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Robert Döpel and his Model of Global Warming

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Preface to the 3rd Edition

This English text is a corrected and improved version of the German 2nd online edition[1] from 2010 that followed the 1st printed (and online) edition[2]. Again it contains a series of complements regarding additional literature. In this context it should be mentioned that the *"German Science Year 2010"* had been devoted to the "*Future of Energy*". For a sense of responsibility as it was represented by ROBERT DÖPEL, this future will extend to a few centuries at least - and not only to a few years or decades, at best, as in politics.

I would be obliged for all activities supporting a more fundamental treatment of the problems and their solution by appropriate institutions. Especially advancements of the more general informatory concerns that are aimed primarily at advanced scholars and at students would be gratefully acknowledged.

Ilmenau, March 2011.

HEINRICH ARNOLD

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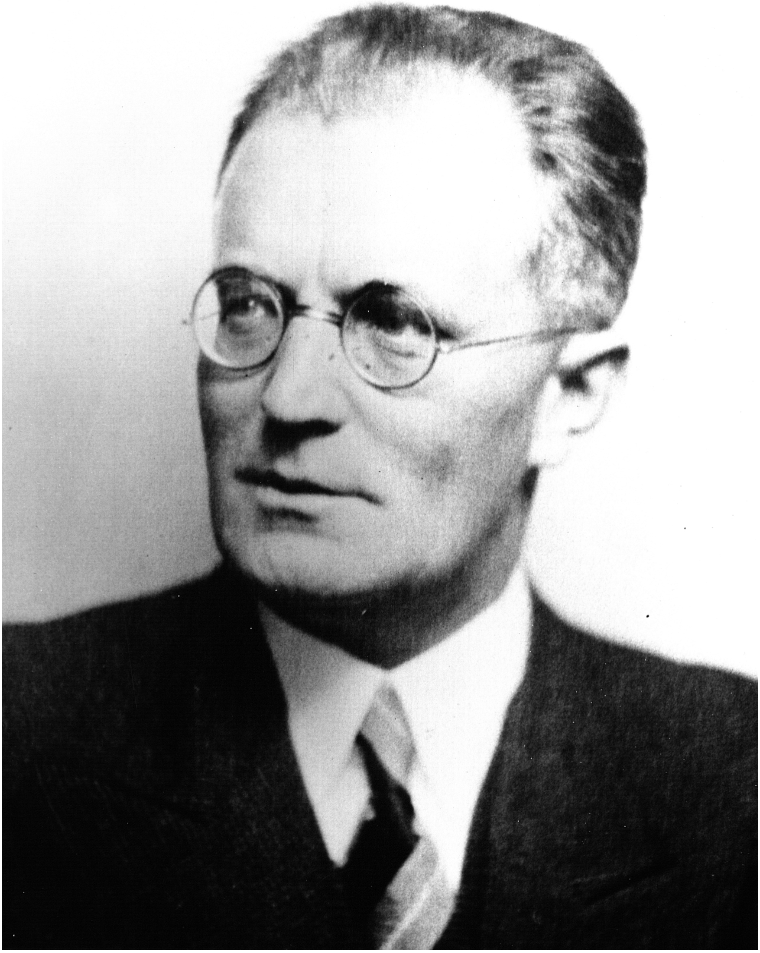
[1] *Robert* DÖPEL *und sein Modell der globalen Erwärmung. Eine frühe Warnung - und die Aktualisierung.* 2. Auflage: http://nbn-resolving.de/urn:nbn:de:gbv:ilm1-2010200125 .

[2] 1. Auflage: Universitätsverlag Ilmenau 2009. ISBN 978-3-939473-50-3. http://nbn-resolving.de/urn:nbn:de:gbv:ilm1-2009100044 .



ROBERT DÖPEL

was born in 1895 in *Neustadt an der Orla,* a small town in Thuringia, Germany. After the school leaving examination, he attended the First World War and became seriously injured in 1918. From 1919 to 1924, he studied physics and additionally mathematics, chemistry and philosophy at the universities of Leipzig, Jena (1920-21), and Munich. Here, in 1924 he received his doctorate under the NOBEL Laureate in Physics WILHELM WIEN. Thereafter he became ROBERT WICHERT POHL's teaching assistant at the University in Göttingen until 1925. Then he worked in a private laboratory in Planegg, just west of Munich, where he continued his philosophical studies. In 1929 he became a teaching assistant and in 1932 a private lecturer at the University of Würzburg. In 1938, he became an extraordinary professor of radiation physics at the University of Leipzig.

The time that follows is described in more detail in section 3.1. In summer 1945, together with other nuclear physicists DÖPEL had to go to Russia, from where he returned in 1958. Until 1962 he was a professor for electrical engineering at the *Hochschule für Elektotechnik Ilmenau* (today *Technische Universität*), and thereafter he still worked in his laboratory until 1975. He passed away in 1982 at Ilmenau.

Content

1 Introduction and Synopsis

Pursuant to our subheading, *"An Early Warning"* has been given by ROBERT DÖPEL whose climate paper appeared in 1973, between the first two reports to the *Club of Rome* from 1972 and 1974 on global growth limits including anthropogenic warming aspects[3]. More than three decades later, a film by Al Gore – a Nobel Peace Prize laureate in 2007, together with the International Panel of Climate Change (IPCC) – has been titled *"An Inconvenient Truth – A global Warning"* [1].

This IPCC with its hundreds of direct and even more indirect coworkers gave the 4th of its Assessment Reports[4] in 2007 ("AR4"). Thereby it contributed again decisively to a politically resilient consensus on global warming and its mitigation. The way of coordinated scientific work in that extent is unique so far, which results in problems, too[5]. The report of working group I from 2007 [2], which

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[3] DÖPEL covered only the anthropogenic waste heat in [3] for global warming, while the *Club of Rome* included also the greenhouse effect, which completely dominates today's discussion. Thereby, the time horizon is only decades versus centuries in [3]. Not only in the English-speaking world, but also in the German language countries DÖPEL's early warning was totally overlooked to this day.

[4] The main parts of these reports [2] are each formed by reports of three Working Groups (WG I-III) titled "The Physical Science Basis", "Impacts, Adaptation and Vulnerability", and "Mitigation of Climate Change". Prepended to each Assessment Report is the Synthesis Report (SYR), the Technical Summary (TS) and the Summary for Policymakers (SPM). – An updated statement facing the 2007 report (corresponding to the knowledge from 2005/2006) has been given in November 2009 by a panel of experts [13b].

[5] Apart from the problems connected with our special DÖPEL themes, see in particular the first subsection in 3.4.

is the most important part of AR4 for our model considerations, contains nearly 1000 pages on its own.

Due to the controversies on the anthropogenic green house effect that dominated for many years (and are not finished so far), warning on global warming due to other global problems have been noticed insufficiently. At first, the physicist ROBERT DÖPEL quantified the influence of exponentially increasing anthropogenic heat release by comprehensive model calculations, based on an impressively simple analysis [3]. This delivered only lower limits for the global temperature increase of surface temperatures. To this day, no more accurate values were calculated, and the overlap with the anthropogenic greenhouse effect can apparently not be grasped so far in the large computer models [2]. But that seems to be no sufficient reason to ignore the estimat ions of the DÖPEL model.

Assuming a continuing exponential growth of industrial energy production by nearly 2% per year that occurred since that time, observable temperature effects of this release are to be expected at the end of the next century. Even with a waste heat growth of only 0.5% p.a. such effects will occur before the end of our millennium. Because of the enhanced sensibility for topics of climate, one can hope for openness to such advisements several centuries ahead. Until now, the following decades are mainly discussed (without regarding long term consequences) or, as the other extreme, 10^4 - 10^6 years for disposal of radioactive waste.

At first, for a better subsumption of DÖPEL's results and its actualization, in chapter 2 some important stages on the way towards the actual state of discussion about climate change are considered, mainly with respect to the actualization of DÖPEL's model. This section can be read independently from the calculations given thereafter. Some older events that younger people have not witnessed and the seniors often have already forgotten[6] are treated more critically and in detail, because they are scarcely accessible by electronic media.

The latter holds also for the work of ROBERT DÖPEL that is appreciated especially in section 3.1, starting with his first professorship in Leipzig and ending with his last years in the thuringian Ilmenau, where he worked at the (today's) University of Technology. He adduced his most important former achievement in the field of experimental physics that was a first step to nuclear technology together with his wife and with the theoretician WERNER HEISENBERG [3a] at Leipzig. On the 100th birthday of ROBERT DÖPEL, there appeared a booklet [4] in which his time at Ilmenau is described comprehensively, too. Here, he developed the geophysical model described in section 3.2 together with actualized calculations.

After generalization (in 3.3), the results are discussed together with results from actual publications on computer simulations of the anthropogenic greenhouse effect (in 3.4). Actually, this effect is much more fatal. Due to its complexity it can be treated here only very simplified. In this context, insight is given into the climate problems, together with usual notions and quantities that belong to fundamental knowledge in geophysics and climatology. - At last, DÖPEL's concept proves to be a special case of the international usual attribution of

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[6] An example is the damage of the ozone layer by fluorochlorohydrocarbons, the atmospheric concentration of which culminated in the middle of the nineteen-nineties and then became reduced. PAUL CRUTZEN, who got the NOBEL price for chemistry (1995) for work in this area, stated in an interview that this former danger which was small compared with the present danger of climate change is ignored. (The newspaper "taz": http://www.taz.de/?id=start&art=4609&id=umweltartikel&src=AR&cHash=cf119839ae 2007.) - See also section 2.3 that contains more about the ozone hole in correlation with the greenhouse effect.

global temperature changes to the climate forcing[7], which is a kind of driving force for global warming.

The requirements in mathematics and natural science for our quantitative treatment do not go beyond the level of secondary (university-preparatory) schools[8]. The model considerations in section 3.2 - 3.4, that have been treated in a short contribution in a digital library[9], too, are useful especially for those engaged in "MINT Sciences", which is an abbreviation[10] for **M**athematics and **I**nformation, **N**atural and **T**echnical Sciences.

The results presented below show that, if energy production becomes enhanced further, the global warming due to the anthropogenic greenhouse effect becomes superimposed by the additional influence of the heat release. The comprehension of Fig. 2 (sect. 3.2), that is fundamental in this context, requires no detailed knowledge of the calculations on which it is based on.

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[7] Briefly: "Forcing", in the sense of the Climate Research Committee within the National Research Council (USA) [5a].

[8] The presentation is based on experience of the author from 1978 to 1999 at the *"Technische Hochschule Ilmenau"* (since 1992 *"Technische Universität"*) mainly with students of technical sciences (also beginners) and last 2008 in an one-week *"Ilmenauer Physiksommer"* on *"Energy and Climate"* for selected scholars. Every year the theme can be treated in a special seminar for students of *"Technical Physics"*.

[9] *Global Warming by Anthropogenic Heat Release,* http://nbn-resolving.de/urn:nbn:de:gbv:ilm1-2009200065 (2009). For corrections see section 3.2 with footnote 56.

[10] "MINT" comes from German speaking countries; see for example http://www.educ.ethz.ch/mint , http://www.mint-ec.de and http://www.mintzukunftschaffen.de/ .

The concluding chapter 4, which is purely verbal again, starts with considerations on nuclear technology. Thereafter, also referring to DÖPEL's work [3], in section 4.2 some social and cultural aspects of the climate debate are discussed, as far as they were not yet included in chapter 2. This section can be skipped if the reader is interested mainly in quantitative considerations. On the other hand, readers not interested in such considerations can omit sections 3.2 and 3.4. – The sequence of sections was chosen so, that not only DÖPEL's model calculations in today's sight will become plain, but also his personality as well as the circumstances and antecedents of his work at Ilmenau.

A science-writer presentation with good term explanations especially for the extended historical background of the following chapter 2 is given in the paperback [5].

2 Facts and Discussions on Global Warming

2.1 The Time from FOURIER to ARRHENIUS

JEAN-BAPTISTE FOURIER has already described (or "supposed", as Gassmann [7] says) in 1822 in the course of his fundamental thermodynamic works the global greenhouse effect as "l'effet de serre"[11]. Following further precursors[12], the Swede ARRHENIUS (NOBEL price in Chemistry 1903) from 1896 on delivered the pioneering findings [8a]. The atmospheric "global average temperature" at the surface of the earth[13] with sunshine would be much lower without the heat congestion by the atmosphere (see section 3.2). This comes from absorption of the emitted heat by clouds, water vapor, carbon dioxide and other trace gases. These atmospheric absorbers adopt the role of a glass roof, whereas the similarity with conditions in a greenhouse is rather limited, of course [9].

SVANTE ARRHENIUS also recognized the anthropogenic intensification potential for the greenhouse effect. In 1908 he wrote about the increase of carbon dioxide, which he expected, however, at first in a few

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[11] The *"Handbuch der Physik"* from 1957 [6] that is cited by DÖPEL [3] uses *"Glashauswirkung"* or *"greenhouse effect"*. – In some American debates on environment, the latter becomes confronted with a *"White House effect"* that can act on global temperatures in the same ore in the opposite direction, depending on the resident of that house.

[12] A chronological literature report on the greenhouse effect is given by WISNIAK [8] with comprehensive comments.

[13] For this average global temperature he used 15°C, as it is usual since that time [9]. However, 14,5°C were not exceeded until 2010 [10a] (cf Fig. 1a).

centuries [8b], that this would give hope on times in which the earth would give multiple crops *"in the benefit of the quickly growing human race"*. So, ARRHENIUS has inaugurated the debate on global warming.

2.2 The Time between ARRHENIUS and Formation of the IPCC

The broad public, and large parts of the scientific community too, scarcely considered the enlargement of CO_2 concentration (Fig. 1b) to be a possible cause of global warming (Fig. 1a) until the beginning of the nineteen seventies. But then in the first two *"Reports for the Club of Rome"* in 1972 [11] and 1974 [12], among the global problems becoming limiting for growth the anthropogenic climate changes by CO_2 increase as well as by industrial heat release[14] were mentioned. About the latter JOHN P. HOLDREN, who became the US presidents advisor for Science and Technology in 2009, wrote in a study [11a] cited in the 1st report,

"… that global thermal pollution is hardly our most immediate environmental threat. It could prove to be the most inexorable, however, if we are fortunate enough to evade all the rest."

Popular-science paperbacks [13] which appeared shortly afterwards warned against both causes for warming, too. In view of the contemporary annual growth of the energy production by 6% p.a., plain

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[14] In the Updates from 1992 and 2006 [12a], the warming by energy production has been mentioned no more, which can be explained by strongly reduced growth rates (section 3.2) and by the limitation of their computer simulations on the 21st century. Now, the more detailed the CO_2-problems for the growth limits became discussed, invoking the IPCC reports [2].

effects of heat release "within one to two centuries" have been predicted therein.

A report of the PUGWASH conference in 1974 on "World Problems and Science" [13a] has mentioned[15] "*noticeable* ***regional*** *or* ***local*** *disturbances of climate … due to combined effects of* CO_2*- and dust particle emissions"* that could take place much earlier than "a far-reaching disturbance of the world climate by heat release to the environment" due to the anthropogenic energy production. This "*is to be expected presumably at the fifty- or hundredfold of the present consume of energy (corresponding roughly 80 to 100 years with a growth of 5% per year)"*.

Such statements can become surpassed estimating the increase of temperature that would be expected at this exponential growth by DÖPEL's model from 1973 (section 3.2). It shows a continued exponential growth to be unjustifiable, as it has been shown by the authors of the Club of Rome on a broader basis for other influences polluting the environment. These statements meant as warnings against exponential growth are often misunderstood and disapproved as prognoses until today. However, the discussions are dominated as before by the correspondingly constant growth rates[16].

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[15] Bold type in the original text.

[16] Sometimes transitions to linear growth are discussed as desirable [36d]. This is contained as initial phase in our later considerations (on Fig. 2c). Therefore it is not separately discussed here.

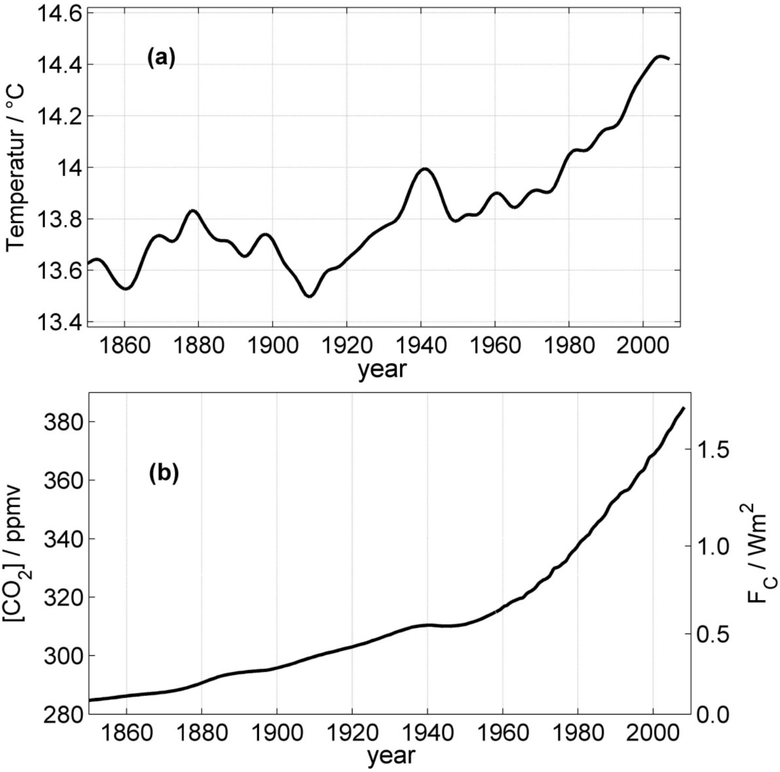

Fig. 1

(a) Averaged global atmospheric surface temperature in dependence on time. (Data from [10a].)

(b) Averaged global concentration of CO_2 in dependence on time. (Data from [10b].) ppmv = parts per million by volume, i.e. volume parts on one million. Additionally, the inscription of the ordinate on the right gives the CO_2-forcing as a logarithmic measure for the ratio of the actual concentration to the "pre-industrial" 280 ppmv in 1750 [2], calculated by eq. (15) in section 3.4.

In the PUGWASH example from 1974 (with 5% growth p.a. for energy consume and heat release), computations as in section 3.2 give some tenths of a degree for the second half of our century[17]. To become impressed by this, one must have the disposition of a lumber jack who looks in advance for several generations, as it means the old silvicultural aim of sustainability.

The time horizon is similar for an energy production by nuclear fusion (see section 4.1). Their conveyors belong also to the target audience of DÖPEL's warnings. Thereby he has completely ignored the intensification of the greenhouse effect, that has recognized meanwhile as mainly responsible for global warming, which already amounts 0.7°C ([13d], Key Message 3).

However, the course of temperature is by no means as monotonous as that of the CO_2 concentration, which is illustrated in Fig. 1. Indeed, carbon dioxide is decisive for the actual temperature increase, and the long time trends both are largely parallel for the past 10^5 years, at least ([1]; [7] Fig. 9). But the "*global warming*" has been interrupted by a "*cooling*" between the beginning of the nineteen forties and the middle of the nineteen seventies, for the last time [2-1990]. This resulted in controversial debates [11b] especially at the end of this time interval, when DÖPEL wrote his work [3], in which he prudently ignored these controversies. As the cardinal reasons for the cooling are to be considered air pollutions by aerosols and volcanic influences ([2], Fig.

[17] This can be read from DÖPEL's Fig. 1 from [3] for the annual growth coefficient q = 1.05. The actualized Fig. 2c in our section 3.2 gives similar results, albeit there has been used for 1970 to 2000 the real q = 1.02, corresponding to 2% growth p.a. Maintaining this lower growth, this model gives some tenths of a degree not until the beginning of the 23rd century.

9.5). Without these influences the actual global warming would be remarkably stronger.

2.3 From Formation of the IPCC until Today

After all, the assumption that the global climate was in danger led to the formation of the initially mentioned *International Panel of Climate Change* by the *United Nations* together with the *World Meteorological Organization* (WMO) in 1988. The atmospheric increase of greenhouse gases became characterized as anthropogenic and alerting already in the 1st report [2-1990].

Fundamental for internationally coordinated measures against the climate change is the *United Nations Framework Convention on Climate Change* (UNFCC) [13c] that passed in 1992 and became obligatory to international law in 1994. It corresponds to the principle newly generated then for the Community of states to respond on strong menaces to global environment even with lack of full scientific certainty. In §3, *"serious or irreversible damage"* to which the anthropogenic greenhouse effect belongs, becomes especially accentuated. This is contradictory to the wrong but still often used plea with respect to this effect, *"that more efficient mitigation can occur in a future richer world"* [44b].

The annual *United Nations Climate Change Conference or "Conference of Parties"* (COP) shall put the UNFCC into action. Thereby, the *Kyoto Protocol* that was adopted in the Japanese Kyoto in 1997, entered into force ultimately in 2005 and expires in 2012, should be fundamental.

More successful (also with respect to the anthropogenic greenhouse effect, see below) was the international struggle against the ozone hole[18], that has been discovered in 1984. Already in 1987, in this context the *Montreal Protocol* has been passed as the first global agreement on environment at all. It has been blessed as *"perhaps the single most successful international agreement to date"* by KOFI ANNAN, Nobel Peace Price laureate and secretary-general of the UN from 1997 to 2006. Together with the revision protocols, it has stopped the damage of the stratospheric ozone layer, the relaxation of which begins to show already and could become complete in the second half of our century [16]. In the "30-Year Update" [12a] of "*The Limits of Growth",* the "*Ozone Story"* is given under the headline "*Back from Beyond the Limits"* as a classical example for transgressing a limit with the danger of a collapse and with its avert. - In-between, for the greenhouse effect a transgression of limits is also emerging, the reduction of which is the main task of climate politics.

Since the halocarbons that cause the ozone hole are strong acting greenhouse gases[19] as well, global warming has been delayed markedly by their reduction[20]. Due to calculations of the Dutch environmental centre MAP (Milieu en Natuur Planbureau) [17], this compensated one decade of the actual CO_2 increase. This is much more than the eligible result of the commitment by industrial countries to reduce their

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[18] See footnote 9 and [14] with sections 1.4.2 and 2, including history.

[19] This holds also for Fluoro-Hydrocarbons (HFCs) that have been introduced for example in refrigeration after the Fluoro-Chloro-Carbons were forbidden. An application for the 22nd Meeting of Parties to the Montreal Protocol in 2010 to prohibit HFCs too has been adjourned. - Refrigeration without any halocarbons is offered by the Greenfreeze style technique, which works in nearly 400 million refrigerators sold up to 2010. In this year it was introduced in the USA as the last industrial country [15].

[20] The other way round, the greenhouse effect acts on the ozone hole, but the amount is uncertain as yet [16].

emissions of greenhouse gases from 2008 to 2012 by 5,2% in the average, compared to the level of 1990.

This (too) low value has been caused not at least by the USA negotiation for the Kyoto protocol with the leadership of Vice President GORE. Asked for this later, he pointed to the real power distribution in the state in which he had been *"the second man only"* [18]. This commemorates fatally the arguments of the Soviet negotiation leader in Montreal 1987, which almost ruined the ozone agreement in last minute: The extent of halocarbon production was fixed by the five-year plan until 1990, which by the constitution wasn't allowed to be changed [19]. At least thanks to GORBACHEV, this problem has been solved with exception clauses. In contrast to this, the CO_2 problem is by far more extensive with respect to economics and power politics, and it is scientifically much more complex, which caused permanent conflicts.

Additionally, the changed international situation in the nineteen nineties raised enhanced claims to reduce the expense for environmental protection [20]. Thereby, the realization that a belated reaction causes higher costs still has been suppressed. In the foreword to the *"30-Year Update"* of "*The Limits of Growth"* [12a], the reduced environmental protection is shown by contrasting the UN Conference on Environment and Development 1992 in Rio de Janeiro with the *"Rio + 10 conference"* 2002 in Johannesburg and by the course of violating the limits in the meantime (Fig. V-1 in the *"Update").* Symptomatically is the formulation from the foreword to a collection of so-called *"environment errors"* that firstly appeared in 1997 [21]: *"The first wave of environmental protection had much success. But it is irrecoverable."*

Trying to prove the latter statement, the authors of this several times reprinted bestseller list disagreements, among others in the climate debate or "climate hysteria", respectively. This is done in great detail –

and not without success. Thereby, not only other journalists and politicians or the "morale multi" Greenpeace become savaged. They polemize also –and first of all - against scientists and their institutions, as the IPCC or the Max Planck Institute for Meteorology, *"rearmed to the German High Performance Computing Centre for Climate- and Earth System Research"* at Hamburg [21].

Within a concluding list of books, the similarly unrealistic account of an American *"eco optimist"* from 1995 with more than 700 pages [21a] is recommended. Such writings which were widely spreaded have contributed to a *"business as usual"*. Thereby, up to now two decades practically became lost to forceful measures against climate change.

Particular in the mass media, the term *"climate change doubter"* (or *"… denier")* became common for those who gainsay the anthropogenic influence on climate, or declare it to be irrelevant (see section 4.2). Traditionally, in the United States whose CO_2 emissions are the highest (neck-and-neck with China) they have a more significant role than in Europe, not at least due to support from business. For example, German media refer rather to dominating views from climate science[22]. Prominent climatologists have contributed popular science presentations in the most favorable sense, e.g. [25, 25a, 25c].

Because the media like apocalyptic climate scenarios which can cause resignation, options for acting against anthropogenic climate change are

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[21] This Max Planck Institute <http://www.mpimet.mpg.de> is only one of several users of the *Computing Centre.* Besides the *Max Planck Society*, three other associates are carriers of this service facility which is at the international forefront of computing capability [22].

[22] Recently, the situation approaches to that in the USA, for that it is described e.g. by Al Gore in [1], [56], and [56a]. See also section 3.2 with footnote 64.

of great importance. Though only 3-4% of the global emission of greenhouse gases come from Germany, it is important, as it is said in a climate brochure of the German Physical Society [24] in this context, *"to achieve contributions convincing the other actors to undertake the right steps"*.

3 ROBERT DÖPEL, his Climate Model, and the Actualization

3.1 Important Life Stages and Works of DÖPEL

ROBERT DÖPEL (1895-1982) wrote in the age of 78 years - motivated by a strong sense of responsibility – at Ilmenau his first and only work on climate [3]. As a *"late entrant"* in this field, he came from the (nuclear) energetic side. Most important was his experimental proof of an effective neutron increase in April 1942 at Leipzig. He adduced it together with his wife and WERNER HEISENBERG (1901-1976, NOBEL Price in Physics 1932) as theoretician [3a], which has been a condition for the use of nuclear fission for energy generation that was aspired in Germany.

At the end of July of the same year, the group around ENRICO FERMI also succeeded in the neutron increase within a reactor-like arrangement. Whereas FERMI had an "unique double aptitude for theoretical and experimental work" in the 20th century [28], the success at Leipzig resulted from the cooperation between the theoretical physicist and the experimentalist, as which DÖPEL had taken up his first professorship in 1938. Even in 1982, a few months before his death, he recollected within a letter [4F] to H. RECHENBERG[23] :

"That was the most pleasant working time I experienced in Leipzig at all. … Sitting together with the most eminent theoretical physicist of that times in the laboratory or elsewhere, all talks were so pleasing light-hearted that all was as ideal

[23] It was a thank-you letter to the co-author of the publication [28] that is fundamental for a correct sight on the course of events.

as one could wish. … But HEISENBERG *occasionally overestimated – or underestimated – the experimental possibilities."*

DÖPEL's wife KLARA [3e] took over *"the conversion of the results of measurement in order to answer the theoretical questions"*.[24] In 1933, she had given up her job as a jurist for political reasons. After their marriage, she attended to physical studies at Würzburg, where her husband was a private lecturer up to 1938. At Leipzig, she cooperated gratuitously in the experiments on nuclear fission, and she has been the first person who *"realized by appraisal of the experimental results, that an urane machine is possible"*.[25]

From Eastern Germany, DÖPEL wrote on 28 December 1966 to HEISENBERG: "*Nowadays, here in the GDR nobody knows anymore, that then such results were achieved."* In-between, the priorities became clarified without ambiguity, but even now they are often presented wrong or reduced. A statement in the epilog of a book from 1967 [29c][26] has contributed mainly to clarification:

"Indeed, the Germans were the first physicists in the world, with their Leipzig pile L-IV, to achieve positive neutron production, in the first half of 1942."

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[24] Letter of 7 March1976 from DÖPEL to ELISABETH HEISENBERG.

[25] Statement of DÖPEL, reported in [29] about the works at Leipzig. There they continued also work [29b] from Wurzburg, that contains an early and important contribution to analytics by neutron activation.

[26] The second title with the *German atomic bomb* is misleading. As is well known, the attempts to construct nuclear weapons were postponed already in an early stage of the war by the Nazi leaders as illusory for Germany. Only the continuation of the project on energy generation was possible, as HEISENBERG reported to the Minister of Armaments ALBERT SPEER on 4 June 1942 [28], and some days later a corresponding governmental decree has been issued.

In June 1942, DÖPEL's "*Uran-Maschine*" was destroyed by an oxyhydrogen explosion [3c, 3d] which finished the work on this topic at Leipzig [4-C]. This was the first accident that disrupted a nuclear energy assembly (cf. sect. 4.1, especially footn. 96). Already afore, a shift of the main works of HEISENBERG towards the *Kaiser-Wilhelm-Institut für Physik* (KWI) in Berlin was decided. In foresight of personnel policy problems[27], the DÖPELS didn't follow him despite his request, and they retired thereby from the uranium project. The Berlin KWI and its extern branches, despite increased expenditures, didn't succeed in getting a reactor critical. However, this was realized by the FERMI group in December 1942, so that the German advantage was definitively lost.

In the so far most popular biography of WERNER HEISENBERG from DAVID CASSIDY [29a] the statement about "DÖPEL *who was closer to the power source than was the Berlin team*" is misleading[28]. He had been

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[27] In his letter from 1982 (footn. 23) DÖPEL wrote: "*Unfortunately, Mr.* HEISENBERG *also at inevitable staff decisions let not off from the gentleness of his methods, even when their unsuccessfulness could be seen from the outset.*" Planning the relocation to Berlin, he had not involved ERICH BAGGE, a member of the Nazi Party, for the KWI. This however "*had no problem to let his transfer to Berlin be commanded by his Nazi comrades of the Army Ordnance Office*". (The full name from the handwritten letter has been inserted here, as in the letter from BAGGE to C. KLEINT from 5 may 1995 [3b] with unfounded criticism on DÖPEL.) The political atmosphere in the Leipzig Institute at the end of the 1930's has been aptly described by another PhD student [29e].

[28] For the German edition of [29a], this has been translated as: "*...Döpel, der dem Zentrum der Macht näherstand als die Berliner Gruppe, ...* ". - Added in proof: Meanwhile appeared the first part of a larger HEISENBERG biography of HELMUT RECHENBERG [28a]. The second, more important for our considerations part will cover the Nazi and the post-war period and the years in the German Federal Republic. The time from World War II on is

summoned and cautioned by the *Gestapo* after political disputes [4-E]. In a bestseller on nuclear energy from 1956 [29d] he was nevertheless explicitly called *"Nazi"*. This insult was banned for later editions, but that changed little in the spread of this insult, especially in the English language area.

In April 1945, a few days before the U.S. invasion, KLARA DÖPEL was killed in an air raid in Leipzig while her husband made a short visit with his parents in Thuringia.

In the Soviet Union

In August 1945 DÖPEL went to Russia[29] where he had to work in a Research Institute near Moscow on the production of heavy water together with other German scientists. It is said, however, "that he could hardly work, mentally destabilized by the death of his wife" [4-E]. Probably he has been removed already in 1948 from the Soviet nuclear program.

Of course he was only allowed to comment on his work without telling details. But overlooking the fragile *"balance of horror"* with mutual assured destruction of the blocs he uttered to see himself on the weaker - as the right - side, corresponding to all his nature. M. HÖTZEL[4-E] wrote further: *"Since* DÖPEL *refused selfish ownership and consumerism he must have felt comfortable among Russian people."* In connection with a letter

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covered by the book of the American science historian CATHRYN CARSON from Berkeley [28b].

[29] In anticipation of East-West alternative to work after a lost war, soon after the war began DÖPEL decided for the East, as WILHELM HANLE reported [32]. Both were still lifelong friends. Against this background, the TH Ilmenau 1990 awarded a honorary doctor title to HANLE, which is known by the effect named after him.

from 1981, H. WADEWITZ [4-B] reported from a conversation with DÖPEL, that *"his decision to go to the Soviet Union in 1945 was encouraged by the fact that Russian assistants had supported idigging up the corpse of his wife after the air attack on the Leipzig Institute".*

Werner Heisenberg sent him at first opportunity a solicitous letter[30] to Russia. After memories of the domestic meetings of the two couples, he wrote:

"Your decision to go to Russia seems after all what we have previously discussed human understandable and logical, and You'll probably just think the same way about the fact that we sit here in Göttingen." [The following text was made illegible by the soviet censorship.]

In 1980 DÖPEL wrote to Mainz (Western Germany) to FRITZ STRASSMANN, the co-discoverer of nuclear fission: *"I don't know whether productivity of socialist systems will reach ever that of capitalism; but I believe that no system where selfishness of the individual, private groups freely can affect, will meet the future problems in the coming century. Of course must also all organizations which want to build a new society learn much that socialism and communism are not the same."* [31]

From 1952 until '57 DÖPEL worked as professor of experimental physics at the university in Voronezh. Here he married his second wife Zinaida, Ukrainian and widow of an officer, who was victim of World War II. As he said later, perhaps they would still be there if the

[30] Posted on the 22.10.1946 and printed as a supplement to the letter to H.. RECHENBERG of the 2.8.1982 [4-F].

[31] A copy of this letter is since 2008 in the archive of the *Technische Universität Ilmenau.* – In [3], DÖPEL hoped for a *"lasting harmonious solution".* After the Prague Spring of 1968, he supported the smashed Czech *"socialism with a human face"* –of course in individual talks merely.

promised construction of laboratories for nuclear physics would not have been delayed. Such laboratories were promised him later by the German *Hochschule für Elektrotechnik Ilmenau*. Although this has not been met, he refused 1959 a renewed call to Voronezh regarding his age of 64.

The Years in Ilmenau

The promise of a nuclear engineering education and research in Ilmenau given to DÖPEL is called mostly thoughtless and he himself gullible, because he relied too much on it [4-E]. But still in October 1957 a Minister signed the application on his appointment for the subject *"Experimental Nuclear Physics"* [30]. Only in December, when he had already started his work, the *"off"* came from the *Secretary of State for Higher Education*. This included the extensive nuclear engineering projects planned with the government before the contacts with DÖPEL. The main reasons for the fights that resulted were so due to East Berlin Government problems.

But also a decision of the University Senate to extend DÖPEL's period of service until 1963 according to the previous minimum commitment was not met. This resulted in renewed, violent conflicts[32].

Finally, he received further but reduced job opportunities at the Institute because otherwise care for his five PhD students was not possible. He did experiments until 1975 although his vision had greatly declined. Because he payed a lab assistant out of pocket he was accused to show "capitalist airs" by the communist university management. He

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[32] This is shown, for example, by a DÖPEL letter of 26.9.1962 [4-F]. In spite of the report of a special commission that confirmed his view the Senate had declared the matter as completed on the 11.9.1962.

wrote this to the Minister of higher education still in 1981 in thanks for the congratulations to his 85. birthday [4-E][33].

His research at Ilmenau was again the physics of gas discharges which even earlier was a *"second pillar"* for him and that now experienced a renaissance [4-D]. From here he sought - as before from nuclear physics - the connection to astrophysics where he also made himself a name [32, 4-D].

His creativity and the love he felt for scientific work still in old age[34] were fascinating and charismatic. Moreover he had great human richness as well as broad intellectual and cultural interests, see the last section 4.2. - He died in 1982 on the day before his 88. birthday in Ilmenau.

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[33] Here one has to object to the incrimination that DÖPEL caused his *"own isolation"* [4-E]. It came from the communist party whose secretary had requested his exclusion from the faculty and caused his resignation (and the resignation as Vice Dean). His opposition against the politically motivated removal of students from the school also played a role. - WILHELM HANLE (see footnote [fn: in foresight the]) aptly described his friend as a *"Gerechtigkeitsfanatiker"* (fanatic for justness). This trait and his *"openness irrespective of the person"* have earned him many difficulties to his disappointment [54].

[34] In the letter of 26.9.1962 [4-F], at the age of 67, he stated for spectral analysis: *"A spectrum is for me not only a physical document, but in addition almost something like a kind of music."* And 1968 he wrote on his former Ph. D. student J. KLEIN [54] about his *"small group of unsettled natures... on a bank of the boundless sea of the unknown": "What satisfies them and moves, this is an eternal longing for new insight; it gives them wings and strength and joy and it is the real meaning of their life. Well, now you will possibly laugh over the old romantic ... ."*

In 1995 a memorial to the 100th return of DÖPEL's birthday[35] with the Rector DAGMAR SCHIPANSKI at the redesigned tomb on the Ilmenau cemetery and a lecture event at the University took place. After CHRISTOPH SCHNITTLER's speech as the *spiritus rector* of the memorial, two lectures were given by authors from Leipzig about themes of their papers [4-C] and [4-E].

In the next section, DÖPEL's considerations to the climate problem and also to energy policy are reflected. The politically especially important nuclear energy, in that the nuclear physicist DÖPEL had share very early, is treated separately in section 4.1, and in the last section 4.2 we come back to his personality in relation to cultural aspects.

3.2 DÖPEL's Model Calculations and their Update

First, the geophysical balance model from the manual article [6] used by DÖPEL is presented with updated parameters, as it is needed in the next section.

In the radiation balance Earth/space, averaged globally and over time, the incoming solar radiation is energetically equal to the reflected and scattered radiation by Earth with its atmosphere plus long wave radiation emitted into space (preferably by higher atmospheric layers) [9]. The latter can be calculated approximately with the STEFAN-BOLTZMANN law for a black body, corresponding to a layer with the

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[35] Reports on the ceremony and its preparation are available in the *Ilmenau University News* (IUN) **39** Nr.1/1996 and **38** Nr.4/1995 are available: http://zs.thulb.uni-jena.de/receive/jportal_jparticle_00140315 and http://zs.thulb.uni-jena.de/receive/jportal_jparticle_00139142 .

effective radiation temperature T_e. That provides the left side of the energy balance equation:

$$\sigma \, T_e^4 = (1 - A) \, l_o/4 \qquad (1)$$

$\sigma = 5.67 \cdot 10^{-8}\ Wm^{-2}K^{-4}$: STEFAN-BOLTZMANN-Constant.

T_e = 255 K : Effective balance temperature of a fictitious, acting as black emitter atmosphere layer.

A = 0.30 : Planetary reflectance coefficient, according to a planetary albedo of 30%.

$l_o = 1\,367\ W\ m^{-2}$: Solar "Constant".

The WMO (World Meteorological Organization) agreed in 1982 to this reference value. It matches well with more recent measurements of radiation flux density, which was thought to be constant at the upper edge of the atmosphere [9] and describes the intensity of the solar radiation in the middle distance of the earth.

In the denominator of the right side of the first equation, 4 is due to the conversion of the cross section area of Earth into the surface of the globe. The additive contribution of anthropogenic heat release is neglected here.

For the effective equilibrium temperature 255 K or $-18°C$ result using this radiation balance model. DÖPEL used 250 K from the Handbook of Physics [6], corresponding to a higher albedo A = 0.35. This temperature for the black emitter is attributed empirically to a height of approximately 6 km, that *"one can accept as medium ceiling of clouds"*.

This attribution is problematic however because of greenhouse gases that are effective mainly in the cloud gaps, and it is not necessary.

Instead, the upper limit of the troposphere that is on average 11 km [9], is essential for newer representations relating to the concept of forcing (section 3.3). Up to this limit, the tropopause, the average temperature decreases to 218 K . Then it remains constant within the stratosphere for some kilometers, and starts growing above. This inversion is a significant limit on the weather. Its intricate details are totally neglected in the radiation balance.

The medium temperature difference between the air at the earth's surface with a mean temperature of 15°C and the fictive layer acting as a black emitter is [15+18] K = 33 K (vs. DÖPEL's [15+23] K = 38 K . It is due to the greenhouse effect.

As easily as the radiation balance approach is DÖPEL's set-up for assessing the impact of anthropogenic heat release F_w to the effective temperature T_e. He assumes F_w to grow exponentially with an annual enhancement coefficient q (corresponding to 100 (q - 1) % p.a.). With the starting value $F_{w,o}$, after $\Delta t = t - t_o$ years results

$$F_w = F_{w,o} \exp\left([q-1] \cdot \frac{\Delta t}{a}\right) = F_{w,o} \cdot q^{\Delta t/a} \quad (2)$$

For the second part of the equation, $ln\, q \approx q - 1$ has been used. The net solar radiation flux density to the earth is the right hand side of eq. (1) or

$$l_s = 239 \frac{W}{m^2}. \qquad (3)$$

After the time Δt is the effective temperature becomes

$$T_{e,t} = T_e \left(\frac{l_s + F_{w,o} \cdot q^{\Delta t/a}}{l_s}\right)^{1/4} \qquad (4)$$

DÖPEL used $F_{w,o}$ = 0.016 W/m² for his first year 1970. It has been neglected in the denominator t versus l_S.

Actualizations

For the updated calculation $F_{w,o}$ = 0.023 W/m² for the first year 2000 is used instead. This results from detailed tabular representation of the German Advisory Council on Global Change (WBGU). Of the entire waste heat given there[36], 13% for renewable energy were subtracted which come from the sunlight and contribute nothing to net warming. With the binomial approximation it is:

$$\Delta T_e = T_{e,t} - T_e = T_e \frac{F_{w,o}}{4 \cdot l_s} q^{\Delta t/a} \qquad (5)$$

$$= \frac{T_e}{4 \cdot l_s} F_w = 0.27\, F_w \frac{K\, m^2}{W} \qquad (6)$$

This is direct proportionality between temperature increase and the current F_w with the factor

$$\lambda_e = 0.27 \frac{K\, m^2}{W}. \qquad (7)$$

Eq. (6) can be considered as an application of the forcing approach[37], which in a generalized manner is the subject of section 3.3 (eq. 12).

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[36] Tab. 4.4-1 in the WBGU report 2003: *World in Transition – Towards Sustainable Energy Systems*. Earthscan London 2003 and: http://www.wbgu.de/en/home .

[37] By differentiating eq. (1) with respect to T_e and equalizing the derivative to the difference quotient, with $\Delta l_s = F_w$ one gets directly eq. (6) and (7).

Terminology and Attribution Problems

Unlike the infrared active greenhouse gases and other influences (section 3.4) which provide a *"radiative forcing"* the waste heat does not directly intervene in the global radiation budget. So it contributes to the "*forcing*" commented in footnote 7 with a *"nonradiative forcing"*. This latter term from the Climate Research Committee within the US National Research Council [5a] is merely mentioned in the IPCC report [2] (section 2.5.1), where it is replaced by *"the similar term 'non-initial radiative effect'"*. Especially on our topic it is stated: *"Anthropogenic heat release is not a radiative forcing, in that it does not directly perturb the radiation budget; the mechanisms are not well identified, and so it is here referred to as a non-initial radiative effect"*.

Furthermore, under the later heading *"Anthropogenic heat release"* (section 2.5.7) the global energy production 0.03 W/m^2 for 1998 is given, similar to the value in footnote 36. Unlike for urban regions, there is little importance awarded on a global scale, without mentioning perspective possibilities[38]. They could still be left aside in 2001 in the 3rd Report [2-2001] with its limited time horizon until 2100. But in the 2007 report AR4 this was not justified anymore, since it regarded the time until the end of our millennium (in other context, see Fig. 2, sect. 3.2).

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[38] Even the actual value of 0.03 W/m^2 is clearly greater than some anthropogenic forcings that have been listed in [2] (table 2.13, with associated fig. 2.21).
This includes the actual contribution of 0.01 W/m^2 delivered by contrails from aircraft that in a summary representation (Fig. SPM.2 in [2]) is included as the smallest radiative forcing. – Arguments for the disregard of actual waste heat contributions to global warming by the IPCC come from our later considerations. They result with eq. (6) and (7) in a lower limit of 0.01 degree that meets also the probable order of magnitude.

As will be shown below, a lower limit for global warming by the waste heat can be estimated that must be recognized prospectively at common growth rates. The estimation works well as a first approximation with the concept of forcing which may break down for (other) *"non-initial radiative effects"*. This breakdown would be a better criterion for speaking of an *effect* rather than of a *forcing*.

In the German summaries (SPMs) of the three AR4 chapters and in the joint glossary [2-2007] these effects (including waste heat) are completely disregarded[39]. This terminological gap reflects the spin-off of *"non-initial radiating effects"* from the forcing by the IPCC. They appear neither in the English index nor in the all-up glossary, and the relevant sections of AR4 contain no mutual references. More attention to these effects and to their quantitative treatment seems to be necessary.

Results until the Year 3000

The section 10.7 of the IPCC report [2] contains model results until the end of our millennium that are compared in Fig. 2 to what the updated DÖPEL model yields.

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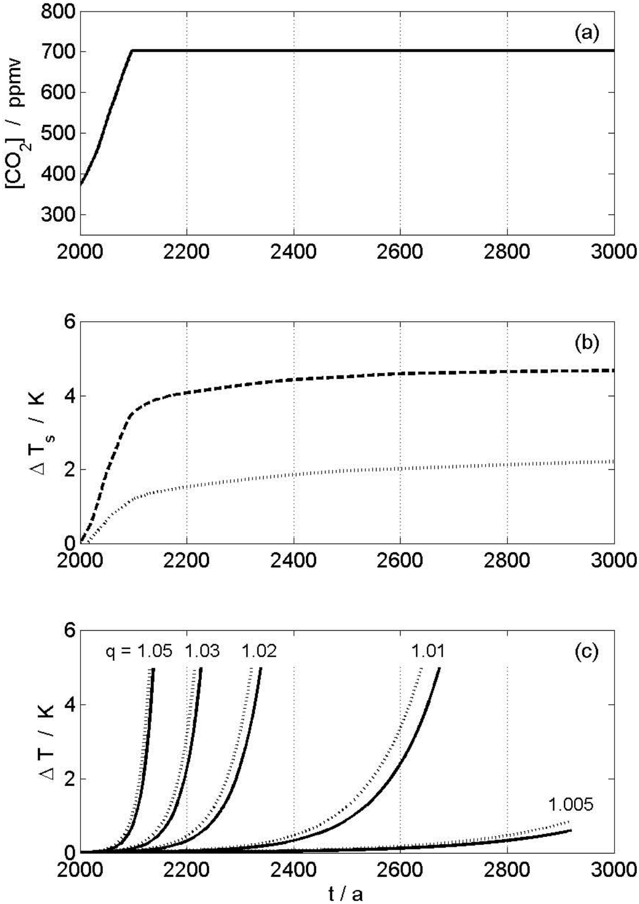
[39] Such effects (e.g. diffusion, or cooling by evaporation) are discussed in a German *"learning server"* http://wiki.bildungsserver.de/klimawandel/index.php/Strahlungsantrieb , but no translation for the English term is offered. – In the German version of this 2nd edition (footnote 1), more is said about translation problems, whereas here the general terminological aspects are accentuated.



(a)
[CO2] / ppmv
(b)
Δ Ts / K
(c)
q = 1.05
1.03
1.02
1.01
1.005
Δ T / K
t / a

Fig. 2

(a) Atmospheric CO2 concentration in dependence of time (based on data from Fig. 10.34a in [2]). Until the year 2100 it corresponds to an emission scenario of type A1B [30] with the concentration of 700 ppmv which is thereafter maintained fictitiously.

(b) Global temperature increase ΔT_s at the earths surface due to (a) from two IPCC model calculations of 2007 to the greenhouse effect:
dashed = Model CLIMBER-3\alpha,
dotted = Model LOVECLIM
from [44] and [45] with data in [2], Fig. 10.34b. (There are 6 more between these two curves from the modeling of other authors. The complete fig. 10.34 is given with further comment in the short contribution cited in footnote 9.)

(c) Effects of anthropogenic heat without taking into account the greenhouse effect and without counter measures.
Coat lines: Change $\Delta T = \Delta T_e$ of the effective radiation equilibrium temperature T e earth/space (255 K), newly calculated from eq. (6) with DÖPEL's model. The parameter q is the annual enhancement coefficient q of not renewable energies (corresponding to 100 (q - 1) % per year). DÖPEL considered ΔT_e as the minimum value for the increase ΔT_s in the global surface temperature Ts (288 K) due to waste heat.
Dotted lines: Change $\Delta T = \Delta T_{ob}$ as a more realistic minimum value for the Ts increase ΔT_s that has been estimated according to a "*surface variant*" of DÖPEL's model with eq. (9).

This figure is fundamental for the following sections, too. It contrasts the pure waste heat effect from the bottom part (c) with the IPCC model representations on CO_2 in parts (a) and (b) that would hold without waste heat. These are commented in section 3.4 with general model considerations for the anthropogenic greenhouse effect. The effort for such calculations can only be indicated there since it surpasses by far that for our elementary waste heat calculations.

The coat lines of Fig. 2c show the increase in the effective temperature according to equation (4) or (6), where the mathematical approximations are nearly without influence on the image. Comments on the dotted lines follow in the next subsection *"Feedback Considerations"*.

The difference between the temperature T_e of the fictitious atmosphere layer (that effectively acts as a greenhouse roof) and the floor temperature T_s acts as a driving force for transporting the solar energy absorbed preferably on the ground to the fictitious layer upwards. This temperature difference related to the feedback effects cannot grow at all if the anthropogenic heat is fed additionally to the ground. Therefore, ΔT_e for the increase in temperature at the surface represents a lower limit.

This is crucial for the comparison with statements on the anthropogenic greenhouse effect as they are shown in Fig. 2b, for example. They ignore the waste heat without having mentioned the implied restriction of growth of energy production to vanishingly low values. Due to Fig. 2c this had to be less than 0.5% p.a. and renewable energies could merely adjourn, as it is shown at the end of this section.

The waste heat has been neglected also in newer model calculations on the greenhouse effect until the year 3000, 4000, and 12 000 [44a - d][40]. They use time-dependent concentrations of CO_2 after the year 2100 that are based on very different emission scenarios instead of the constant concentration in Fig. 2a. Its fiction of a far-reaching irreversibility of the atmospheric CO_2 content over centuries and millennia is thereby justified in principle[41].

The permanently exponential growth for Fig. 2 c had to be replaced in optimistic scenarios by the gradual transition to constant energy production postulated by DÖPEL. The logistic function could be used as a fictional analytical expression as usual for population dynamic models[42]. The differences of the temperature trajectories in Fig. 2c to DÖPEL's figure 1 in [3] are small[43]. Between 1970, the first year for DÖPEL's calculations, and 2005 for example in [35] a medium growth of consumption of 2% p.a. is given. Therefore the difference between the course in his fig. 1 and the continuation from the year 2000 in our fig. 2 c for q = 1.02 is particularly small[44].

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[40] With respect to a comparison of waste heat with [44d] see subsection *"Global Stocks …"* in 3.4.

[41] The same applies for corrective statements in [44d] on conditions in the model calculations for fig. 2b.

[42] See for example [14] (section 3.3-3.5) to the more probable limit violation or transgression from [12a].

[43] His two curves for each q value for the temperature (in ℃) coincide in our representation of temperature differences and correspond to the coat curves.

[44] These differences are caused in part by a higher albedo (A = 0.35 instead 0.30 in eq. (1)). But most importantly, DÖPEL's starting value $F_{w,o}$ (from the *Geneva UN Conference of nuclear Energy*) is too high. This results with a 2% growth and comparison with the year 2000 value below eq. (4).

For the remaining q values their difference from the updated 1.02 value between 1970 and 2000 results in slightly larger deviations for the continuations. They remain still well below the influence of the enhancement coefficient q even at its highest values. These were favored in DÖPEL's discussions - according to the high growth rates in the developed countries at that time. Only q = 1.07, which was omitted here, he considered "maybe too ambitious".

At the bottom of the scale, q = 1.005 has been added. In this case the particularly far-reaching linear initial course shows that growth limitations are to be expected at sub-exponential rates, too.

Feedback Considerations

Feedbacks shall be considered in going beyond DÖPEL's determination of a lower limit for global warming by waste heat. He mentioned only the increased evaporation of oceanic water associated with increased albedo of then denser clouds, but he did not take this feedback into account explicitly.

On the other hand, for fig. 2b in the IPCC model calculations all known feedbacks[45] [2] have been included. These mainly cause the large differences in the results of the eight models mentioned in the legend of this figure.

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[45] In the review [38 c] by BONY, the *"PLANCK response"* described in the simplest case by our eq. (1) is called in an appendix *"the most fundamental feedback in the climate system"*. Even though SANDRINE BONY was a *"Lead Author"* for the relevant chapter 8 of [2], this attribution to feedback was not adopted there (especially in footnote 6) and generally in the literature. See also our sections 3.3 and 3.4 in context with eq. (14) and tab. 3.

Similar in size are the differences between values of the temperature rise in fictive concentration doubling compared with pre-industrial in the IPCC report [2] from a far larger number of model calculations. This *"Climate Sensitivity"* is further considered in section 3.4, where *"equilibrium"* values are given in column 2 of table 3. Without any feedback it amounts to 1.0^o in the simplest case, and the actual value gives the feedback factor as a measure for the feedback influence. This rough estimation includes a changeover from the effective temperature T_e of atmospheric radiation balance to the surface temperature T_s.

A factor 1.5 was used for a so-called surface variant of the DÖPEL model[46] to calculate the dotted curves in fig. 2c as ΔT_{ob}. This corresponds to the *"very likely"* lower limit of the *"Climate Sensitivity"* and shall give a vague idea of the lower limit for ΔT_s. With

$$\frac{\lambda_{ob}}{\lambda_e} = 1.5 \qquad (8)$$

results analogous to eq. (6):

$$\Delta T_{ob} = 1.5 \cdot \Delta T_e = 0.41\ F_w \frac{K\,m^2}{W} \qquad (9)$$

$$\text{and} \qquad \lambda_{ob} = 0.41 \frac{K\,m^2}{W}\,. \qquad (10)$$

The small differences of the calculated dotted curves compared to the drawn through curves in fig. 2c demonstrate that changes in the pre

[46] The forcing is unchanged in this variant. It has nothing to do with a *"surface forcing"* that is used sometimes (preferable for aerosols) in addition to the radiative forcing in the IPCC reports. Both quantities may vary with time opposite to each other ([2], Fig. 2.23).

exponential factor have relatively little impact as long as one keeps waste heat growing exponentially. It has to be noted, however, that the feedback factors from section 3.4 of the substance specific anthropogenic greenhouse effect of CO_2 were calculated. This involves e.g. the material transfer between atmosphere and hydrosphere (sect. 3.4), while here only the heat transfer has to be taken into account.

On the other hand there are older feedback calculations for fictive variations of the solar constant or an unknown *"ghost forcing"* [38a]. They provided comparable factors such as the greenhouse effect, but are not substance-specific such as the waste heat[47].

The increase in the surface temperature is therefore in Fig. 2 c not only above the coat ΔT_e corresponding to DÖPEL but very likely also above the dotted ΔT_{ob} surface variant, but significantly less than an order of magnitude . The latter is suggested by the feedback factor 3 for the *"best estimate"* as the doubled 1.5 for the *"very likely"* lower limit of the climate sensitivity in table 3.

A much earlier heat-related temperature rise than for the ΔT_{ob} courses is therefore not expected. This is the message of our rather complicated and uncertain feedback comments. More complex feedback calculations for the waste heat influence alone would be hardly worth the effort. A common calculation with the anthropogenic greenhouse

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[47] This also applies to earlier estimates of (not substance specific) feedback factors to the greenhouse effect that only consider the atmospheric water vapor pressure and the melting of ice, increasing with temperature. For example, in [7] factors are specified with an "*uncertainty interval*" of 1.2 to 4, while [33] uses a factor 2 (in the mathematical annex 4). The corresponding actual interval from tab. 3 in section 3.4 is between 1.5 and 4.5 [2]. – In our 1st edition (from footn. 2), the factor 1.5 for Fig. 1c was primarily deduced from another uncertain source without lower or upper limits.

effect which this influence in reality would overlap will be wait. This results also from the above mentioned restraint of the last IPCC report [2007] on this topic. However, its treatment by the institutions equipped with large computer technology seems not a fundamental problem. The relation between emission and temperature effect is certainly more straightforward for waste heat than for the greenhouse gases and especially for CO_2 with its complex coupling to the terrestrial and the marine carbon cycle (sect. 3.4).

Prospects for Energy Production and Population Growth

Today's growth forecasts for the energy production (with varying percentages of not renewable energies) until the middle of the 20th century group around 2% per year[48]. Thus, a further doubling arises with the approximate equation for the doubling time of exponential growth

$$\frac{t_{dop}}{a} = \frac{\ln 2}{q-1} \approx \frac{70}{2} = 35$$

until 2040. In the 2003 report of the German Advisory Council on Global Change from footnote 36 it is even forecasted to triple by 2050, according to nearly 3% growth p.a. But the forecast of the *World Energy Council* [35] corresponds to an increase of 1.4% p.a., and in the commentary on a *"Total Concept for Energy Economics 2030"* from 2008 [36] an increase *"until the middle of this century by more than two-thirds of the current state"* is assumed, which means abundant 1% p.a.

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[48] This value can be found for the period until 2050 in table TS-3 from [34] for scenarios of type A1B, which applies to Fig. 2a. Thereafter (until 2100) slightly declining values are used.

This increase has to be seen in the light of the world's population growth. It increases from currently about 7 billion after a medium-sized UN scenario [36a] to around 9 billion in the middle of our century. Then it iterates through a flat maximum, to increase again after an also flat minimum (to almost 9 billion in 2300) [36b]. The current leading industrialized countries contribute less and less to the growth of global energy and the world's population while the current emerging economies already establish the majority. The latter are summarized together with the *"least developed"* to the *"less developed countries",* which are faced to the current industrialized as the "*more developed countries*" [36a]. These groups and labels are still preserved in the more distant future[49]. Essentially they agree with the *"Annex 1"* and *"Non Annex 1 parties"* of the UNFCCC [13c].

A significant difference between the two is already achieved with respect to the demographic transition, i.e. a slowed population growth with following entrance on a plateau or maximum [14]. In the more developed countries this has already happened in the two last centuries, while in less developed countries the process started not earlier than in the previous century and will continue at least until the middle of our century. The living standards increased in the more developed countries, which is called the demographic-economic paradox compared to the original demographic theory [36 c].

[49] That is also problematic due to increasing migration flows, as they are to expect from the less developed to the more developed regions in consequence of climate changes and of the economic wealth gap.

Regarding the possibilities for continuing this phenomenon follow information and estimates of per-capita consumption of energy[50] for 2005 and 2050 [32, 36a] in the more developed and less developed countries (**megawatt hours per year**):

Table 1:

	more developed countries	**less developed countries**
2005	64	10
2050	72	16

Despite the projected growth of the world's population by 150%, which mainly takes place in the less developed countries, per-capita energy consumption grows there approximately to the same extent.

It achieves by 2050 only 1/4 of the value of the more developed countries[51] by 2005. Even if the accompanying raise of living standards should be enough to start the demographic transition there would still be a considerable need to catch up, if less developed countries insisted on the same standards as the more developed countries. That the global performance of such claims would lead to a global collapse, knowing at the least since the first report to the Club of Rome [11].

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50 As in the global forecast used above, again the primary energies from [35] are used that include losses in producing the final energy for the consumer from the primary energy.

51 Among these, the USA with an average 93 MWh/a rank high while Germany is in the lower midfield of the "developed" countries. The other extreme are "Least developed countries" as Haiti with less than 3 MWh/a: http://www.worldenergy.org/publications/Energy_Policy_Scenarios_to_2050/default.asp. The global average is 20 MWh.

The level of economic growth is still used as an indicator of successful policy [36d] because it positively affects unemployment and seems to be essential for social peace. But there are clear signs that the growth of the economy and of energy production are decoupling[52] in the more developed countries [36f]. Together with other environmentally harmful influences this was investigated in a Swiss study for some European countries, Japan and the United States [36e]. The comparison shows the lowest decoupling progress in Switzerland. That is linked among others to their early, extensive use of opportunities to save energy, which probably encountered limits[53].

Speculation about how the nuclear fusion technology affects the growth of energy production after the mid-century are covered in section 4.1. If it can be realized all possibilities of the DÖPEL growth scenarios are open.

Global Resources for Sustainable Energies

"Most intense technical exploitation of irradiated solar energy": With these words DÖPEL captioned his section 5.3, treating only the photovoltaic production of electrical energy. He recognized their efficiency with a maximum of 20% that should be exceeded in the future. The usable part of the mainland area, 30% of the globe, he estimates to be 10%, which seems quite ambitious.

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[52] For example, the less developed China specifically strives this decoupling by increasing energy efficiency. Incidentally, its double-digit percentage growth cannot prevent an unemployment rate by 10% (http://socio.ch/internat/t_reiser.htm , 2008).

[53] For Germany refers are mentioned to special features, related to the reunification. For example, per-capita energy consumption was 125% of the Federal Republic of Germany value in East Germany last [37a].

With this result[54] $5 \cdot 10^{14}\, W$ are achieved, a half order of magnitude more than the latest IPCC assessment of 10^{14} W ([2-2007] WG III, table 4.2)[55]. The utilization coefficient for the whole irradiated solar energy is then

$$\mathrm{K} = 0.2 \cdot 0.3 \cdot 0.1 = 6 \cdot 10^{-3} \,.$$

By inserting in eq. (2) it results:

$$\frac{\mathrm{F_w}}{\mathrm{l_o}} = \frac{\mathrm{F_{w,o}}}{\mathrm{l_o}}\, \mathrm{q}^{\Delta \mathrm{t_k}/\mathrm{a}} = 0.75 \cdot 10^{-3} \qquad (11)$$

with the global energy demand $\mathrm{F_w}$ and its seed $\mathrm{F_{wo}}$. The global temperature would remain constant if photovoltaic electricity is used exclusively until this value is reached. But then a further growth of energy demand must be covered from other sources.

If these additional contributions $\mathrm{F_{wz}}$ would be unsustainable, minimum temperatures would rise again after the time $\Delta \mathrm{t_k}$ according to eq. (5) or (9), but with $\mathrm{F_{wz}}$ instead of $\mathrm{F_w}$. It is used to estimate[56]:

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[54] For the solar radiation arriving at the Earth's surface here half of the radiation in the atmosphere has been inserted, as usual today [9]. This is $l_o/8$ = 171 W/m², whereas DÖPEL used (1-A) $l_o/4$ = 225 W/m² in his eq. (3). This value is by a factor of 1.3 greater which is insignificant for further lower estimates.

[55] The specified source is updated each year: http://www.ren21.net with *"Renewables 2010 Global Status Report"* and further links, also for discussions of the IPCC assessment report. For more general considerations see [36 g].

[56] In the short English version (online) from footnote [fn: global warming by] is a correction need expression to substitution by GL. (11a). The resulting approximations for Δt_k remains however unchanged.

$$\frac{\Delta t_k}{a} = (\ln q)^{-1} \ln \frac{0.75 \cdot 10^{-3}\, l_o}{F_{w,o}} \approx \frac{4}{q-1} \quad (11a)$$

Resulting value pairs are, for example:

Table 2:

q	$\boldsymbol{\Delta t_k / a}$
1.05	80
1.02	200
1.01	400
1.005	800

The (rounded) times of constant temperature Δt_k shall apply also from the year 2000 chosen for Fig. 2c as a start[57]. Would these periods non-regenerative rather than the solar energy uses, the increase ΔT_{ob} would become less than 0.5℃ . The corresponding stated DÖPEL for ΔT_e , and with his starting value $F_{w,o}$ for 1970 similar times Δt_k arose as above. Having in mind much longer spaces in time than our actual debate on climate, he says that *"also the most intense exploitation of solar energy changes practically nothing in the state of affairs"*. More general, his conclusion in the summary is:

"The only way to prevent that threatening increase of temperature lies in a global, gradual transition to the complete constancy of total energy production".

[57] Each further bisection of annual percentage growth increases Δt_k about to double (due to $\ln q \approx q - 1$).

Referred to as zero growth - that has been extended to the entire economic growth - this conclusion[58] temporarily entered some Green party platforms during the nineteen eighties in Western Europe. A politically correct name from economics for the lack of growth is stagnation. This will probably not be called for, but can only be endured, as well as a shrinking economy. Indeed even the authors of the Club of Rome [11, 12] distinguished between different types of growth, and they knew how to defend themselves against the accusation of *"Doomsday Prophecies"* [12, 12a].

With the economic developments that occurred since then accompanied by the advent of parliamentary democracy in parts of Eastern Europe, new possibilities arose. The leading region in Europe in photovoltaics is the *"Solar Valley"* in an East German region that previously caused highest pollution[59]. New technical aspects have opened up on everyone's lips are present. Again under the motto *"Exploitation of solar energy"* electricity generation by solar thermal power plants shall be mentioned here, which has technically been possible for decades but only starts now [60]. Within the "Sun belt of the Earth"

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[58] Among the striving for unbroken growth East German regime, which wanted to overtake the West such conclusions were very suspect. The zero growth was called an *"utopian reactionary political conclusion"* [37] and DÖPEL's publication [3] considered irresponsible in the management of the Institute of Technology Ilmenau.

[59] It covers formerly highly industrialized parts of Saxony, Thuringia and Saxony-Anhalt <http://www.solarvalley.org> which do not form a *valley*, but share the hope of *"flourishing landscapes"* as they were announced to the acceding territory of 1990.

[60] Already in 1992 by the competent "Enquete Commission" of the German Bundestag [23] the *"in almost 20 years research and development has been achieved"* referenced and strongly recommended a thermal power plant patterns in a

similar efficiencies as with photovoltaics are reachable, the techniques are also combined. The solar thermal ability to save daytime heat, which can be released if necessary has advantages. - Especially in the Mediterranean region, great opportunities are possible with the DESERTEC power project[61].

Considering the comparison made above, DÖPEL's estimate of solar resources is smaller than those in table 4.2 from [2-2007] WG III by a factor of 1/5. In this range are the other renewable energy resources registered in the table - except of geothermics, having the triple value of solar energy. It is however important to distinguish between the shallow geothermal energy, used exclusively for heating by a heat pump, and deep geothermal energy. Only the latter can contribute significantly to the global energy production. It has to be taken into account in the anthropogenic heat[62], whereas shallow geothermal energy belongs to the sustainable sources.

Thus we remain within the rough but yet internationally agreed estimates of the IPCC table in [2-2007] for all sustainable energy

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southern partner country. Such power plants are now created and one hopes for early economic competitiveness.

[61] For supply of Europe, the Middle East and North Africa: http://www.desertec.org/en/concept . Apart from political difficulties, for Europe the energy transfer over long distances by *High Voltage Direct Current (HVDC)* is a challenging problem.

[62] It comes from 400 meters depth at least (according to the glossary in [36 g]). This source of energy can be described as *"almost renewable"*. - The radioactivity of earth crust contributes to global warming as little as the so-called residual heat from the earth creation. Its insignificance in the natural heat flux DÖPEL [3] noted in a footnote to his global radiation balance equation (1). Thus the terrestrial heat flow as a whole is negligible, including the contribution of geysers.

specified in the table after eq. (11a) times as a ceiling. At the latest from then on energy that provides waste heat would be needed again.

For clarification it is specified that the calculated ceiling almost would be halved in the case of 2% p.a. growth of the use of sustainable energies, if per-capita consumption worldwide would adopt the value of the United States given in footnote 51 . The children of children living today could still experience this limit.

In 2009, the *"Plan to Solve the Climate Crisis"* [56a] by Al Gore[63] again offered many important arguments against the climate change deniers, but it is still focused on growth. Especially, it reflects the widespread belief in future availability of *"virtually unlimited amounts of electricity from solar, wind and geothermal generators..."* as he writes in a concluding vision[64]. Should however the current global per-capita consumption become placed to his own height, so something more than the $5 \cdot 10^{14}$ W of sustainable energy would be needed, that have been estimated ahead of eq. (11) as a whole on Earth. Not only the worldwide acquisition of living standards of developed countries and especially of the today's ruling class, but also a corresponding consumption of only sustainable energy thus leads to absurd consequences.

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[63] In 2008 AL GORE urged his country to cover the complete electricity from renewable energy sources within 10 years: http://www.algore2008.com . Referring to this vision, a University study 2009 appeared in California [56c], whereby the entire energy need on earth could be covered by renewable energies (including geothermics) within 20 years.

[64] Asked on energy consumption in his family that is clearly more than an order of magnitude over the US per capita average from footnote 51, Gore referred to his extensive promotion of sustainable energies - without a deny of his own consumption [56b].

Apart from the occasional mention of current insignificance[65], no quantitative treatment of the waste heat was found in the recent literature. One must probably assume that the publication [3] in a small scientific newspaper, but from a renowned physician - as well as relevant forecasts and warnings in more accessible papers from the nineteen seventies (sect. 2) - is largely forgotten. The heat influence that is possible medium to long term is currently ignored, but the requisite growth limitations for energy production forecasts are not named. In Germany and other industrialized countries, where the permanent disposal of nuclear waste is questioned by the demand for security up to 10^6 years, this is not possible to understand. Anyway, the possible medium to long term waste heat influence in relevant forecasts should be named if not the growth limits that are requisite for it to be neglected become specified.

Computer simulations of global warming (with fig. 2b as an example) concern so far only the anthropogenic greenhouse effect which is far more urgent to combat. It is included, limited to the essential aspects

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[65] Examples are [2, 25] , and a FAQ *"Is waste heat produced by human activities important for the climate?"* with the answer *"No."* from <http://www.mpimet.mpg.de> (see footn. 21). In another FAQ "*What role do condensation trails play in our climate?",* this effect with its even smaller actual forcing (footn. 38) *"cannot be ruled out as being a future player in climate change".* The unbalance in these two answers corresponds to the IPCC presentation [2], chapter 2. - In the *"introductory guide to climate change"* [25c], airplane effects are also discussed with their uncertainties, whereas the waste heat is not mentioned at all.

concerning such modeling in section 3.4. Previously, in 3.3 common conceptual issues are discussed.

3.3 The Concept of Forcing and the Sun

Forcing reconsidered

When the equality between the solar radiation of the Earth's atmosphere and the emitted infrared temperature radiation (described by eq. (1)) is disturbed, the difference of radiation flux densities acts as *"start driver"* or forcing for the reinstatement of radiative balance. The driving force decreases during this process to zero while the initial value is always given for the forcing.

Following a *"standard definition"* (in [2, 38]) the forcing is generally given by the net radiation flux density into the troposphere at its upper limit, the tropopause. As described above by eq. (2), a temperature minimum with an overlying *"inversion cover"* is given in this border area for the weather. This is a relatively well defined situation. Moreover, the thermal equilibrium setting in the stratosphere[66] and above is much faster than in the troposphere.

Its greater thermal inertia is mainly due to the coupling to the oceans. Without this coupling, less than a month would result for the tropospheric balance setting. But involving the upper it takes years to decades and with the deep ocean and ice sheet centuries to millennia (according to [2], box TS. 9).

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[66] The forcing F that thereby results is also called *stratospheric adjusted forcing* (F_a in [38] fig. 2; see also [2] fig. 2.2). It is a little different from the original *instantaneous forcing* (F_i) neither used here nor further variants from these sources.

For the forcing F applies the fiction of an unchanged temperature gradient within the troposphere. As a thought experiment all processes are in thermal equilibrium, their respective forcings add to F. This increases the temperature of the earth's surface to

$$\Delta T_s = \lambda \cdot F \qquad (12)$$

as the *response* in this *forcing-response relationship*. λ is the (climate) sensitivity parameter[67] and represents the global average annual temperature due to a change of the forcing by one unit.

Of course, the concept of forcing is not strict at all. For example, it can be softened by a time dependence of λ (see sect. 3.4) or by deviations from the proportionality between response and forcing [38]. But it is widely accepted at least as a first approximation, and it is entirely sufficient for a rough treatment of waste heat effects.

The case with $\lambda = \lambda_e$ from eq. (7), but ΔT_s instead ΔT_e from eq. (6), results without any feedback [38b] and is called the simple form of the *"Planck response"* on the black body radiation[68] in [38 c] (see our

[67] Not to be confused with the *climate sensitivity* as a special CO_2 forcing from section 3.4. Unlike our terminology from the glossary in Appendix I of [2] this is called e.g. in [7] climate sensitivity *parameter*, whereas in [38] conversely λ as *climate sensitivity* is being declared. The dimension clarifies here. (See the footnote that follows, too.)

[68] The parameter given there and in footnote 6 of chapter 8 in [2] is $\lambda_P = -1/\lambda_e$. Corresponding to the glossar in Annex I of [2], it is a Climate Feedback Parameter (see our footnote 43) with the general symbol Λ (units $m^{-2}K^{-1}$) , whereas the lowercase λ (with inverse units) is used for the Climate Sensitivity Parameter here as mostly in the literature (and in [2] page 133, for example).
Such formal disparities - even within the IPCC report [2] - complicate the clarification of factual issues related to climate sensitivity (sect. 3.4).

footnote 45). This form is applicable if the forcing *"does not notably alter the vertical temperature structure",* e.g. for solar flux and surface albedo influences, *"but does not work simply for CO_2"* [38b], where somewhat larger λ values are used (sect. 3.4, table 3).

A not delayed setting of radiation balance with the current forcing F is thereby assumed. Such a *"change at permanent equilibrium"* (precisely: *steady-state at quasi stationarity* [14]) was assumed for our *"surface variant"* estimation with eq. (9) and (10) when $= \lambda_{ob}$.

The Sun

For the natural change of solar radiation flux density from eq. (3) to a forcing F_{sol} applies without feedback [38b]:

$$\Delta T_s = \Delta T_e = 0.27\, F_{sol}\,. \qquad (13)$$

For the 11-year cycles of sun spots with a difference of 0.08% from maximum to minimum radiation flux density [2], according to a $\Delta T_{sol}^{cyc} = 0.2\, W/m^2$, results without feedback:

$$\Delta T_{sol}^{cyc} = 0.05\ °C\,. \qquad (14)$$

The same scale (between 0.02 and 0.08 degrees) results from this trial also for the contribution to the increase in global temperature since 1750, which is still poorly understood [2]. Uncertainty exists also with regard to secondary effects such as a modified number of nuclei for the cloud droplet formation by variation of the cosmic radiation as a result of the earth's magnetic field modulation. Thereby it holds, however [25]:

"During the strongest warming over the past 25 years, the Sun has not contributed".

The opposite is announced in [39] by a meteorologist with judicial attitude, whereupon carbon dioxide becomes "acquitted". In contrast to this, the *Max Planck Institute for Solar System Research* states in a press release *"that the Sun is not the cause of the present global warming",* whereas the earlier influences *"must still be investigated"* [40]. – It has been observed *"that the Sun is currently in the longest and deepest sleep phase for almost a century".* Even if this phase continues until the end of the 21st century, no significant reduction of the temperature rise (by more than 10%) is expected, calculated for continuingly increasing greenhouse gas emissions until then [40a][69].

Because of the uncertainties in the solar forcing (as a reference magnitude used in earlier publications), it has been replaced e.g. in [38] by the better understood CO_2 with the greatest anthropogenic forcing. It is preferred also by the IPCC and discussed in the next section.

3.4 Inclusion of the Anthropogenic Greenhouse Effect

In view of the very extensive documents about the causes and consequences of current global warming can this section only give background information on fig. 2a and b (sect. 3.2) as well as general comparisons. Possibly they are useful because some gaps between technical and popular "greenhouse literature" and climatology and "simple physics" [25a]. Uncertain influences and facts that are particularly stressed in current research presentations are taken into account here not (explicitly).

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[69] Anyhow, the growth reduction calculated for a "*sleeping Sun*" up to 0.3 degrees is not negligible with regard to the "*2-degree target*" discussed in a subsection of 3.4.

About IPCC Reports

The particularly important for this section IPCC reports [2] are extremely extent with four-digit page numbers. That is due striving for consensus and lower voidability of presentations, also from outside science. However, the strict *Principles Governing IPCC Work*[70] are as a result, hardly consistently meet.

An especially view example for the media was the forecast of the disappearance of the Himalayan glaciers in three decades after [2-2007] with a self-criticism by 2010[71]. Although the (foreseeable) falsification is an isolated incident, this brought serious losses of trust. Reform considerations to avoid such breakdowns and more general problems followed. The UN Secretary-General entrusted in march 2010 the international umbrella organization of science academies (IAC) as an independent supervisory board with the IPCC consulting. First results of this cooperation have been published[72].

Greenhouse Gases and their Effects

Forcings from the two previous sections were as additional contributions to the short-wave solar radiation flux density in the radiation balance eq. (1) on the right side to add. In contrast, the forcing resulting from the anthropogenic greenhouse effect is from the

[70] http://www.ipcc.ch/pdf/ipcc-principles/ipcc-principles.pdf with Appendices A - C.

[71] http://www.ipcc.ch/pdf/presentations/himalaya-statement-20january2010.pdf . See also [25b].

[72] http://www.ipcc.ch/news_and_events/press_information.shtml . Here also the preparations for the 5th Assessment Report for 2013/2014 are reported.

long wave contribution on the left to subtract. Thus an inequality results again (according to eq. (1): left < right).

The effect is primarily due to infrared active, containing more than two atoms gas molecules with varying dipole moment [41]. They absorb part of thermal radiation emitted by the Earth's surface. By their emissions they contribute much both to surface heating by reflection and to the radiation into space (together with the clouds).

The calculation of the forcing connects to the natural greenhouse effect and uses the well-known molecular spectra in one-dimensional radiation transport models [9] for power transfer. Thereby is averaged globally on length- and width-dependent vertical profiles [42].

So e.g. for the global CO_2 forcing the proximity expression results that was accepted by the IPCC since its 3rd Assessment Report [2- 2001][73]:

$$F_c^3 = 5.35 \frac{W}{m^2} \ln \frac{[CO_2]}{280 \text{ ppmv}} . \qquad (15)$$

In Fig. 1b (sect. 2.1), the right hand side (logarithmic) ordinate scale corresponds to this function with 280 ppmv as pre-industrial initial value[74] from 1750. For 2005 the CO_2 forcing was $F = 1.66$ W/m². This

[73] In previous years, a logarithmic factor 6.3 instead of 5.35 in eq. (15) has been used [2-1994]. This was in our 1. Edition (see footn. 2) incorrectly interpreted.

[74] The concentration varied over the years from 1000 BC until 1750 only between 275 and 285 ppmv [2]. Therefore, 280 ppmv are preferred over the 291 ppmv for 1880 instead used sometimes (e.g. in [38]).

largest of total 13 posts[75] is the (anthropogenic + solar) resulting forcing F_{res} practically equal:

$$F_{res} = 1.6 \frac{W}{m^2} \approx F_c^3 .$$

Accidentally, largely compensate all other posts. Thereby, the uncertainty range resulting for F_{res} is much greater than for F_c^3 (cf. [2], fig. SPM 2). The next smallest positive contributions provide methane, tropospheric ozone[76] and the halogenated hydrocarbons. The reduction of the latter for the time being brought the strongest slowdown of the anthropogenic greenhouse effect (see sect. 2.3 in context with stratospheric ozone). The aerosols through increased back scattering (directly or through clouds) supply the largest subtractive contribution. More upon the several contributions give e.g. [25] and [2] (FAQ 2.1).

For the future development also the individual effective lifetimes [14] of species are important. They differ due to their different chemical resistance and atmospheric residence time by orders of magnitude . Together with the natural conditions which include also unforeseen events such as volcanic eruptions, human activities determine the development of emissions.

For the policy-specific emissions scenarios, already a wide range of computer simulation has been tested ([34], [2-2007]). As an aid for

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[75] The functions for the other greenhouse gases are completely different from (15) [42]. This complicates the generalization as well as the different residence times when using the so-called equivalent concentration. This has the same forcing as a mixture of CO_2 with other greenhouse gases (and possibly aerosols; see [2], SYR-Topic 2.1).

[76] About their interaction as well as about other physicochemical aspects of the greenhouse effect see [14].

predictions serves the Global Warming Potential (GWP), that is referred to CO_2 with the GWP = 1. It results from the product of the effective lifetime with the time integral forcing of a unit of mass of the respective atmospheric species in relation to those from CO_2. Multiplication with the perspective emitted mass gives the *"equivalent CO_2 emission"*. -The Kyoto Protocol is based on the values for a period of time of 100 years.

Due to the *"forcing-response relationship"* (eq. (12)), the ultimate interesting global temperature development over time is determined primarily by the forcing. Secondly the sensitivity parameters λ in general also contributes to the time dependence of ΔT_S , while it originally as a time constant proportionality factor (as in eq. (7), or (9)) was designed. First of all It depends on the specific climate model. To its calculation, in addition to the radiative transfer the convection processes with tactile and latent (evaporation) heat transport as well as various feedbacks (sect. 3.2 with [38c]) must be taken into account.

For example, the H_2O content of the troposphere increases (according to the vapor pressure curve) with the temperature which greatly increases the greenhouse effect[77]. Relating to the interaction with the ocean, the material transfer is to consider here additionally besides the already mentioned heat transfer . The solubilities are temperature dependent, and for the CO_2 they are co-determined through the formation of carbonic acid and its dissociation [14]. This increases the acidification of the ocean where the impacts on the marine carbon cycle are serious but still uncertain ([2] box 7.3).

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[77] This is not taken into account within the forcing, because H_2O as the only greenhouse gas both with the liquid and solid state coexists. - To the natural greenhouse effect H_2O together with the clouds contributes more than half.

The oceanic and terrestrial CO_2 reservoirs act as sinks and absorb more than half of the total emissions of CO_2 [13b]. - For modeling the processes in the biosphere quantities and parameters mostly are set out so far, whereas the geophysical processes are described by system quantities that can adapt to the global change during the simulation.

About Climate Models

In contrast to the one-dimensional models to eq. (15) mentioned, three-dimensional circulation models are used for climate simulation ([9], section 11.5; [14], section 1.3.7). The related, comprehensive equation systems, which include a full description of the physical processes in principle, can be only solved numerically. Highest computing power is required for that. In taking into account the nature and extent of physical, chemical and biological processes the global circulation models (GCMs) differ within the hierarchy of varying complexity ([2] box TS. 8).

Especially for larger time horizons "EMICs" (Earth System Models of Intermediate Complexity) have proved, as have been used for Fig. 2b in global simulations until the year 3000. They are in the hierarchy below the atmosphere ocean circulation models (AOGCMs) with the highest complexity. These are relatively limited in the time horizon due to their computational expense and beneficial for example for regional considerations which are not at issue here. For table 8.3 and Fig. 10.34 in [2], underlying our figure 2b, they delivered curves to the year 2300 that are not plotted there. They are more in the upper temperature range of the EMIC results.

The IPCC scenario A1B used until the year 2100 for all 8 EMICs is further characterized in [34]. Among the three types of the A1 family it occupies a moderate position between the *"fossil-intensive"* and the *"not fossil"* type. The A1 family is in turn among the three families that are preferred for longer-term considerations (e.g. for Fig. 10.4 in [2]) the moderate between family B1 and A2. (See also [2-2007] WG II, box 2.8.)

The climate of the distant past – as far as it is accessible from paleoclimatic data - is described correctly by the models in principle. With its extreme events it is used for testing purposes ([2], sect. 9.3.4). For the industrial age ensembles of model calculations supply different temperature profiles with and without anthropogenic greenhouse effect ([2], fig. 9.5). In the latter case the agreement with the measurements becomes increasingly worse especially after 1970, whereas the first case as before corresponds to the measured curve from fig. 1a (sect. 2.1). Confidence in the predictive ability of the models is strongly supported by these results ([2], FAQ 2.1).

Climate Sensitivity

As a more descriptive alternative to the climate sensitivity parameter λ for CO_2 often the Climate Sensitivity S is given now. It is specified as temperature increase at doubling atmospheric CO_2 concentration compared to the pre-industrial value, this is to 560 ppmv. Especially the Equilibrium Climate Sensitivity S^{eq} ([2], box 10.2) holds for a so-called equilibrium (balance) case in which the temperature not more noticeably change according to the respective model.

With eq. (15) results F_{do}^{3} = 5.35 ln2 W/m² = 3.71 W/m² (upper index 3 again from 3rd Assessment Report [2- 2001]) and

$$S^{eq} = \Delta T_{s,do}^{eq} = \lambda^{eq}\, F_{do}^{3} = 3.7 \cdot \lambda^{eq} \frac{W}{m^2} \qquad (16)$$

S^{eq} and λ^{eq} enable comparisons of the different models that are independent of the emission scenarios. With $\lambda^{eq} = \lambda_e$ from eq. (7) results row no. 1 in table 3. As already mentioned to eq. (12) (sect. 3.3), this holds without any feedback and only for influences which affect surface and atmospheric temperatures uniformly. But this does not hold for CO_2 , where an approximation is used from GCM calculations for an *uniform temperature response* [78]. This results in a factor 1.2 compared to the *simple response* and is given in row no. 2 in table 3 as the reference case for all (other[79]) CO_2 feedback factors.

For the values "around 1.2 ℃", in [2] together with [38c] from 2006 has been cited the more than two decades older source from row 3 of table 3. Hoever, the similarity of the results come merely from a compensation effect[80]. This has been mentioned already by MONCKTON [38d] together with biting and unjustified polemics[81].

The remaining rows no. 4 to 7 in tab. 3 contain generalized results from numerous model calculations and their statistical analysis ([2], box TS1 and 10.2), where *[very] likely* means a [90% respectively a] 66% probability. These results have been mentioned in our *feedback considerations* of section 3.2 with eq. (10) for fig. 2c, where $\lambda_{ob} = \lambda^{eq}$ from row no. 4 as a guide value. The considerations questioned the direct transferability of feedback results for CO_2 with reference to row

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[78] This condition cannot become fulfilled exactly in the calculations due to footnote A1 in [38c].

[79] These are separated in footnote 6 of chapter 8 in [2] from "the *'uniform temperature'* radiative cooling response" $\lambda_P \approx -3.2 \frac{W}{℃\, m^2} \approx -\frac{1}{\lambda^{eq}}$ in our tab. 3, row 2. The index P is adopted from [38c] with the reference to PLANCK (see our footn. 45).

[80] The comment of the 1.2 ℃ value with a long tradition [25] or with laboratory measurements [25a] is accordingly not appropriate.

[81] Other examples from this most prominent British denier of anthropogenic climate change related to the UN Climate Conference 2010: http://scienceandpublicpolicy.org and http://sppiblog.org/?s=monckton&submit=go .

no. 2 on the heat release, where row no.1 has been used without feedback. But the disparity by a factor 1/1.2 = 0.8 is insignificant compared to the other uncertainties The older feedback limits in footnote 40 are supported by rows no. 5 and 7, and the *best estimate* of no. 6 assists our former statement that DÖPEL's lower warming limit meets the right order of magnitude for the waste heat effect.

Table 3:

	$\Delta T_{s,do}^{eq}\ (K)$	$\lambda^{eq}\ (\frac{K\,m^2}{W})$	**Comment**
1	1.0	0.27	BONY [38c] 2006: *"Simple response"*
2	1.2	0.32	[38c], [2]: *"Uniform temperature response"*
3	1.2 – 1.3	0.29	HANSEN 1984 [38b] with $F_{do} > F_{do}^{3}$
4	> 1.5	> 0.41	*very likely* (after [2]; also:)
5	> 2	> 0.54	*likely*
6	3	0.8	*most likely:* Best estimate
7	< 4.5	< 1.2	*likely*

The equilibrium values S^{eq} and λ^{eq} are temperature independent by definition. However, in the effective climate sensitivities S^{eff} and in the appropriate parameters λ^{eff} a temporal variability (i.e. an increase) occurs[82] mainly because of inertia of the climate system.

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[82] By [2] for example in the section 10.7.2 nonlinearities in the feedback are discussed at AOGCMs, and in section 10.5.2.2 sensitivity for certain EMICs is

After stabilization of the forcings is still a temperature increase to expect by 0.5^o and more, occurring mainly within the next hundred years ([2], section TS. 5. 5). From the curves in Fig. 2b (sect. 3.2) for the fictitious constancy of the CO_2 concentration from the year 2100 that is clearly visible.

In this context, an estimate to the currently active anthropogenic greenhouse effect and its future impact can be rescheduled. Below eq. (15) the forcing that occurred since the beginning of the industrial revolution was given as F_{res} = 1.6 W/m^2. With the measured temperature rise by 0.7^o this gives a λ^{eff} = 0.5 vs. λ^{eq} = 0.8 K m^2/W from row 6 of table 3 as the best equilibrium estimate. The difference is due to the so-called *"Long-Term Commitments"* ([44a], [2] sect. 10.7). Especially the CO_2 remains in the atmosphere for long times[83]. The duration of climate change commitments is particularly important for the "2-degree target" in our next but one subsection.

CCS and Geo-Engineering / Climate Engineering

For fossil fuel combustion, the *Carbon Dioxide Capture and Storage* (CCS) is currently tested [2-2007, 24e]. The feasibility of similar chemical processes has been a long time before[84]. In the light of imminent or already occurring climate damage significant costs will be in rich

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considered to be a fittable parameter. - Maintaining the forcing-response relationship (9) as a basis for discussion is in such cases useful, but of course not mandatory.

83 Cf. particularly Fig. S2 in the online supplement of [44b].

84 For example, the separation of CO_2 after *"coal gasification"* is practiced long in the industrial hydrogen production and now tested for power plant operation as *"pre-combustion capture"*. For a permanent CO_2 storage (sequestration) there exist experiences after its separation from natural gas in the North Sea [24].

countries at least apply. They reduce the market advantage over sustainable energies. However, geological storage capacity could be limiting within decades for many industrial countries[85]. Storage on the ocean floor is more problematic and expensive [24a].

Storing of CO_2 at the CCS is by geology assigned to the geo-engineering (in distinction to the procedural CO_2 capture) [24b]. On the other hand, in the IPCC report ([2-2007] WG III) CCS is not listed under *"geo-engineering",* that is characterized by *"Technological efforts to stabilize the climate system by direct intervention in the energy balance of the Earth for reducing* global warming" in the glossary[86]. More specifically, but under the title "Climate Engineering", such interventions are declared in a German[87] research project [24 d]: "*Climate engineering or geoengineering* denotes scientific concepts aiming at manipulating the global climate system either by intervening in the global carbon cycle or by shielding solar radiation".

Climate engineering could CCS include better, what but rarely happens though the engineering term implies no limit on manipulating concepts or procedures. So the long-winded headline of this subsection was applied that shows again *terminology and attribution problems* as in the second subsection of 3.2.

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[85] It should be noted that the investment cycles in energy sector be 30 or more years.

[86] A corresponding headline is 11.2.2: Ocean fertilization and other geo-engineering options.

[87] To avoid translation problems (see the German version from footn. 1), in a report of the *Deutsche Forschungsgemeinschaft* [24 c] it is spoken of "*Geo-engineering im Sinne eines* (in the sense of a) *Climate engineering*". – This has not to be confused with *Geotechnical engineering* which corresponds to the German *Geo-Ingenieurwesen.*

H. GRASSL [25] accepts CCS yet most likely in a chapter "*Geo-engineering* – Manipulation bei Halbwissen" (*manipulation with half knowledge*) adverse other proposals. The main reasons are that thereby hardly international repercussions are to fear and that the reduction of CO_2 emissions must get currently first priority. This objective is endangered by daring hopes on *"Ersatz"* for the reduction strategies. International coordination problems with regionally varying interests and *"largely absence of global governance"* [24 c] have been very clear at the UN Climate Conferences 2009, and 2010 (to a lesser extent).

A much discussed proposal from PAUL CRUTZEN (cf. footn. 6) is compensating global warming according to the *"global cooling"* (as it inadvertently occurred in the nineteen seventies within the lower troposphere, see sect. 2.2) and to the effects of volcanism by targeted production of aerosols with sulphuric acid in the stratosphere. This would deplete the ozone layer (sect. 2.3), which would but accept CRUTZEN. - Further suggestions include the oceans with regional and hence even harder enforceable measures.

Nevertheless research on cloud production by fumigation of sea water as well as on the stratospheric aerosol entry was by a panel[88] of 5 "Top Economists" (including three NOBEL laureates) *"Very Good"* (1) graded. In contrast, proposals for emission taxation and trade got the classifications *"Poor"* or *"Very poor"* (4, or 5 as the worst category).

This small selection shows that opinions be far apart. It is feared that a short-range economy also in this area gets the upper hand when not

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[88] *Top Economists Recommend Climate Engineering*, by E. Bickel (Lead Author). Press Statement (Washington DC, 4. 9. 2009) of the *"Copenhagen Consensus"* , acting since 2004: http://fixtheclimate.com . This group is not to be confused with [13b] and with the so-called *"Minimal Consensus of Copenhagen"* [24f].

can be counteracted according to international law. At a round table discussion of the *"Deutsche Forschungsgemeinschaft"* in 2009 [24 c] such researches were supported only to see a kind of *"emergency technology"*. She would be initiated if CO_2 mitigation measures against global warming were insufficient, or if sudden unforeseen effects [13b, 43b] accelerate climate change.

The 2-Degree Target

The *UN Framework Convention on Climate Change [13 c] contains the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system"* in article 2 as a final destination. Soon after its legal validity in 1994 a 2-degree target above the pre-industrial value was proposed to do so. This target was 2009 written in the compromise proposal of 25 "Annex I Parties" at the Copenhagen Conference COP 15 [24f]. This remained non-binding until the COP 16 with the Cancun agreement from 2010 [24g] which has been accepted by 193 of the 194 participating parties. There furthermore the need of considering a 1.5-degree limit is included in section I.4. However, the commitments entered into by then can represent only the beginning towards an post Kyoto agreement effective as of 2013. However, the commitments of the parties entered into by then[89] can mark only the beginning towards a Post Kyoto Agreement envisaged as of 2013.

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[89] UNEP Press Releases: http://www.unep.org/newscentre/default.asp?ct=pr ; e.g.*: Emissions Gap Report handover to Government of Mexico.* Cancun, 7 December 2010.

Have a look at fig. 2a and b[90] as well as at table 3 shows that the CO_2 increase far below a doubling (560 ppmv) compared to the pre-industrial concentration must attach. By the researchers of *Copenhagen Diagnosis* in 2009 [13b] calculations have been made with three scenarios for an emission reduction that is required for compliance with the 2-degree limit (with 67% probability). Correspondingly, the emission peak must be achieved not later than 2020, and virtually no greenhouse gas may be emitted once a cumulative emissions budget has been consumed (prior to 2040).

Because today the temperature rise is already 0.7 degrees compared to the pre-industrial level may only 1.3 degrees are added if together 2 degrees are allowed. Moreover, with this global medium value significant but unsafe regional differences are to be regarded. Because the temperature increases over the oceans are smaller, they are over the mainland considerable higher due to the global area proportion of about 30%. Also increases the effect with the latitude, so it several times over the equatorial can be in arctic areas ([2] Fig. 10.6 and Fig. 10.8).

Important implications and dangers can be read on a scheme of the *Federal Environment Agency* of Germany [43a] depending on the global temperature rise. They make understandable that the 2-degree target is considered as insufficient especially by vulnerable countries. International support is particularly important for these on mitigation measures [24g neu].

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[90] Even the lowest CO_2 scenarios of the IPCC ([2], table TS. 2) by the Federal Environment Agency (UBA) of Germany were characterized in terms of the 2-degree target inadequate [43].

Generally, mitigation is becoming increasingly important in the future. As has been stated in 2011 on a German conference of experts [24h], *"the 2-degree target cannot be achieved with current politics. Without the United States you will not come to a concentration of CO_2 in the atmosphere, which appropriately limits heat"*. This would include the case that all decisions made at the conference in Cancun [24g] would be implemented.

Global Stocks for Unsustainable Energies

After the sustainable energy resources were discussed in a subsection to 3.2, the same for the other energy sources should be done here. Thereby, fossil fuels under this section to the anthropogenic greenhouse effect are the main problem.

Distinction is made between the currently proven and recoverable *reserves* and the *resources* that include also suspected and still not economically and technically recoverable stocks. Current values are listed in [36 h] (tab. 1.1) by pointing out that such figures are *"often interest guided"*. The averaged *"static reach"* [91] of fossil reserves that results with constantly maintained consumption amounts about 90 years. Values for the *"Dynamic reach"* [14], resulting for exponential growth in consumption with different scenarios would currently more realistic and shorter.

DÖPEL [3] announced that fossil reserves *"go between 2100 and 2200 to end"* against the background of the high growth rates in the nineteen seventies. For oil and natural gas this is already earlier to expect whereas coal will possibly be exhausted after this period.

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[91] So the header 9.1.1 reads in [36 h], where the problematic character of this quantity is highlighted.

Interesting model calculations have been made to the extreme scenario of combustion of fossil resources up to the year 2300 [44d].This would give a maximum increase near to the year 3000 in global temperature of almost 8 degrees unless countermeasures. This was calculated using a cumulative emission of $2 \cdot 10^{19}$ g CO_2 according to data from the nineteen nineties. In contrast, there result $4 \cdot 10^{19}$ g with the more actual resources from [36h] and the CO_2 equivalent of energy from oil, gas and coal specified in [2-2007] (WG III, table 4.2). This corresponds to a cumulative energy of $1.6 \cdot 10^{20}$Wh .

If it would continuously and uniformly released during a fictitious period of 100 years, the corresponding forcing were $F_w = 0.36$ W/m² . This gives a lower limit for $\Delta T_s = 0.1^o$ with λ^{eq} from row 1 in table 3, and 0.3^o with the *best estimate* from row 6. So, even with complete *Carbon Capture and Storage* fossil fuels would contribute some to global warming which amounts currently 0.7^o from the greenhouse effect. In addition the contributions of other unsustainable energies would have to be regarded.

For nuclear fission fuels (section 4.1) the energy reserves are below those of oil and gas and their resources are located in between [36h]. Thereby, the dangerous reprocessing has not included, capable of providing an order of magnitude more ([2-2007] WG III Tab. 4.2). Thus the nuclear fission resources in the range of coal energy resources can come. Thus, the time indicated above for fossil inventories can - again speak with DÖPEL - *"about a century be extended"* [3].

Conveying deep geothermal energy (footn. 62) is geographically limited, can be done but virtually indefinitely. The latter also applies in realization of nuclear fusion technology (see section 4.1), since there is hardly a restriction on the raw material base.

Even without *"such speculation"* DÖPEL's statement by the end of his introduction in [3] applies:

"From the aspect of existing energy supplies is no barrier for a continued increase of industrial energy consumption for several hundred years".

As then, so there is today no indication that humankind has other realistic barriers in perspective.

About Weather Forecast

To what has been said above in the subsection "About climate models" here follows a complementary comparison of weather forecasts with prognoses of climate (as a means of weather over long periods of time). Both use the same system of physical equations, and often using everyday uncertainties of weather forecasting as an argument against climate prognosis.

After the famous mathematician JOHN VON NEUMANN (1903-1957) predicting the weather is – behind predicting human behavior - the second hardest prediction problem [9]. 1963 the meteorologist E. W. LORENZ with his simple equation system of a chaotic weather model instituted a rapid development of the science of chaos (see e.g. [7, 14]). This is determinative also for the atmospheric dynamics and reveals fundamental limits for weather forecasting.

Such limits apply but a climate prognosis not. As an apt analogy from the human sphere, [2] (FAQ 1.2) contrasted the difficulty to predict accurately the mortality age of a certain man with the exact predictability of his average life expectancy (currently 77 years in a developed country as a scenario). However, the emission scenarios underlying the climate scenarios combined to a climate prognosis, depends on humans. Thus ultimately the existing for their behavior prediction problem after v. Neumann is concerned, which is the main subject of humanities disciplines (see sect. 4.2).

Simple Simulation Possibilities on Climate Issues

This section ends with references to further possibilities of the system dynamic simulation for readers with computer ambitions. Easiest are provided online, interactive simulators of the American *Sustainable Institute*[92] . They treat the time-based greenhouse gas emissions and the resulting concentrations, regional and associated global emissions with variable targets etc.

In-depth considerations with even more programs are in a broad-based course by HARTMUT BOSSEL [46] included. It is suitable according to the preface also as a compendium for independent project work in school, college or research guide. The programs also include surroundings of the climate problems (such as demographic development and chaos dynamics). The narrower set of problems of our section 3.4 includes simulation models like *"Global carbon cycle"* (Z302) and several following on the carbon dioxide problem in *"System Zoo 2"*.

Further global problems are treated in "System Zoo 3", among others based on the well known *"world model"* WORLD 3 [12a]. Such models that are not as simple as that from DÖPEL, but they can be understood and varied far better than the accessible only for experts, large research models**.**

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[92] http://www.sustainer.org : As a non-profit organization founded by DONELLA MEADOWS (1941-2001), leading scientist in system dynamics and co-author of reports to the *Club of Rome* [11, 12a]. For more simulations: http://climateinteractive.org/simulations .

4. Final considerations

4.1 Nuclear Energy?

In the previous section, statements on nuclear energy reserves and resources and their temporal reach under the subheading "*Global stocks of unsustainable energy*" were given. Now the nuclear technologies and their surroundings are discussed further.

Nuclear Fusion

Since 2007 the contract about the jointly funded experimental reactor ITER[93] is in force, and the prototype is built in France. In addition to the Continental-European EURATOM countries joined the United States, South Korea, Japan, Russia, India and China. The acronym is often interpreted as the Latin *iter*, "the way". There is a long previous history.

ROBERT DÖPEL was one of the first who dealt intensively with the idea to exploit the energy of nuclear fusion [32]. In the nineteen thirties he investigated for example the yield of nuclear processes especially with light elements in the interior of stars [4-C]. The technological use of such processes and their hardly limited resource base has been discussed in the introduction to his climate publication [3].

For ITER the common fusion principle with Russian abbreviation TOKAMAK is used. It has been created in 1952 by I. J. TAMM and A. SAKHAROV, the later human rights activist and NOBEL Prize Laureate for Peace (1975). He was involved in the Soviet clone of the American

93 International Thermonuclear Experimental Reactor: http://www.iter.org/default.aspx .

hydrogen bomb, too. This is based on same physical principle, and is ignited by a fission bomb. Without such ignition, i.e. in the future fusion reactor, there is no security risk which is comparable to a meltdown in the fission reactor as it occurred in 1986 at Chernobyl.

Because the reactor development broadly just empirically can be taken forward with step by step growing plants, $10^9 - 10^{10}$ € are consumed to a year worldwide. A power generation in fusion plants is expected as of mid-century if the remaining tests are successfully ([46a; 2-2007] WG III Tab. 4.2).

If the price of electricity would be finally similarly low as fission [24] markedly higher growth rates could be possible as they until 2050 to eq. (10) were called. Already for a medium growth of 5% p.a., which is still lower than at the time of DÖPEL's forecast, would according to Fig. 2c already towards the end of the 20th century the waste heat for the global temperature noticeably.

Fusion reactors could then play the same role in global warming as currently the fossil power plants. Basically it holds that the fusion is desirable to bridge in CO_2 avoid. But then must the growth limits even more have to be observed which following eq. (11) were discussed. Fusion once again shows that the next centuries in the interest of the much heralded sustainability deserve greater attention.

Not only because their heat emission, but also because of radioactive waste[94] fusion is not a sustainable technology. This is however often

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[94] Both the quantities of radioactive inventory in the fusion reactor and waste that arises in particular by enabling its inner walls and regularly disposed must be, are comparable with those of a fission reactor of the same performance. But the toxicities of radiation and the decay times are much lower. The

said in public and even in academic debate. Due to this belief it was promoted in Germany by those Government which decided in 2002 an earlier shutdown of fission power stations [48], as well as before and after that with very high sums. These are in the same range as for all sustainable energy technologies together [50a][95] . They wear but in contrast to fusion now, although still far too little to reduce the current CO_2 problems with.

Nuclear Fission

Because the risk perception [14] which is outstanding for fission technology especially in Germany the remainder of this section to that problem is dedicated.

The above mentioned Federal Government decision of 2002 for an earlier shutdown of nuclear power plants was abolished by a changed Atomic Energy Law in 2010 [48], and the lifespan of nuclear reactors was extended by more than a decade. This conformed with the older recommendations of the German physical society [24].

But old fears of a Chernobyl meltdown[96] or of a terrorist attack were enhanced. Moreover, plane crashes into nuclear power plants were

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percentage of fusion waste that must be sent in a geological repository is given as between 30 and 3% [50a], or null [49].

[95] The amount on a global scale is difficult to compare because of the different national and international conveyance instruments. All unsustainable energy promotion together significantly predominates in the EU and the USA the sustainable: http://www.ren21.net/Portals/97/documents/GSR/RE2005_global_status_report.pdf .

[96] The most likely cause of the Chernobyl disaster was described by MIKHAIL GORBACHEV in the annex to his 2006 book on environmental problems

newly categorized as a *"residual risk"* so that the operating companies would merely need to take safety measures against this contingency. Mainly for older reactor equipments, this terroristic risk is associated with that of a meltdown [52].

The latter is impossible in the so-called pebble-bed reactor (PBR) using spherical fuel elements. It was developed in Germany and worked here until 1988 [53]. Several countries are working on its further development. For example, the Chinese Government announced 2003 to build until 2020 thirty such reactors. There was talk of the pebble-bed reactor as one in Germany *"missed opportunity"* for energy production [53], although the dangers of the discharge of radioactive matter remain. A major advantage is that its nuclear fuel is not appropriate to the nuclear weapons [56a].

The danger of proliferation of nuclear weapons is a main reason for the restrained position e.g. of the IPCC (in [2-2007], WG III, section 4.3.2.3) to expand the fission technology.

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[47]. Thereafter the meltdown was caused by an unauthorized experiment of the power plant headmaster and not - as often surmised - by the catching up a previously failed checkup arranged *"from above"*. The disaster seems not to have been specific for an authoritarian regime but could occur everywhere.
Added in proof: 25 years later, regrettably such like events occurred after the tsunami in Fukushima. Oxyhydrogen explosions as in the Japanese reactor buildings [51] were known since the damage of DÖPEL's experimental reactor in 1942 (sect. 3.1). For more accidents with the level of 4 to 7 on the *International Nuclear Event Scale* (INES), see
http://www.iaea.org/Publications/Factsheets/English/ines.pdf .

4.2 Climate Change and the "Other Culture"

Cultural aspects of climate change already played an important role for ROBERT DÖPEL, who liked philosophy[97] and saw science and Humanities as a whole [54]. In his climate paper [3], under the heading *"Perspectives"* he wrote relating to a call for radical restrictions of (energy) consumption:

"Whoever thinks that also the further development of culture have to suffer by this the should wonder just how many kilowatt-hours were necessary to make such as the culture from the time of GOETHE *and* BEETHOVEN*!"*

The Two Cultures

At that time, *"The Culture"* was in the Eastern hemisphere still given by the arts and the related ("soft") sciences. In contrast, in the West it is spoken since 1959 - and now all over the world - after a famous lecture of the chemist and novelist CHARLES PERCY SNOW of (at least) two cultures [53a, 57a]. They are grouped around science[98] and humanities, respectively, and his goal was the reduction in the divide separating them.

This by no means disappeared, but now largely repressed divide arose in the times of BEETHOVEN and GOETHE [52]. The latter embodied

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[97] See the brief biography preceding the foreword. Already at an early age, DÖPEL loved philosophical reasoning, as the friend HANLE [32] reported in his memoirs from their common Gottingen assistant times: "*He was not only a great physicist, but also a great philosopher before the Lord.*"

[98] Roughly speaking, this first group corresponds to the MINT subjects (footn. 10). From its point of view the remaining subjects belong together with art and literature to *"the other"* culture. - An example of a *"third culture"* is given in [53b], where SNOW's optimism about the closure of the divide is not shared.

the unity of all culture as a poet with comprehensive scientific and technical knowledge and ambitions as one of the last. In Germany, this was especially important in the debate about snow's theses.

Among scientists, exceptionally the physicist and philosopher [53c] WERNER HEISENBERG who was gifted also for fine arts and music (footn. 28) delivered *"an important contribution ... to bridge the divide between natural sciences and Humanities - a goal that certainly envisioned Goethe"*. So ends a treatise [55] of the HEISENBERG biographer RECHENBERG for the international *Goethe Society in Weimar*. This small but famous town was then East of the iron curtain, and as a West German board member HEISENBERG (as a successor of PLANCK) also contributed to political bridge after World War II. At the 1967 meeting of that society Heisenberg gave an acclaimed speech *"Goethe's picture of nature and the technical-scientific world"* [30] in the crowded National Theatre in Weimar. Then he visited the nearby located *"Goethe-Stadt"* Ilmenau, and there was the last face-to-face meeting and domestic interchange of ideas with DÖPEL[99] .

While for the rest of the 20th century debates about the two cultures also in Germany flourished, the present-day German scholars know hardly anything about this topic[100]. In contrast to English speaking countries, here one learned little about the lecture of SNOW even to its 50th anniversary except from English journals, for example the special

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[99] Friendly connected as before, they had last 1966 to HEISENBERG's 65. birthday exchanged elaborated letters [4-F].

[100] In the course of a reform with reduction of the Humanities at the universities of the united Germany, the chairs of history of Science (and related domains) were further reduced. This *"born brace between the two fields of Sciences and Humanities"* [60] had partially fell victim to a university reform in East Germany in 1970.

issue of 2009 of "Nature" [57a] with the editorial *"Doing Good, 50 Years on"* and three related essays. In Cambridge, the place of the original lecture, there was the "*2009* C. P. SNOW *lecture*" [57b], in which also *"the great issues of climate change and environmental destructions"* were brought up to that now follows more.

The cultural divide and the climate crisis

Following SNOW, the loss of communication between the two cultures is one of the major obstacles to solve critical problems of the world. For AL GORE, the gap has not decreased since 1959, and it represents a major problem *"in thinking about the climate crisis"* [1]. In an in-depth presentation of 2007 [56] he examined also the resistance against specialist counseling by decision-makers.

The Czech President VACLAV KLAUS sees freedom threatened in his controversial book [57] through climate campaigns with the risk of an *"Eco-Socialist dictatorship"*. According to the foreword global warming would be *"more a matter of human as one of natural science"*. The appendix contains his theses against those of AL GORE for a US Congressional Hearing and his controversial speech at the UN Conference on Climate Change 2007.

In the epilogue of the far more thorough and detailed book of a historian [58] also of 2007[101] in context with problematic dating methods for the Earth's history is written:

"Only by the historical chronisticler it is possible to bring the 'exact' natural sciences on the right track. Humanists - that saying to the year of the humanities - are not used to such a lack of exactness."

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[101] In Germany, this was the *"Year of the Humanities"*.

"Strikes against the climate's tale" were made in the text, and ozone hole as well as forest dieback[102] are incorrectly classified as unnecessary *"environmental fears"*. However, in principle the approach of cultural history is important for predictions of climate change impacts if we want to think until the end of our millennium.

The discussed examples of *'climate change skepticism'* on the part of the humanities illustrate the - at least in this sector - growing divide between the two cultures. But there are also initiatives for co-operation in fighting climate change. Here only two examples from German universities will be given.

The project [24d] on climate engineering (sect. 3.4) includes the cooperation of natural with social science and jurisprudence as with psychology and philosophy. Another transdisciplinary project *"Climate and Culture"* joins three Universities. Their description is: *"Founded in 2008, this research area is the first major research project to focus on the cultural and political consequences of climate change, and it takes a new approach to the analysis of far-reaching processes of social change"*.

More about Culture and Ethics

Finally, thoughts from DÖPEL's climate paper [3] (see the beginning of the current sect. 4.2) are taken up again. In the same spirit KLAUS TÖPFER , former chairman of the *United Nations Environment Program* (UNEP), in his *"Weimar Speech"* of 2008 [61][103] predicted a *"significant*

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[102] Footnote 6 refers to the true history of ozone depletion, and without sustainable measures (mainly flue and car exhaust cleaning and chalk fertilizer) the dieback of forests [14] would not have been transformed into a forest decline.

[103] The honorific speech of the artistic director, which is printed ahead of Dr. TÖPFER's lecture at the *Weimar National Theatre*, reported his worldwide

change of consumer behavior" and called for a stronger *"back binding in culture"*. With regard to global solidarity and environmental ethics he referred to the *"World Ethos"* of the theologian and philosopher HANS KÜNG [62].

The recent development [63] underlines TÖPFER's call after an examination by the UN *"how powerful early warning systems make the prevention of looming disasters possible"*. He raised but also *"the great opportunities for science and research for economic applications and export success"* and thus for the labor market that arises in real response to climate change - not least in Germany.

He also emphasized the present *"renaissance of the regional"* and its importance and necessity for the cultural identity. The yet unused possibilities for the University and the region Ilmenau to remember ROBERT DÖPEL permanently as the region's most important scientist have to be pointed out.[104]. His merits and his ethos appear to be even higher when taking into account the socio-political life circumstances.

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activities. Additionally, in 2009 TÖPFER was appointed founding director of the *Institute for Advanced Studies Climate, Earth System and Sustainability Sciences* (IASS) at Potsdam (Germany), which will perform research between climate problems and sustainable economics.

[104] As a curiosity, the link to a site with 23 important people born in the *Grand Duchy of Saxe-Weimar-Eisenach* (1815-1918) to which Robert DÖPEL's birthplace Neustadt belonged is given. He is registered together with ERNST ABBE and CARL ZEISS and several writers and aristocrats: http://en.wikipedia.org/wiki/Category:People_from_Saxe-Weimar-Eisenach . - In this English encyclopedia mainly the part of DÖPEL's life before his last stage is covered, of course relating to the research with HEISENBERG and its critical assessment. But from today's perspective his late model calculations and positions to the climate problem are more important for future generations.

Most of his life, he lived in war (heavy wounded in 1918) and with the threat of war - facing those present with their rich possibilities.

Relating to the first citation of DÖPEL of this section against undue consumption he wrote furthermore [3]: *"Often it seems even just the wealth of sparkling baubles which fly every day round muchly the people of the Western Hemisphere, downright dazzling closing the eyes before the entire wide range of inner values and objectives."*

Now globalization spread worldwide both the negative and positive values of this hemisphere. Given the unrestricted financial flows K. TÖPFER saw *"dramatic, unrestrained global consequences for economic stability and living conditions"* [61]. However, the countermeasures taken imply a back reinforcement of economic growth virtually without regard to the climate and future generations.

In the interest of these generations, the famous actor KARLHEINZ BÖHM, since three decades a protagonist against poverty in Africa,[64] wrote:

"It is important to act. And not to accept the world as it is."

5 Summary

A very short summary is available under “Beschreibungen” on the online portal of this document with the URL in footnote 3.

A seven-page English online-presentation confronting especially our updated results of the DÖPEL model with IPCC results from 2007 was already referenced in footnote 9.

For the historical subsumption of the model considerations for global warming, after the introduction a short outline of facts and of debate history on **climate change** and of progress **until now is given**, starting with the discovery of the greenhouse effect.

Graphical comparison of temperatures observed since then with the course of the atmospheric CO_2 concentration shows only allusively the correlation which is now clear for much longer time intervals. This makes understandable that ROBERT DÖPEL ignored the anthropogenic increase of the greenhouse effect in his **work of 1973 on the waste heat influence** that was discussed contradictory at that time. (Much less today's ignorance of the waste heat perspectives e.g. by the IPCC can be understood.) Almost simultaneously both influences were reported by the Club of Rome as important to the climate, where the anthropogenic heat affects *“merely”* later generations – in contrast to the greenhouse gas emissions.

Following up the brief biography preceding the foreword, after the historical considerations main stages of **DÖPEL’s career** are outlined *in extenso*, starting with his first professorship in Leipzig. There he scored the first effective neutron multiplication in nuclear fission worldwide together with his wife and W. HEISENBERG, who provided the theoretical foundations and drafts.

During the last part of his life in Ilmenau DÖPEL created his simple **geophysical model for global warming**. While at that time other representations warned against a global influence of waste heat, too, it is now largely ignored. This holds even for model calculations of greenhouse action until the end of our millennium e.g. in the IPCC Assessment Report AR4 from 2007. Until then DÖPEL extended his calculations which showed a marked temperature increase not before the end of our century in the case of further increasing waste heat. This was confirmed by the actualization and a discussion of feedback influences. These influences are far less clear than the original DÖPEL model, and they are better understood in the anthropogenic greenhouse effect which also had to be regarded in some detail for confrontation.

For biological possible temperature increases by only a few degrees, DÖPEL's formalism is equivalent to the usual linear relation with the forcing as a driving force for global warming, approximated from the radiation balance with the STEFAN-BOLTZMANN law. The **concept of forcing** serves as a common thread for the analysis of global warming influences. As by others, the forcing term had to be extended opposite to the most recent IPCC report.

Since the start year 1970 for DÖPEL's calculations the growth rate of waste heat was 2% per year on average. While maintaining this, a contribution of some tenths of a degree to the global temperature would result there from around the year 2200 (with a doubling time of 35 years). If a 2% increase of energy production would be achieved rather solely with **sustainable sources**, whose estimated production possibilities at the global limit would be also in two centuries, as an order of magnitude. Thereafter, the global energy production would have to be constant to avoid further temperature increase.

For sustainability, neutrality is postulated here not only with regard to CO_2 as for sun or coal force with carbon capture and storage (CCS).

Different than usual, **neutrality regarding heat** must also exist so that CCS, nuclear fusion, and deep geothermal sources are unsustainable in that sense, i.e. for many generations in the sense of DÖPEL. Of course such energy sources are important as bridge technologies for a transitional period of a few decades to the sustainable energies.

Despite improvements in energy efficiency, an increase in global energy production seems to be without alternative currently due to its **coupling with economic growth, labor market and social peace**. This is true not only for the established industrial countries and democracies but also for emerging authoritarian economies like China. Generally, it is true for all social systems which have existed since the industrial age so far.

As long as the energy consumption grows, the permanent mitigating of climate change even with sustainable energy sources is not available for more than a few centuries. Alternatives from *"Geo-Engineering / Climate Engineering"* are discussed controversially and could serve as **emergency technologies**, if sudden unforeseen effects accelerate climate change further.

Finally, after considerations on **nuclear energy** mental-cultural aspects for **changes of life style** were discussed in terms of sustainability, again following DÖPEL's reflections. Perturbances in the relationship between scientific and humanistic culture in climate-related questions were named as well as interdisciplinary approaches to problem solving. They must be strengthened so that not only the civilization, but also its culture is preserved against setbacks as they led in the past to the described shortcomings in combating climate change.

6 Acknowledgements

First of all already deceased colleagues are to be remembered. The physical chemist Friedrich Kohler, as a friend, since 1960 discussed the *"global problems"* of the environment with me a lot. From Vienna, he provided me with relevant writings, such as the Pugwash Conference papers and especially literature on climate issues. – I am especially grateful to Robert Döpel that I could join his improvised discussions with colleagues about anything and everything, and on his publication from 1973 about climate too. - At about the same time in Ilmenau, the systems engineer and well-known cyberneticist Karl Reinisch took up environmental problems. In friendly cooperation, in which I played the scientific part, we included it from the end of the nineteen seventies in the teaching.

This treatise would not be without the support of my wife, and our three sons were also motivating. They provided contributions from a mathematical, scientific and technological perspective.

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Heinrich Arnold

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