm, Dlugi, and Zelger (2009) showed that his entire paper is wrong.[13] Smith used inappropriate and inconsistent formulations in averaging various quantities over the entire surface of the Earth considered as a sphere. Using two instances of averaging procedures as customarily applied in studies on turbulence, Kramm, Dlugi, and Zelger show that Smith's formulations are highly awkward. In their

[e] In order to verify the curious reader is recommended to activate the "search and find" option of his favorite text viewing software.

[f] However, we must think so.

work, Kramm, Dlugi, and Zelger scrutinize and evaluate Smith's discussion of the infrared absorption in the atmosphere. They show that his attempt to refute our criticism is rather fruitless. The same holds true for the comment of Halpern *et al.*[9] Qualified readers as well as laymen can verify the invalidity of many of the claims communicated by Halpern *et al.* simply by using the "search and find" option of their document reader. Therefore, in what follows, we restrict ourselves to list some general remarks on the physics related to the statements appearing in the paper by Halpern *et al.* Some more important topics are treated more comprehensively below in separate sections, namely

- the Clausius law and the related errors of Rahmstorf, Hoffmann, Halpern *et al.*, Ozawa *et al.* in Sec. 3;
- the radiation spectra and the related errors of Bakan and Raschke in Sec. 4;
- the adiabatic lapse rate (barometric formula) and the related claims of Rahmstorf and Schellnhuber that Venus suffers from an atmospheric CO_2 greenhouse effect in Sec. 5.

We find that these points are very important, since, once again, they refute the greenhouse myth underlying the mainstream view of the influence of CO_2 on the climates. We as physicists emphasize: The "mainstream" view is clearly wrong.[3,4,13]

2.2. *Some remarks on section 1 (Introduction)*

Let us start with Halpern's favorite object of lust.[9,10] In our falsification paper we criticize the suggestive abuse of a graphical language by global climatologists.[3,4] This is very important in the case of radiation balance diagrams, since one must never confuse classical radiation intensities, energy flows, and heat flows. For instance, Rahmstorf himself charismatically confuses energy and heat:[15]

> Manche Skeptiker behaupten, der Treibhauseffekt könne gar nicht funktionieren, da (nach dem 2. Hauptsatz der Thermodynamik) keine Strahlungsenergie von kälteren Körpern (der Atmosphäre) zu wärmeren Körpern (der Oberfläche) übertragen werden könne. Doch der 2. Hauptsatz ist durch den Treibhauseffekt natürlich nicht verletzt, da bei dem Strahlungsaustausch in beide Richtungen netto die Energie von warm nach kalt fließt.

This may be translated to

> 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.

This is not a quotation out of context, it is plainly wrong, since it confuses "radiative energy" and "heat" in such a way that the brainwashed reader is losing all orientations.

Normally, arrows indicate that the relevant physical quantities are flows (vector fields) that can be superposed due to their inherent linear structure. The intensities of classical radiation theory are not flows. In addition, energy flows, in general, and heat flows, in particular, have to be strictly distinguished in the context of a thermodynamical analysis. Moreover, in the movie by Al Gore[16,17] there are diagrams, reminiscent of wave reflection. This is nonsense too. In mainstream graphical representation, all this is mixed together, and, in addition, reduced to a one-dimensional view far from any reality.[3,4]

Let us now discuss the diagrams in Fig. 23, p. 322 in our paper.[3,4] We do not discuss only one option for the interpretation of such diagrams, as is suggested by the objection of Georg Hoffmann[14] and Joshua Halpern *et al.*[9,10] Rather, we discuss four possible interpretations, that were introduced for paedagogical/didactical reasons to emphasize that any diagrammatic language in science has to have a well-defined syntax and semantics.[3,4] Once again: The mentioned examples, e.g., "Feynman diagrams", "SysML", should only remind the reader of the important fact that a graphical language in science should always have a well-defined syntax and semantics. This was the problem with Pauli's negative opinion on the graphical language introduced by Stückelberg. This language was later refined by Feynman, and the end of the story is well-known. Pauli called Stückelberg's ideas "Stimmungsmalerei" (Painting of moods).[18] That is what it exactly is — in the case of radiation balance diagrams! In the case of Stückelberg-Feynman diagrams, these graphic representations could be integrated into the rigorous formalism of Green functions, pioneered by Julian Schwinger.[g] The introduction and application of graphical languages is an interesting topic in informatics and related to mathematical problems such as graph theory, knot theory and so on. On the other hand, there are many other fields, where a poorly defined graphical language is used, e.g., in business related topics, and, of course, in all kinds of brainwashing.

Radiation balance diagrams, however, are really useless. They never occurred in the talks of the first author (G. G.), who takes the opportunity and freedom to add a much simpler argument here: Especially in the diagram depicted in the paper one cannot find one single ratio (in percent) that is a ratio of measured numbers!

Furthermore, we remark in the context of Sec. 1 of Ref. 9:

(a) Halpern *et al.* confuse Global Climate Models (which they abbreviate as GCM) and General Circulation Models (GCM), i.e., coupled atmosphere-ocean models. By global climatologists, the latter are considered as the "key components" of the former, whatever this means,

[g]Many years ago, one of us (R.D.T.) had the opportunity, to discuss the issue of graphical representation with Professor Schwinger and his amusing rivalry between Feynman and him.

but not identified with each other.

(b) It is impossible to calculate temperature fields of the Earth's atmosphere by using radiative transfer equations regardless of an introduction of CO_2 concentration or molecule spectra, let alone "line-by-line" and/or "state-of-the-art" calculations.

(c) The critique that we rely on unrefereed sources is distorting the facts; most of our citations are peer-reviewed or from classical textbooks. And if not, then it will have its own reason.

(d) Halpern *et al.* intentionally misunderstand and exaggerate side remarks (as shown above) in order to discredit us.

(e) It is true that the heat conductivity of a gas is relatively small. However, it is still finite. Heat conductivity plays an important role at the interface between ground and atmosphere and, of course, serves as a germ for heat transfer by convection. The latter surmounts ordinary (static) heat conductivity typically by four orders of magnitude.[h]

(f) Contrary to what Halpern *et al.* state, we emphasize the importance of the non-radiative forms of heat transfer including convection and latent heat, e.g., already in Sec. 1.2. of our paper.[3,4]

2.3. *Some remarks on section 2 (The Greenhouse effect and the Second Law of Thermodynamics)*

Some common misunderstandings related to the Second Law of Thermodynamics are discussed below in Sec. 3. At this point, we emphasize

(a) We never claimed — allegedly with reference to Clausius — that a colder body does not send radiation to a warmer one. Rather, we cite a paper, in which Clausius treats the radiative exchange.[19,20] The correct question is, whether the colder body that radiates less intensively than the warmer body warms up the warmer one. The answer is: It does not.

(b) Speculations that consider the conjectured atmospheric CO_2 greenhouse effect as an "obstruction to cooling" disregard the fact that in a volume the radiative contributions are already included in the measurable thermodynamical properties, in particular, transport coefficients. These will show no measurable variations if one doubles the CO_2 concentration. Furthermore, the "obstruction models" often neglect the fact that "radiative balance" is introduced as a preposition of the standard analysis.

(c) We repeat a statement from above: It is true that the heat conductivity of a gas is relatively small. However, it is still finite. Heat conductivity plays an important role at the interface between ground and atmosphere and, of course,

[h]That is why our soup becomes cold when the door is left open. The same effect happens during the bake-out of donuts in sizzling oil: The cook ends up in a screaming frenzy.

serves as a germ for heat transfer by convection. The latter surmounts ordinary (static) heat conductivity typically by four orders of magnitude.

(d) Of course, heat conductivity of the ground is non-negligible. Halpern *et al.* should read our paper more carefully. By the way, the pot-on-the-stove example, only shows that infrared absorption and heat conductivity are not related to each other.

(e) The Stefan–Boltzmann T^4-law does only apply to an idealized black body, that is a cavity with a hole placed in a heat bath of constant temperature T. Global climatologists use crude approximations, from which they compute tiny variations of measurable quantities unscrupulously. This is inadmissible. One example is the conjectured atmospheric CO_2 greenhouse effect. Even if their theory were correct, the error bars would render their predictions useless, since being gigantic.

(f) A so-called grey body obeying a modified Stefan–Boltzmann T^4 law (i.e., a Stefan–Boltzmann law multiplied by a factor) is a phenomenological construct whose physical realization does not exist.

(g) The Earth is a multi-colored object characterized by an inhomogenous color distribution, not a black or grey body, which cannot be altered by Arthur B. Smith, who essentially has plagiarized our inequality[12] and did not refute anything of our work.[3,4,13] By using the Stefan–Boltzmann law, one always computes radiations that are far too large.[3,4,13]

(h) Gaseous layers never obey the Stefan–Boltzmann T^4 law. All these calculations (e.g., the shell layer calculations performed in detail by Halpern *et al.*) are fundamentally wrong and prove nothing. The corresponding four pages of the comment by Halpern *et al.* are obsolete.

(i) If one introduces discretizations (lattice cells, finite number of layers) one must always discuss either the continuum limit or the artifacts generated by the discretization thoroughly. The "philosophy" communicated by the numerical mathematician and global climatologist von Storch[i] "The discretization is the model"[21] is not only simplistic but fundamentally unphysical.[j]

2.4. *Some remarks on section 3 (A rotating planet etc.)*

This section presents nothing new. The reader is referred to our paper and the work of Kramm, Dlugi, and Zelger.[13] We emphasize:

(a) Repeating our statement from above, it is impossible to calculate the temperature fields of the Earth's atmosphere by using radiative transfer equations regardless of an introduction of CO_2 concentration or molecule spectra.

[i]It should be noted that von Storch was one of the first global climatologist who refuted the "Hockey Stick" by Michael Mann *et al.* However, as his textbook shows, he still accepts the atmospheric CO_2 greenhouse hypotheses.

[j]A nice example is the comparison of the discrete and continuous versions of the logistic equations (Verhulst, Feigenbaum).

(b) The radiative transfer equations do not yield the portion of radiation energy that is transformed into heat. This can be easily seen by observing that the direction of the gradient of the temperature determines whether the lines of the spectrum are present as absorption lines (Fraunhofer lines) or emission lines. In case of the so-called scattering atmosphere after Chandrasekhar,[22] no portion of the radiation energy is thermalized at all.

(c) It is impossible to measure the temperature fields of the Earth's atmosphere or any warming effect in spectroscopic experiments. Halpern *et al.* do not prove their assertion stated in Sec. 3.4 of Ref. 9 that the "downward emission" term is "by a factor of roughly two" larger than the incident solar radiation. The origin of the Planck curves in the Fig. 7 of Ref. 9 is rather obscure. Taken seriously, it would mean that the detectors are gauged with the help of idealized black body measurements.

(d) Again: We never claimed — allegedly with reference to Clausius — that a colder body does not send radiation to a warmer one. Rather, we cite a paper, in which Clausius treats the radiative exchange.[19,20] The correct question is, whether the colder body that radiates less intensively than the warmer body warms up the warmer one. The answer is: It does not.

2.5. *Some remarks on section 4 (Climate Models)*

Halpern *et al.* correctly recognize that, in our opinion, global climate models and the study of scenarios, do not belong to the realm of science.[3,4] To put it bluntly, they are science fiction. Their review of climate models reminisces what can be read in the mainstream literature. and presents nothing new. Halpern *et al.* find it inappropriate that we discuss some fundamentals of the philosophy of science in the context of our paper. However, it is important to remember that science is a method to test hypotheses. We would be glad if Halpern *et al.* conclusively explained why the predictions of different climate models differ fundamentally and miss the reality completely. From a physicist's point of view, we should emphasize:

(a) Repeating our statement from above, Halpern *et al.* confuse Global Climate Models (which they abbreviate as GCM) and General Circulation Models (GCM), i.e., coupled atmosphere-ocean models. By global climatologists, the latter are considered as the "key components" of the former, whatever this means, but not identified with each other.

(b) The Navier–Stokes equation has a friction term. Without this term, this equation becomes the Euler equation. With a friction term, the velocity field obeys a different boundary condition than without.[k] In the case of a friction term, one needs the second derivatives of the velocity fields that cannot be approximated with the help of the wide mesh lattices of the climate models. The same fact

[k]cf. Ludwig Prandtl's interface layer.

holds for the heat conduction equation. In our paper, we emphasize that even the simplest form of time evolution equations for the Earth (atmosphere and oceans) cannot be treated numerically near reality.

Thus, global climate models are nothing but a very expensive form of computer game entertainment.

2.6. *Some remarks on section 5 (Systematic problems: Definition of the greenhouse effect, assertions, theoretical arguments)*

In our falsification paper[3,4] we discuss different versions of the greenhouse effect which, in part, contradict to each other.

(a) As already emphasized, Halpern *et al.* do not choose from the existing versions of the greenhouse effect nor define their own one which they prefer to defend. Thus the comment of Halpern *et al.* is scientifically worthless.
(b) Again: It is impossible to calculate temperature fields of the Earth's atmosphere by using radiative transfer equations regardless of an introduction of CO_2 concentration or molecule spectra.
(c) Again: The radiative transfer equations do not yield the portion of radiation energy that is transformed into heat. This can be easily seen by observing that the direction of the gradient of the temperature determines whether the lines of the spectrum are present as absorption lines (Fraunhofer lines) or emission lines. In the case of the so-called scattering atmosphere after Chandrasekhar[22] no portion of the radiation energy is thermalized at all.
(d) Contrary to the claims of Halpern *et al.*, the system of equations discussed in the Section 4 of our paper, "Physical Foundations of Climate Science",[3,4] is entirely relevant as it includes the oceans, the stratosphere, the electrodynamics, and so on. Halpern *et al.* try to channelize the discussion by arbitrarily labeling issues as relevant or irrelevant. Do the authors of the comment have a reason which makes them sure to know enough?
(e) Contrary to the claims of Halpern *et al.*, the equations of magnetohydrodynamics, and in particular, electrodynamics belong to the physical basis of the atmospheric problem. They are relevant to the description of clouds, thunder and lightning, electromagnetic radiation, and in particular, dielectric properties of the components of the atmosphere.
(f) The beloved CO_2 is a dielectricum. Not only physicists like Georg Hoffmann should know the consequences with regard to the Maxwell equations and Beer's law,[23] namely one has to distinguish between scattering and (true) absorption. Prominent astrophysicists as Chandrasekhar (Chicago) and Unsöld (Kiel) have elaborated on this difference. Global climatologists should become more familiar with the work of these giants.[22,24]

3. Halpern *et al.* versus Clausius

3.1. *Objections adapted from Georg Hoffmann*

In the acknowledgment of their paper, Halpern *et al.* thank Georg Hoffmann (among others) for his suggestions. Georg Hoffmann argues we would state that " there is no greenhouse effect, that this effect contradicts the second law of thermodynamics and climate modelers do not know anything about physics".[14] The quotes indicate, that this quotation is supposed to be *verbatim.* However, one cannot find this in the text of the falsification paper.[3,4] In order to verify, one only needs to activate "search and find", inputting the corresponding search terms.

Naturally, from our own experience we know — and we often point this out in discussions — that individuals, who — escaped from the science department — flew to and finally got lost in the domains of global climatology often suffer from a barely modest infection by mathematics and physics. For instance, Georg Hoffmann apparently does not know how to apply the second law of thermodynamics. The second law is not a real process that is forbidden, its description, however, is!

3.2. *Descriptions that contradict the second law of thermodynamics*

In our paper, we explicitly isolate those descriptions that contradict the second law of thermodynamics. Of course, there are some descriptions that do **not** contradict the second law. For instance, it suffices to remove only a single sentence in the proposal of Dipl.-Phys. Professor Dr. Peter Stichel:[25]

> "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."

However, in its original form, it describes a Perpetuum Mobile of the Second Kind. We repeat our statement from above:

> - Once again, we never claimed — allegedly with reference to Clausius — that a colder body does not send radiation to a warmer one. Rather, we cite a paper, in which Clausius treats the radiative exchange.[19,20] The correct question is, whether the colder body that radiates less intensively than the warmer body warms up the warmer one. The answer is: It does not.

Thus the critique of Halpern *et al.* does not apply.

3.3. *Four examples of objections against our discussion of the fictitious greenhouse effect and the second law*

3.3.1. *The argument by Halpern et al.*

According to Halpern *et al.*[9]

> It is not admissible "to apply the Clausius statement of the Second Law of Thermodynamics to only one side of a heat transfer process rather than the entire process"

3.3.2. *An argument by Rahmstorf*

According to Rahmstorf[15]

> "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."

3.3.3. *An argument by Hoffmann*

According to Georg Hoffmann[26]

> "2nd law is always a statement on net heat flows. To consider only one part of the exchange is incorrect."

3.3.4. *An argument by Ozawa et al.*

In their paper "The Second Law Of Thermodynamics And The Global Climate System: A Review Of The Maximum Entropy Production Principle" Ozawa *et al.* write:[27]

> "This is not a violation of the second law of thermodynamics since the entropy increase in the surrounding system is larger."

3.4. *The work of Ozawa et al.*

Comparing these four examples,[9,14,15,27] one observes that there is confusion about the division of the world into a system and an environment, and how to handle the basic concepts. In particular, a discussion of the errors of Ozawa *et al.* clarifies these widespread misunderstandings.

Firstly, one observes, that what Ozawa *et al.* writes on the first page about Carnot is not true. Apparently, the authors did not read the original work of Carnot:[28] He postulated the conservation of heat. According to Carnot, work was produced when heat drops from the higher temperature level to the lower level. He did not transform heat into work. The so-called "principle" of maximum entropy production is not the second fundamental law of thermodynamics. We give

the correct formulation,[3,4] which was given by the inventor of entropy, Prof. R. Clausius,[19,20] who gave the mathematical formulations of the first and second fundamental law of thermodynamics.

However, to explain the additional mistakes in this paper is much more difficult, because even in very famous textbooks of Theoretical Physics the formulation of the second fundamental law of thermodynamics often is wrong, for instance, in the book "Statistical Physics" of Landau and Lifshitz.[29,1]

A short additional remark concerning Carnot: We are sorry to say, that everything that Ozawa *et al.* write about Carnot (in the whole paper) is incorrect. For instance in Sec. 2 of Ref. 27 the authors write something about Carnot, which one cannot find in Carnot's treatise: Carnot did not study the earth as a heat engine, but he studied the theoretical description of steam engines (cf. pp. 9–14 of Ref. 31). Furthermore, one cannot find — in the entire paper — a correct formulation of the second fundamental law of thermodynamics and a formulation of the maximum entropy production principle.[27]

All three statements in Ref. 27, Sec. 8

(1) "The second law (the law of entropy increase) is valid for a whole (isolated) system."
(2) "When we sum up all the changes of interacting subsystems, the total change must be nonnegative."
(3) "This is the statement of the second law of thermodynamics."

are wrong. One can find the correct formulation of the second fundamental law in Sec. 3.9.1. of Ref. 3, 4. One can formulate with both fundamental laws of thermodynamics inequalities which are similar to the given statements, but with more assumptions and constraints, not about the entropy, but about the sum of entropies. One can find the correct formulations in Ref. 31, pp. 50–52.

The definition of the entropy (of a system) is incomplete, thus wrong. In the formula (1) of Ref. 27, Sec. 8

$$dS = \frac{dQ}{T} \tag{1}$$

the important point is that dQ is the *reversible* differential form of the heat exchange and T is the absolute temperature, say

$$dS = \frac{dQ^{\mathrm{rev}}}{T}\,. \tag{2}$$

The entropy change is calculated for one system, which has only one temperature. Within the context of classical thermodynamics, one only has one value for the change of the temperature, of the internal energy, of the free energy, volume, density,

[1] One of us G. G. intents to write a collection of brief textbooks in theoretical physics with the main title "The Mathematical Principles and Methods of Physics" based on his lectures given at Braunschweig Technical University. At present, only the lecture notes can be downloaded and cited.[30]

entropy and so forth. When one would like to use functions of space and time one has to go over to the field description of irreversible thermodynamics for instance hydromagnetics.

The entropy production equation (for the sum of entropies) in our preprint is Eq. (143) in Refs. 3, 4. One has to integrate this equation over a finite volume. Then one has to take into account boundary conditions for the surface integrals. With the first fundamental law of thermodynamics, one gets the inequality (in linear approximation)

$$dQ^{\mathrm{rev}} \geq dQ \tag{3}$$

which follows from

$$dW^{\mathrm{rev}} \geq dW \tag{4}$$

where dW is the differential form of the outer work (e.g., $dW^{\mathrm{rev}} = p\,dV$), cf. Ref. 31, p. 21. These inequalities give the inequalities of the sums of entropies Ref. 31, pp. 49–53. There are very similar looking inequalities Ref. 31, p. 49. The first one is a statement about the sum of entropies of two systems:

$$\Delta S_1 + \Delta S_2 > 0\,. \tag{5}$$

We quote from Ref. 31, p. 49:

> Diese Summenentropie des aus zwei Systemen zusammengesetzten Systems, das insgesamt keine Wärme und Arbeit austauscht, kann nur zunehmen, bis sie maximal ist und die Teilsysteme die gleiche Temperatur haben.

which may be translated to

> The sum entropy of the system which is composed of two sub-systems and which does not exchange neither net heat or net work, can only increase so long, until it reaches a maximum and both sub-systems have the same temperature.

Without additional assumptions, one cannot prove these inequalities for more than two systems Ref. 31, p. 51. Then, there is another similar looking inequality Ref. 31, p. 49

$$\frac{Q_1}{T_1} + \frac{Q_2}{T_2} \leq 0\,. \tag{6}$$

In our case, we have only one system, which exchanges heat at two temperatures and is back in the initial state. One gets the equality when both heat exchanges are reversible. One could not find in Ref. 27 a precise definition of the "maximum entropy production principle". Usually one has constraints and boundary conditions, when one formulates a variational principle. It is necessary to give the region of the possible states, which are allowed. Otherwise it is undefined.

4. The work of Bakan and Raschke

4.1. *A review of mistakes*

Some time ago, the first author of the falsification paper[3,4] was concerned with the work of Bakan and Raschke (on the so-called natural greenhouse effect),[32] because on its first two pages so many mistakes can be found that it never should pass the referee process. At that time, the climate hysterics sharply attacked[33–35] CO_2-history expert Beck,[36] since he inadvertently omitted the units of the ordinate that probably got lost during layout. This has been inadequately characterized as a scientific fraud.[m]

But what is then the paper by Bakan and Raschke?[32]

The first author informed Dr. Eberhard Raschke that in his joint paper co-authored with Dr. Stefan Bakan[32] also the ordinate unit is missing, a very crucial point with respect to the quantification of their greenhouse hypothesis. Other serious errors in Ref. 32 are:

(1) The year of Fourier's paper is 1824 rather than 1827. This is important since this error winds its way through the literature. It leaves a trace of experts behind it who never read Fourier's paper that does not describe the greenhouse effect contrary to what is communicated.
(2) The contents of the papers by Fourier and Arrhenius is summarized incorrectly. On page 320 of the IJMPB version of the falsification paper[3] one will find in the facsimile of the text by Arrhenius that the temperature rise for a doubling of the carbon dioxide concentration is 1.6 degrees Celsius rather than 6 degrees Celsius.
(3) In the figure caption of the diagram Fig. 2-1, p. 2, the temperature for the ground is given by 250 K, whereas in the accompanying text it reads 255 K.
(4) Equal areas do correspond to equal intensities rather than energy quantities.
(5) In the diagrams of Fig. 2-1, p. 2, the black body Planck curves are never drawn, as stated, since the curves associated with the lower temperatures always lie below the curves associated with the higher temperatures. Without specifying a norm the adjective "normalized" has no meaning. The Planck function for the surface of the sun has to be reduced by a factor given by the ratio earth orbit per sun radius (i.e., 46225 = 215 squared) if one prefers to compare them with the radiation of the ground. Even in this representation these curves do not look equal. Choosing the temperatures 5780 K and 290 K, as done in the falsification paper,[3,4] one has to scale down the intensity of the solar radiation by 3.5 (cp. Fig. 13, p. 295, l.h.s.). In case of the temperatures chosen by Bakan and Raschke themselves this factor rises to 7.1, which one can easily prove with a standard computer program. An obfuscation of this necessary rescaling

[m]Recently, these false accusations have been repeated.[37]

(3.5 resp. 7.1) is a suggestive deception because the maximum radiation of the ground is much less than the incoming solar radiation.

(6) Hence, it will remain Georg Hoffmann's personal secret, to which extent this diagram "visualizes beautifully" Wien's displacement law. To put it bluntly, this diagram does not visualize Wien's displacement law at all! This can be verified with rather elementary mathematics skills. Namely, it is not simply the ratio (6000/300) times 0.5 μm yielding 10 μm, which does matter here, but, rather, one encounters the maximum at a different location, namely 0.63 μm, since obviously (6000/250) times 0.63 μm yields 15.12 μm. In the diagrams in Fig. 10, p. 293, one may recognize Wien's law, though with some effort.

(7) The multiplication of the Planck function with the wave length, Georg Hoffmann's aggressively exaggerated issue, magnifies the values at larger wave lengths (cf. Fig. 12, p. 295) but does not suffice to yield equal areas under the curves. One always needs a rescaling with factor 3.5 (in case of 5780 K, 290 K) and with factor 7.1 (in case of 6000 K, 250 K), respectively. Hiding this rescaling intentionally in a scientific publication is definitely misleading and may be characterized as scientific misconduct.

The authors emphasize: The multiplication of the Planck function with the wave length — Georg Hoffmann's aggressively exaggerated issue — was performed by the authors in their falsification paper (cf. Figs. 12 and 13 of Refs. 3, 4, left hand side and the text below).[3,4]

4.2. *"Twin Peaks" gallery*

4.2.1. *Overview*

In what follows, we try to shed some light on the background of the "twin peaks". Two questions are relevant:

(1) Why did Bakan and Raschke include diagrams in their paper[32]
   - that are normally recognized as clearly wrong both by meteorologists and by layman;
   - that suggest the incorrect statement the radiation intensity of the ground being equal to the intensity of the incoming solar radiation?

(2) Why did Bakan and Raschke not take Fig. 5.8 of the textbook by Thomas and Stamnes[40] cited by themselves?

Surely, Joshua Halpern knows the correct answer. Let us now evaluate the diagrams from the perspective of a physicist.

4.2.2. *Luther and Ellingson (1985)*

The diagram (Fig. 1) in Luther and Ellingson (1985) depicted on page 29 is incorrect.[38] To the ordinate "ENERGY (REL. UNITS)" no units are attached. The text

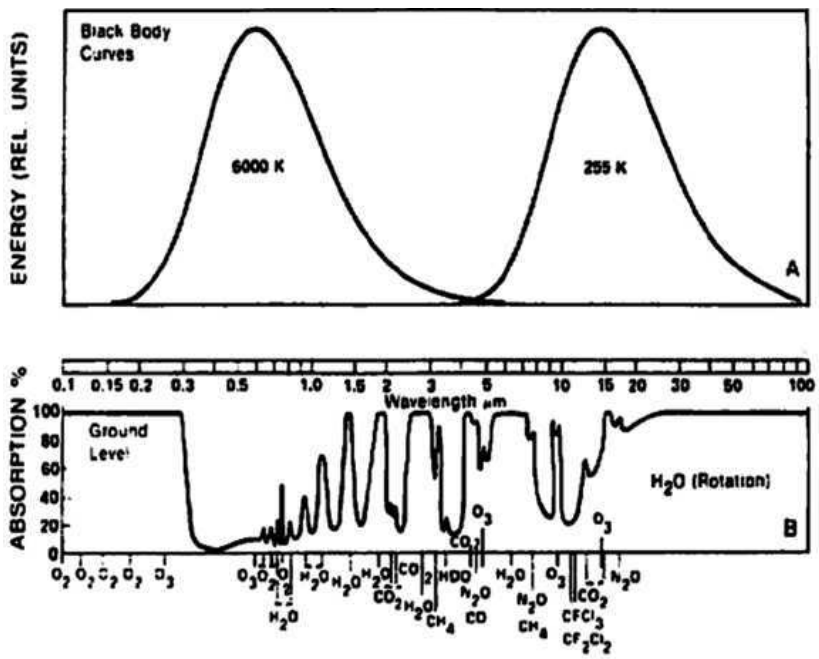

Figure 2.2. (A) Black-body curves for 6000 K and 255 K, which approximate the mean emitting temperatures of the sun and the Earth. (B) Atmospheric gaseous absorption for radiation passing from the top of the atmosphere to ground level.

Fig. 1. Diagram by Luther and Ellingson 1985, p. 29.

in the diagram reads “Black Body Curves”, “6000 K”, “255 K”. The figure caption reads “blackbody emission at 6000 K . . . and at 255”.

4.2.3. *Goody and Yung (1989)*

The diagram (Fig. 2) in Goody and Yung (1989) depicted on p. 4 is incorrect.[39] This diagram looks similar to the discussed diagram by Bakan and Raschke depicted below. To the ordinate “$\lambda \cdot B_\lambda$ (NORMALIZED)” no units are attached. The text in the diagram reads “BLACK BODY CURVES”, “6000 K”, “250 K”. The figure caption reads “Blackbody emission for 6000 K and 250 K”.

4.2.4. *Thomas and Stamnes (1999) — Diagram 1*

The diagram (Fig. 3) in Thomas and Stamnes (1999) depicted on p. 149 is correct.[40] There are two distinguished ordinate axes with two well-distinguished scales: The scientific method at work.

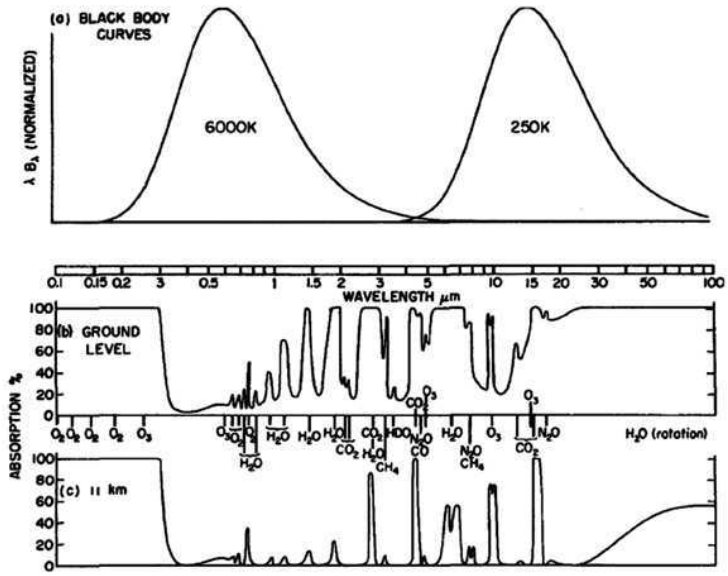

FIG. 1.1 Atmospheric absorptions. (a) Black-body curves for 6000 K and 250 K. (b) Atmospheric absorption spectrum for a solar beam reaching ground level. (c) The same for a beam reaching the temperate tropopause. The axes are chosen so that areas in (a) are proportional to radiant energy. Integrated over the earth's surface and over all solid angles, the solar and terrestrial fluxes are equal to each other; consequently, the two black-body curves are drawn with equal areas. Conditions are typical of mid-latitudes and for a solar elevation of 40° or for a diffuse stream of terrestrial radiation.

Fig. 2. Diagram by Goody and Yung (1989), p. 4.

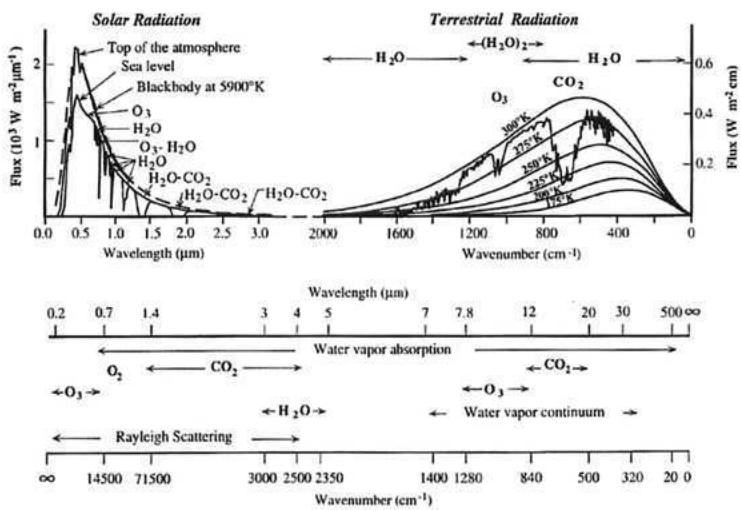

Figure 5.8 Spectral distribution of solar (shortwave) and terrestrial (longwave) radiation fields. Also shown are the approximate shapes and positions of the scattering and absorption features of the Earth's atmosphere.

Fig. 3. Diagram by Thomas and Stamnes (1999), p. 149.

4.2.5. *Thomas and Stamnes (1999) — Diagram 2*

Unfortunately, on p. 420 of their textbook Thomas and Stamnes (1999) include a diagram (Fig. 4) that is incorrect.[40] It is reminiscent of that depicted by Goody and Young (1989) on p. 4.[39]

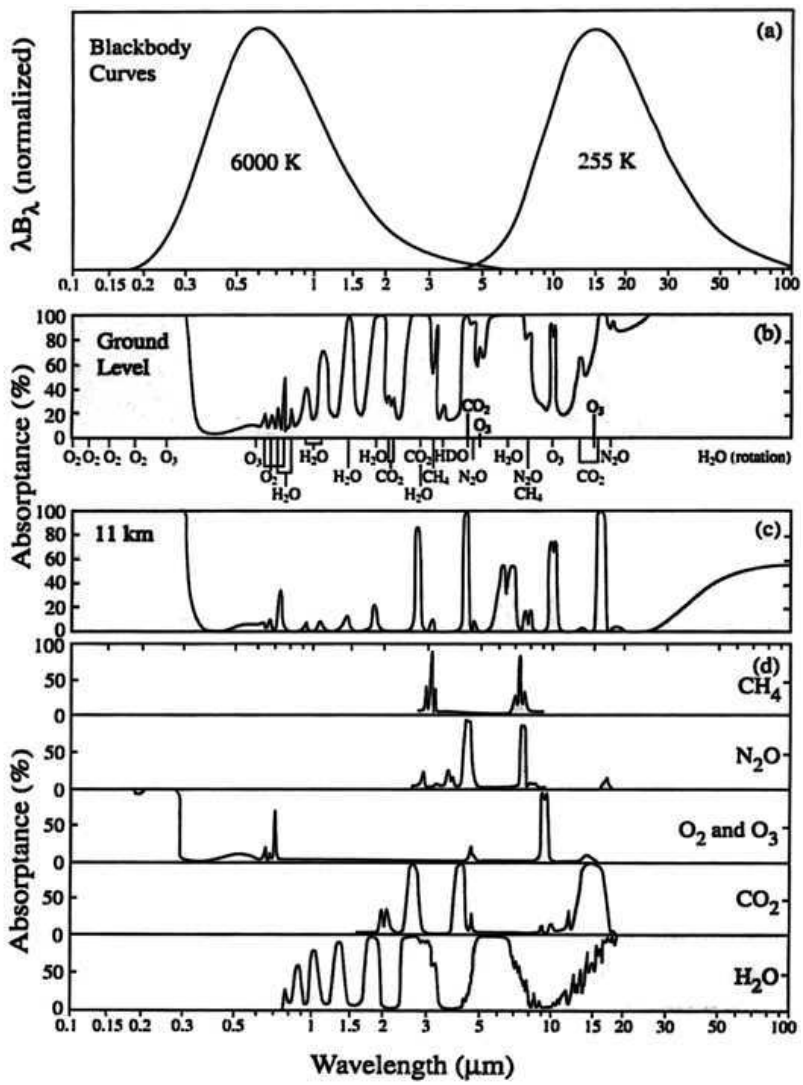

Figure 11.2 (a) Blackbody curves for solar radiation (6,000 K) and terrestrial radiation (255 K). Absorption spectra for (b) the entire vertical extent of the atmosphere, (c) the portion of the atmosphere above 11 km, and for (d) the various atmospheric gases between the top of the atmosphere and surface of the Earth.

Fig. 4. Diagram by Thomas and Stamnes (1999), p. 420.

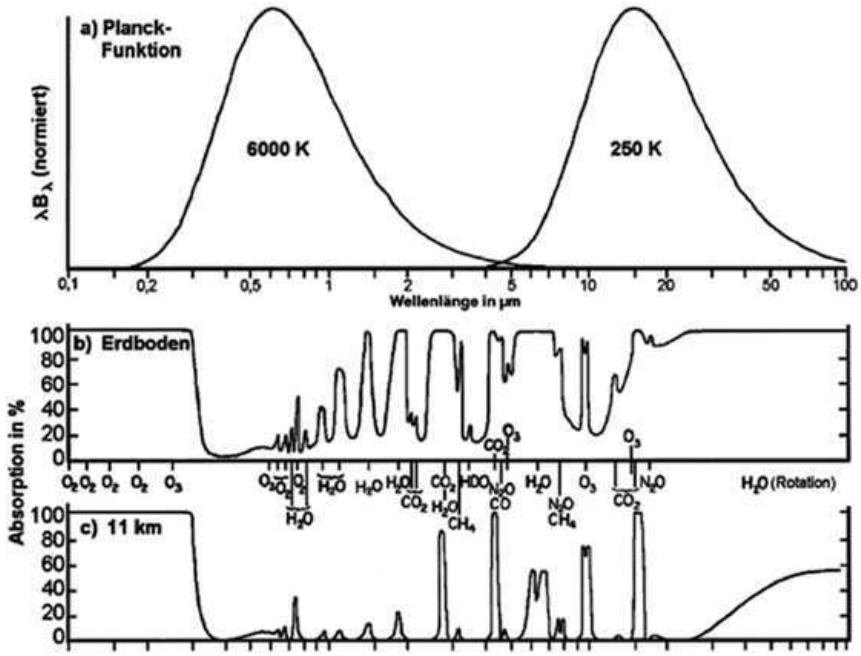

Abb. 2-1: Spektrum der als Schwarzkörper idealisierten solaren (6000 K) und terrestrischen (255 K) Wärmestrahlung (a), aufgetragen über der logarithmischen Wellenlängenskala von 0,1 bis 100 µm. Das Produkt aus Wellenlänge und Stahldichte auf der Ordinate stellt sicher, dass gleiche Flächen gleichen Energiemengen entsprechen. Die Bildabschnitte b und c darunter zeigen schematisch das Transmissionsvermögen zwischen dem Oberrand der wolkenfreien Atmosphäre und dem Boden (b) bzw. 11 km Höhe (c). Die „Spurengase" Wasserdampf, Kohlendioxid, Methan, Stickoxid und Ozon stellen die wesentlichen natürlichen Treibhausgase dar. (Abb. aus Goody und Yung 1995)

Fig. 5. Diagram by Bakan and Raschke 2002, p. 2.

4.2.6. *Bakan and Raschke 2002*

Contrary to what Joshua Halpern *et al.* and Georg Hoffmann say, the diagram (Fig. 5) depicted by Bakan and Raschke 2002 is incorrectly scaled and incorrectly cited.[32] Although Bakan and Raschke refer to the book by Goody and Yung (1980)[39] they introduce additional errors. For instance "Planck Function" in this context is complete nonsense. On the bottom line, they did not cite scientifically (correctly), that is, they did not cite.

4.2.7. *Petty (2006)*

The diagram (Fig. 6) in Petty (2006) depicted on p. 65 is incorrect.[41] To the ordinate "$\lambda \cdot B_\lambda$ (NORMALIZED)" no units are attached. The figure caption reads "Normalized blackbody curves corresponding to the approximate temperature of the sun's photosphere (6000 K) and a typical terrestrial temperature of 288 K."

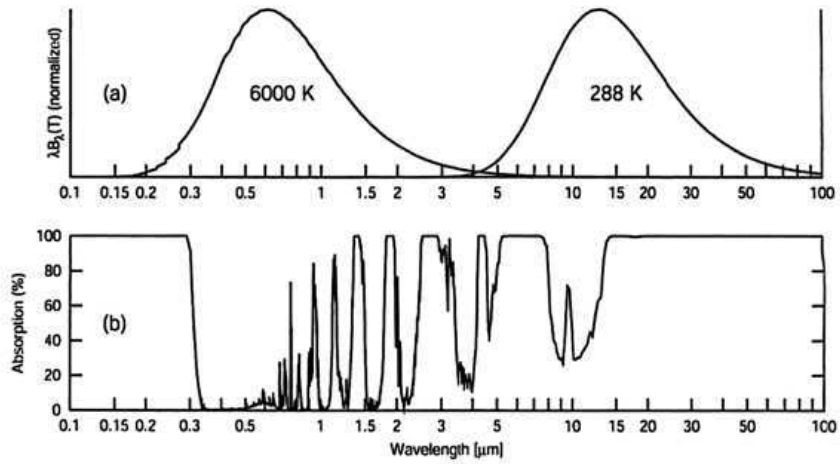

Fig. 3.3: Overview of the relationship between solar and terrestrial emission and the transmission properties the atmosphere. a) Normalized blackbody curves corresponding to the approximate temperature of the sun's photosphere (6000 K) and a typical terrestrial temperature of 288 K. b) A coarse-resolution depiction of the absorption spectrum of the cloud-free atmosphere.)

Fig. 6. Diagram by Petty (2006), p. 29.

4.2.8. *Gerlich and Tscheuschner (2007, 2009)*

In our falsification paper,[3,4] we offered three correct diagrams (Figs. 7–9). They clearly show that the radiation from the ground is much smaller than commonly suggested.

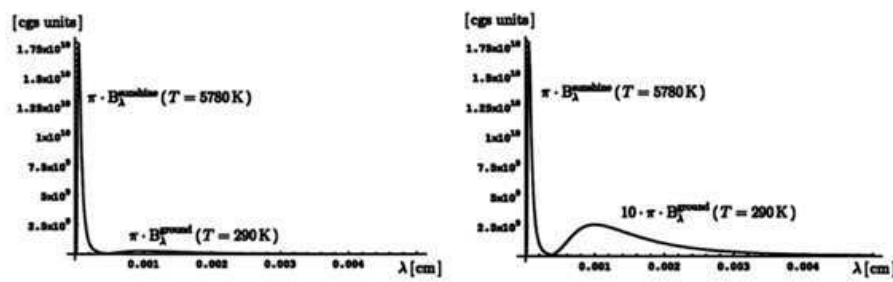

Fig. 11. The unfiltered spectral distribution of the sunshine on Earth under the assumption that the Sun is a black body with temperature $T = 5780$ K *and* the unfiltered spectral distribution of the radiation of the ground under the assumption that the Earth is a black body with temperature $T = 290$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

Fig. 7. Diagram Fig. 12 by Gerlich and Tscheuschner (2007, 2009).

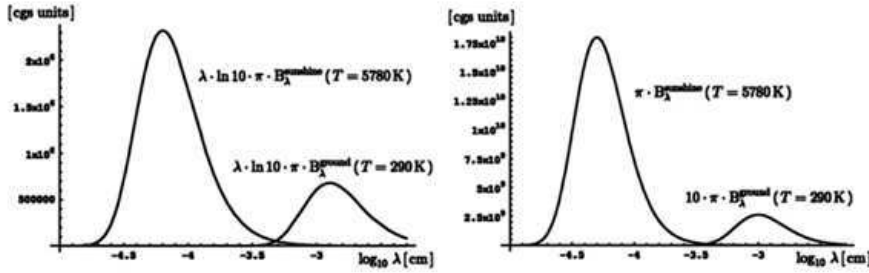

Fig. 12. The unfiltered spectral distribution of the sunshine on Earth under the assumption that the Sun is a black body with temperature $T = 5780$ K *and* the unfiltered spectral distribution of the radiation of the ground under the assumption that the Earth is a black body with temperature $T = 290$ 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. 8. Diagram Fig. 12 by Gerlich and Tscheuschner (2007, 2009).

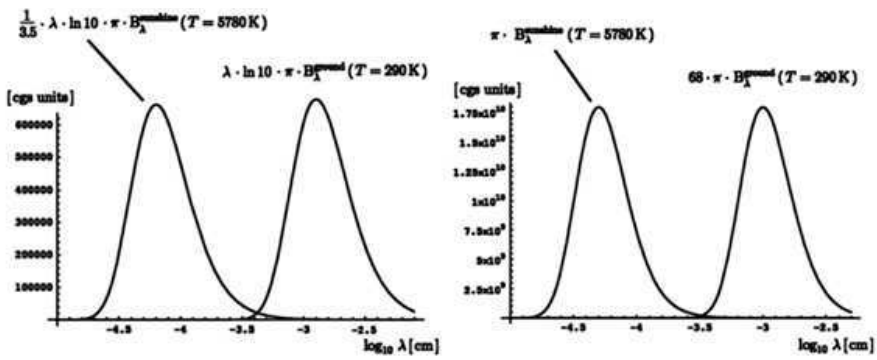

Fig. 13. The unfiltered spectral distribution of the sunshine on Earth under the assumption that the Sun is a black body with temperature $T = 5780$ K *and* the unfiltered spectral distribution of the radiation of the ground under the assumption that the Earth is a black body with temperature $T = 290$ 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).

Fig. 9. Diagram Fig. 13 by Gerlich and Tscheuschner (2007, 2009).

5. The Barometric Formulas

5.1. *Overview*

In the speculative discussion around the existence of an atmospheric natural greenhouse effect[11] or the existence of an atmospheric CO_2 greenhouse effect it is sometimes stated that the greenhouse effect could modify the temperature profile of the Earth's atmosphere. This conjecture is related to another popular but incorrect idea communicated by some proponents of the global warming hypothesis, namely

that the temperatures of the Venus are due to a greenhouse effect. For instance, in their book "Der Klimawandel. Diagnose, Prognose, Therapie" (Climate Change. Diagnosis, Prognosis, Therapy) "two leading international experts", Hans-Joachim Schellnhuber and Stefan Rahmstorf, present a "compact and understandable review" of "climate change" to the general public.[42] On page 32 they explicitly refer to the "power" of the "greenhouse effect" on the Venus.

In Refs. 43 and 44 we explicitly derive the approximate pressure profiles, density profiles, and temperature profiles of an atmosphere, also called *barometric formulas*. Our variant of a derivation goes beyond the common standard exercise of a thermodynamics lecture, where commonly the discussion of the underlying physical assumptions is missed.

These are:

(1) The neglection of the electromagnetic field terms.
(2) The independency of the wind velocities $\mathbf{v}(\mathbf{r}, t)$ on the location $\mathbf{r}$.
(3) The vanishing of the external force densities $\mathbf{F}_{\text{ext}}$.
(4) The verticality of acceleration due to gravity.
(5) The horizontality of the wind velocities.
(6) The validity of ideal gas laws for the air of the atmosphere.
(7) An isothermal atmosphere resp. an adiabatic atmosphere.
(8) The independency of the specific heats of the gases on the absolute temperature in the case of an adiabatic atmosphere.

We depart from the Navier–Stokes equation and explicitly point our attention on the physical assumptions disregarded elsewhere. By the way, this derivation is a good example on how to apply the magnetohydrodynamic equations regarded as redundant by some of our critics. Furthermore, it explicitly shows that in physics, an application of formulas is valid *only in a finite space-time region*. In addition, we show that the usual assumptions can be relaxed leading to generalized formulas that hold even in the case of horizontal winds.

A brief historical review of the barometric formula is given in Ref. 45. The reader is also referred to the textbook by Riegel and Bridger on "Fundamentals of Atmospheric Dynamics and Thermodynamics" where the standard derivation of the barometric formulas can be found.[46]

5.2. *Results*

By combining hydrodynamics, thermodynamics, and imposing the above listed assumptions for planetary atmospheres, one can compute the temperature profiles of idealized atmospheres. In the case of the adiabatic atmosphere, the decrease of the temperature with height is described by a linear function with slope $-g/C_p$, where C_p depends weakly on the molecular mass. As elucidated in our paper[3,4] mixtures of gases are covered in the context of Gibbs thermodynamics. Since the measurable thermodynamic quantities of a voluminous medium, in particular the specific heat

and the thermodynamic transport coefficients, naturally include the contribution from radiative interactions, we cannot expect that a change of concentration of a trace gas has any measurable effect. At this point, it is important to remember that the barometric formulas do not hold globally but have only a limited range of validity.

Let us return to the claim of Rahmstorf and Schellhuber that the high venusian surface temperatures somewhere between 400 and 500 Celsius degrees are due to an atmospheric CO_2 greenhouse effect. Of course, they are not. On the one hand, since the venusian atmosphere is opaque to visible light, the central assumption of the greenhouse hypothesis is not obeyed. On the other hand, if one compares the temperature and pressure profiles of Venus and Earth, one immediately sees, that they are both very similar. An important difference is the atmospheric pressure on the ground, which is approximately two orders higher than on the Earth. At 50 km altitude, the venusian atmospheric pressure corresponds to the normal pressure on the Earth with temperatures at approximately 37 Celsius degrees. However, things are extremely complex (volcanic activities, clouds of sulfuric acid), such that we do not go into details here.[47]

6. Concluding Remarks

In our falsification paper, we have shown that the atmospheric CO_2 greenhouse effects as taken-for-granted concepts in global climatology do not fit into the scientific realm of theoretical and applied physics.

Halpern *et al.* did not refute our conclusions. Rather, they make false statements about the content of our paper, on which they erect their system of objections. Their main mistakes are:

(1) Halpern *et al.* make false statements about the contents and the rationale of our paper.
(2) Halpern *et al.* do not understand what a physical effect really is.
(3) Halpern *et al.* — adapting Georg Hoffmann's view — apparently do not know how to apply the second law of thermodynamics.
(4) Halpern *et al.* do not understand our critique on the abuse of diagrams in the context of simplistic radiative balance models.
(5) Halpern *et al.* like many others do not understand that any supposed warming effect (or cooling effect) cannot be derived from spectroscopic analyses or radiative transfer equations.
(6) Halpern *et al.* neither define a greenhouse effect nor offer a mechanism how the concentration change of the trace gas CO_2 influences the climates.
(7) Halpern *et al.* do not recognize the fundamental errors of the paper by Bakan and Raschke.

In summary, the paper of Halpern, Colose, Ho-Stuart, Shore, Smith, and Zimmermann is unfounded.[9]

Note added in proof

As Gerhard Kramm informed us recently, a correct version of the "twin peak" diagrams can already be found on page 17 in a forty years old textbook on meterorology by Heinz Fortak.[48] We are very grateful for his hint.

Acknowledgment

We are grateful to all for giving us the opportunity to make our point. Discussions with Dipl.-Met. Dr. Wolfgang Thüne, Dipl-Ing. Paul Bossert, Gerhard Kramm (University of Alaska, Fairbanks), and Klaus Ermecke (KE Research) are acknowledged. Gerhard Gerlich thanks Grant Petty sending him an electronic copy of his book.[41] Ralf D. Tscheuschner acknowledges an interesting discussion (10. January 2008) with Prof. Dr. Friedrich-Wilhelm Gerstengarbe (PIK), Dr. Österle (PIK), Prof. Dr. Peter C. Werner (PIK), and Dipl.-Ing. Michael Limburg (EIKE) on evaluation of terrestrial temperature measurements. We extend our thanks to Dipl.-Phys. Dr. Manfred Dinter for a critical last-minute reading.

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