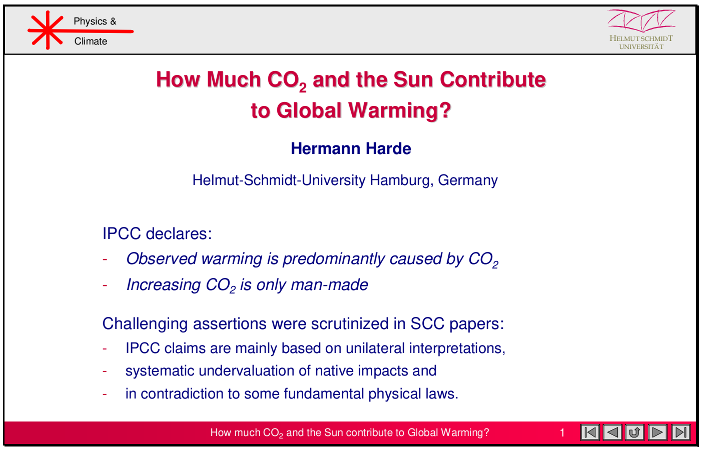
Talk on Seminar of Klimarealistene on board of the Ferry Oslo-Kiel: 28. 09. 2022

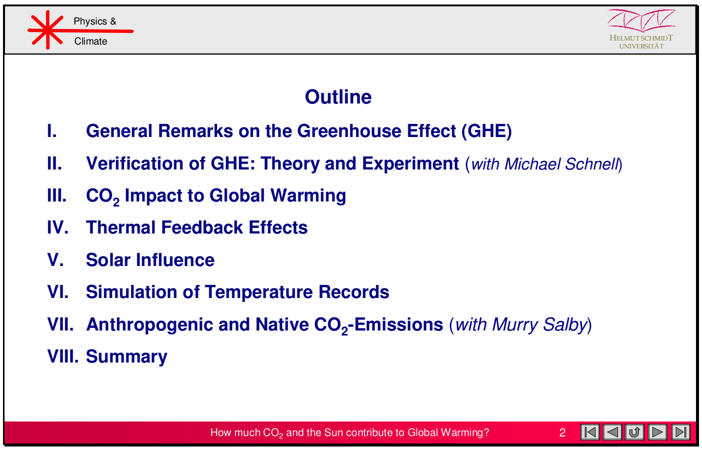
Hermann Harde



The IPCC declares that:

- the observed warming is predominantly caused by CO_2
- and increasing CO_2 is only man-made

These are two challenging assertions, which we have scrutinized in our SCC papers [1 - 3]. I'll show that these IPCC claims are mainly based on unilateral interpretations, which systematically underestimate native impacts and are in dissent with some fundamental physical laws.



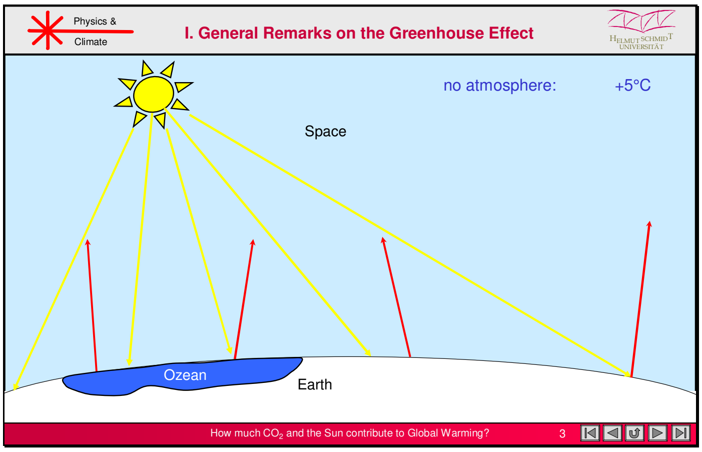
Sec. I and Sec. II :
First it will be made clear – different to many antagonists of global warming – that the atmospheric GHE is a real physical phenomenon.

The experiments to the GHE were performed by Michael Schell in his private laboratory [1].
Sec. III and Sec. IV:
But it will also be explained that this effect is significantly less contributing to global warming than claimed by the IPCC [4].

The solar influence is considered in Sec. V and Sec. VI. The calculations are compared with observations, and from this is deduced the CO_2 to solar contribution to the warming over the last century [2].

Sec. VII: Finally, a few remarks about anthropogenic CO_2 emissions, their residence time and their contribution to global warming. This goes back to a closer cooperation with Murry Salby from Sidney [3].

*After this talk I got notice that Murry already passed away in April 2022, when he was visitingd his son in Melbourne.

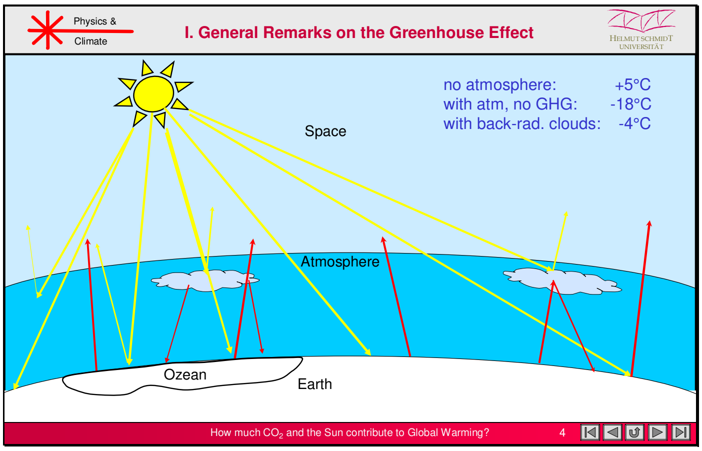


Section I

Maybe the greenhouse effect (GHE) is one of the most controversially discussed effects in our times, about which experts and laymen are disputing. As this is the basis for any assessment of CO_2 on our climate, we first look to some fundamentals but also misinterpretations of this effect.

Without atmosphere and no reflection losses the incident solar radiation is absorbed 100% by the Earth's surface which releases the same amount of energy via lw IR-radiation over the whole surface.

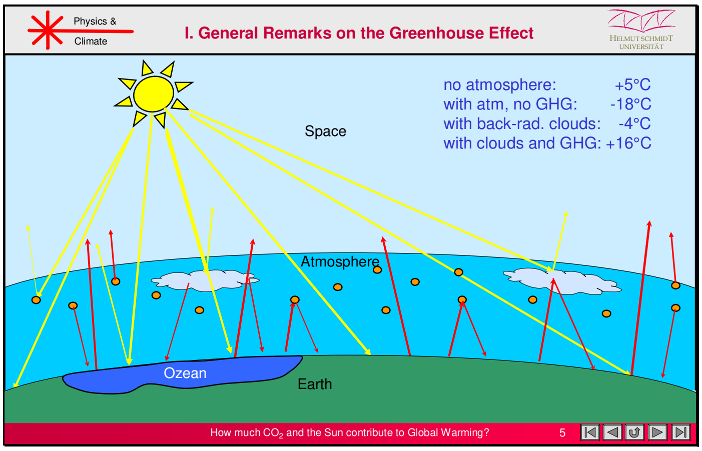
This would contribute to an average surface temperature of +5°C. Larger areas of the surface would already be covered by ice.



With an atmosphere and clouds but no GH-gases the temperature drops to -18°C and the Earth would be a whole snow ball. This is the result of sw solar scattering at gas molecules (Rayleigh scattering), at clouds (Mie scattering) and partial reflection (about 7%) at the surface.

Up to here more or less this is accepted by most antagonists.

A stronger dissent comes up when additionally including scattering and absorption of lw radiation by clouds and their back-radiation to the Earth, which would increase the temperature from approximately -18°C to -4°C.



Additionally considering GH-gases the mean temperature increases from -4 to about 16°C with water vapor (WV) as the main contributor.

Physics & Climate

I. General Remarks on the Greenhouse Effect

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Experimental verification of the GHE in the atmosphere is difficult

- Most studies rely on theoretical considerations or on laboratory experiments.
- But for more than 100 years quite contradictory results are published,
  on the one hand
  - with unrealistically high temperature increases of 10°C and more (Ditfurth – German TV), obviously caused by a stratification effect or
  - as unreproducible experiments like Al Gore's TV-experiment, meanwhile refuted by Klimarealistene and A. Watts,

  on the other hand
  - experiments and explanations refuting the GHE (Allmendinger, Seim & Olsen).

Motivation enough to penetrate this mystery with our own studies of the GHE

How much CO_2 and the Sun contribute to Global Warming? 6

Experimental verification difficult: see chart.

Al Gore's TV-experiment, refuted by Klimarealistene and Antony Watts

Physics & Climate

I. General Remarks on the Greenhouse Effect

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Two Main Objections to the Greenhouse Effect

1. The radiation from a colder body cannot be absorbed by a warmer body, as this would violate the 2nd law of thermodynamics.

- **Rudolf Clausius** (one of the founders of the 2nd law) already considered "*a simultaneous double heat exchange by **radiation** between the two bodies*", as found from our daily life experience.
- **Distinguish:**

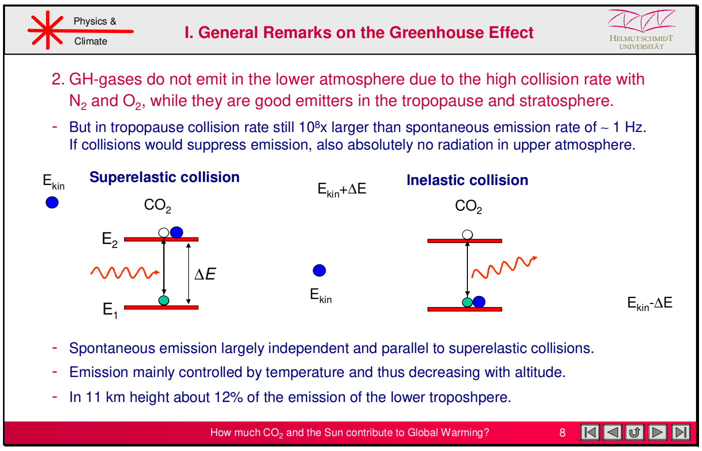
  Closed system: *the colder body experiences an increase in heat at the expense of the warmer body, which in turn experiences a slower rate of cooling.*

  Open system: *With external heating, the back-radiation from the cooler body leads to a **higher temperature of the warmer body than without this radiation**.*

How much CO_2 and the Sun contribute to Global Warming? 7

Before looking closer to the investigations, a few comments on two main objections to the GHE (see chart).

See Clausius



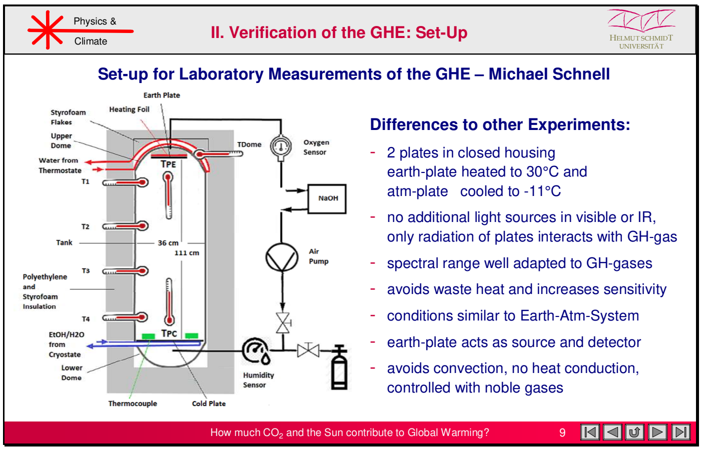
2. objection (see chart).

We have to distinguish two kinds of collisions:

Superelastic collisions: a CO_2 molecule has absorbed a photon and is excited to an upper state. When this molecule collides with other molecules, the absorbed energy can be transferred to these molecules as increased kinetic and thus thermal energy.

Inelastic collisions: they remove kinetic energy from the gas mixture and convert it back to excite the GH-gas molecules.
→ lower-lying energy levels are continuously re-populated, when there is sufficient thermal energy, and these collisions appear with almost the same rate as the de-exciting collisions.

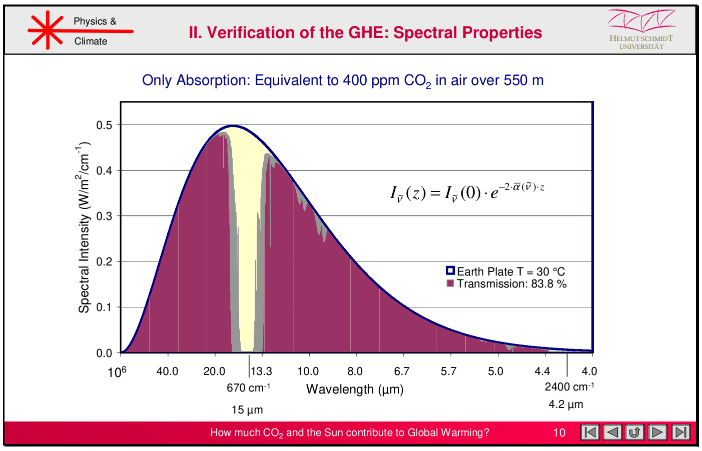
The population rate is determined by the Boltzmann distribution and only determined by the energy splitting relative to the thermal energy of the gas. See lower dashes.



Section II

The set-up for our own investigations has been developed and built by Michael Schnell [1]. Differences to other experiments, see dashes on chart:

- The heated earth-plate acts simultaneously as radiation source and as sensitive detector for the back-radiation from GH-gases. In this way the radiation of the gases is measured as direct temperature increase of the upper plate or, alternatively at stabilized temperature, as energy saving of the plate's heating.



Before looking to the measurements a few theoretical remarks how GH-gases are interacting with lw radiation.

The spectral range emitted by the earth plate as Planck radiator at 30°C extends up to about 2500 wavenumbers. In wavelengths this corresponds to the inverse scale and opposite direction from 4 µm till 1 m.

As an example we look to the absorption spectrum of CO_2 [1]. The strongest absorption band is found around 4.2 µm, but there is the incident radiation almost zero.

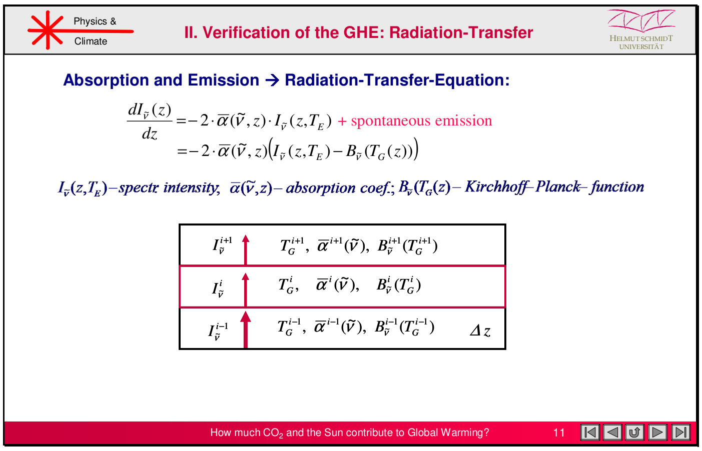
On the other hand the 100x weaker bending mode around 15 µm or 670 cm^{-1} almost coincides with the maximum, and with a concentration of 20% and a pathlength of 1.1m we already observe 100% absorption of the incident radiation on the band center, shown as yellow funnel. Only on the wings and the weaker bands displayed in gray, the absorption is not saturated.

This is the result when assuming Lambert-Beer's law of absorption. The factor 2 comes from integrating the spectral radiance over all propagation directions.

In the atmosphere with 400 ppm this is equivalent to a propagation path through a layer of about 550 m.

Altogether this results in an absorption of 16% which is released as heat, while 84% of the incident radiation transmits the gas layer.

But this is not what we can really expect.

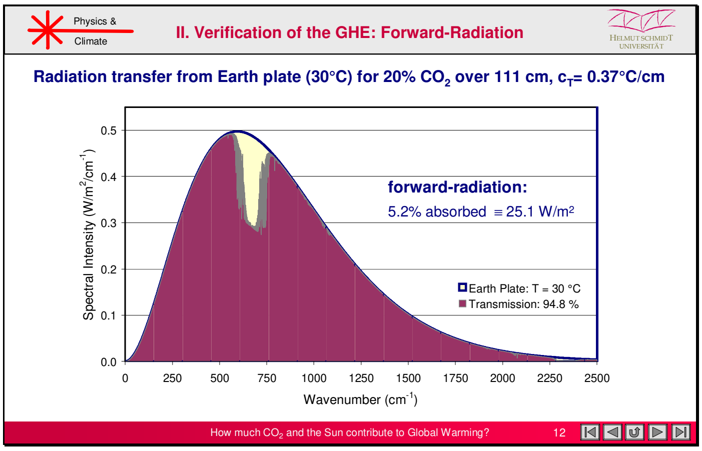


As previously mentioned CO_2 molecules not only absorb but also emit on their transitions, and this spontaneous emission is superimposing to the incident radiation.

For shorter propagation lengths this emission can be added to the absorption changes, here represented by the Lambert–Beer-equation in differential form (see also Harde, 2013, Eq.(86)).

As the emission on a spectral line is proportional to the absorption coefficient and the radiation of a black body at the gas temperature T_G, one gets a modified Lambert-Beer equation, which is known as Schwarzschild equation with $B(T_G)$ as the Kirchhoff-Planck-function representing the blackbody emission at the gas temperature.

Since over a longer pathlength the gas density, pressure and temperature are changing, this equation has to be solved stepwise for thin layers with the respective parameters and integrated over the pathlength. This is known as line-by-line radiation transfer calculation.



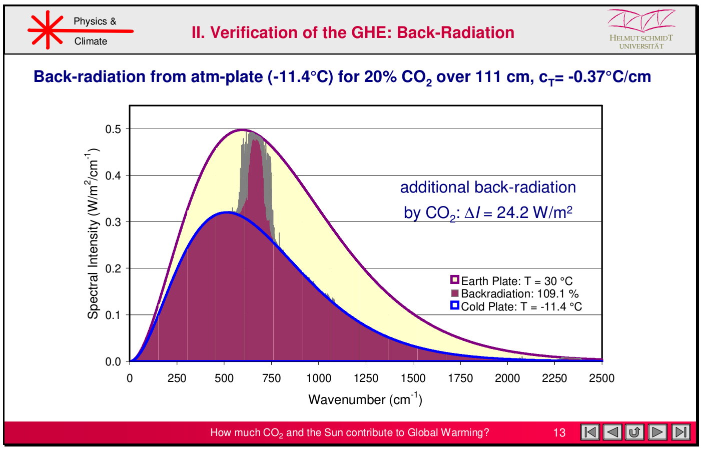
The respective RT-calculation is shown here. Over this spectral range CO_2 possesses more than 30,000 lines and the emission and absorption spectra are calculated with a layer thickness of 1 cm.

The emitted radiation of the earth plate is again indicated as Blue graph on a yellow background, the transmitted spectral intensity in front of the cold plate in Plum.

In analogy to the terrestrial radiation we call this the forward-radiation.

As a consequence of the eigen-radiation of the gas the spectral intensity at the band center no longer drops to zero and the overall absorption reduces to 5.2%. This is less than one third we got, considering only absorption.

This means, first 16% of the initial radiation is absorbed, but 2 thirds of this are again reemitted in forward direction. In absolute numbers these are 25 W/m^2, which remain in the gas volume and can contribute to warming and/or radiation.



But we have not only radiation from up to down but also opposite from the atm-plate to the earth-plate as back-radiation.

The emitted spectral intensity of the cold plate at -11.4°C is displayed as blue graph and as comparison the blackbody radiation for 30°C in Red-Yellow like the earth plate.

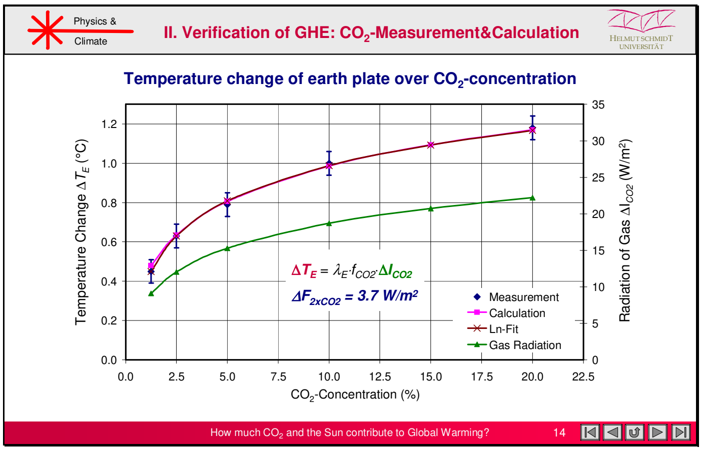
When this back-radiation from the colder plate traverses the gas column in upward direction, it is further amplified around 670 cm^{-1} due to stronger emission than absorption of CO_2 in this spectral range.

This is a consequence of the increasing gas temperature in upward direction, now as negative lapse-rate, this although the molecule density in the tank is declining in this direction.

Despite this short propagation path in the tank at the band center the spectral intensity achieves the intensity of a blackbody radiator of 30°C like the earth plate, which means that at this CO_2 concentration already over a few cm the gas is an optically thick layer and emits like a Planck radiator on these transitions.

Compared to the radiation of the cold plate the back-radiation increases by 24.2 W/m^2, which is 9.1%. This larger back-radiation is almost identical to the losses in forward direction, so that within observational accuracies the total balance of absorption and emission of the gas is zero.

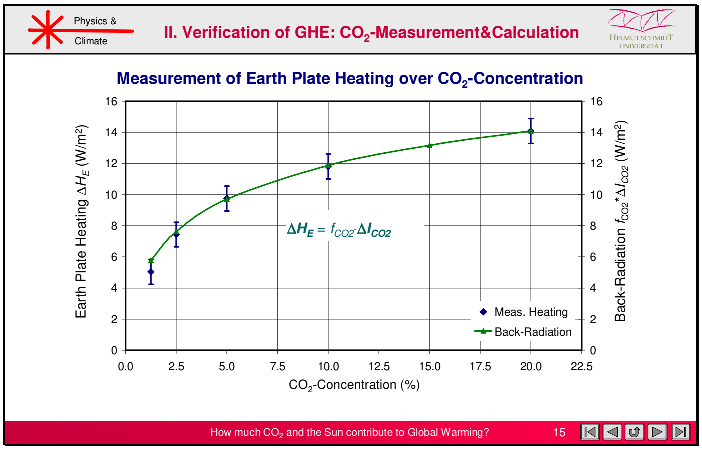
This is an important aspect that speaks against measuring the gas temperature to prove the GHE.



This figure displays a first measurement with the presented set-up. The recorded temperature of the earth plate as a function of the CO_2 concentration is indicated as blue diamonds (with error bars). Starting with a concentration of 1.25% from one measurement to the next the concentration is doubled up to 16x [1].

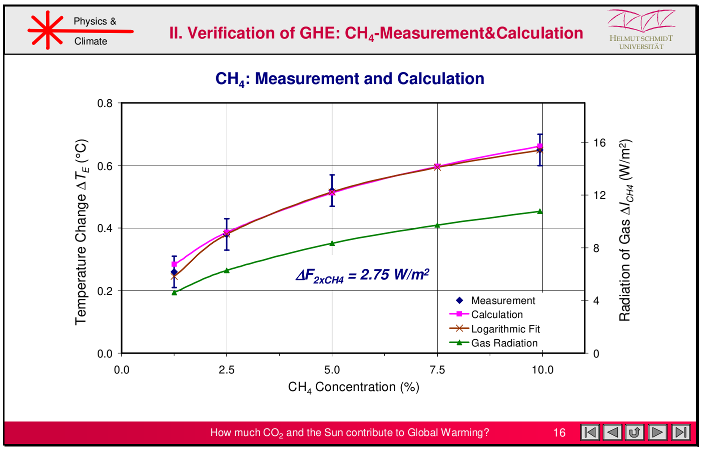
Also plotted is the calculated additional CO_2-emission as green graph. When this graph is multiplied by the previously measured temperature response factor λ_E of the earth plate and a transmission factor f_{CO2} of the CO_2-backradiation of 60%, which can be estimated from the radiation losses of the cold to the warm plate, we get the calculated temperature increase (Magenta curve).

Despite the short propagation path all graphs show clear saturation with increasing CO_2 concentration, and in the same way also the emission saturates at these concentrations. The measured and calculated temperature variation ΔT_E can well be represented by a logarithmic curve, shown as Brown graph, from which we derive a radiative forcing as intensity increase at doubled CO_2-concentration of 3.7 W/m^2.



An independent means for detecting the back-radiation is to measure the saved heating ΔH_E for the earth-plate when stabilizing this plate on a fixed temperature (30°C), while increasing the CO_2 concentration.

This is represented by the Blue Diamonds and can again directly be compared with the calculated CO_2 back-radiation times the transmission fraction.



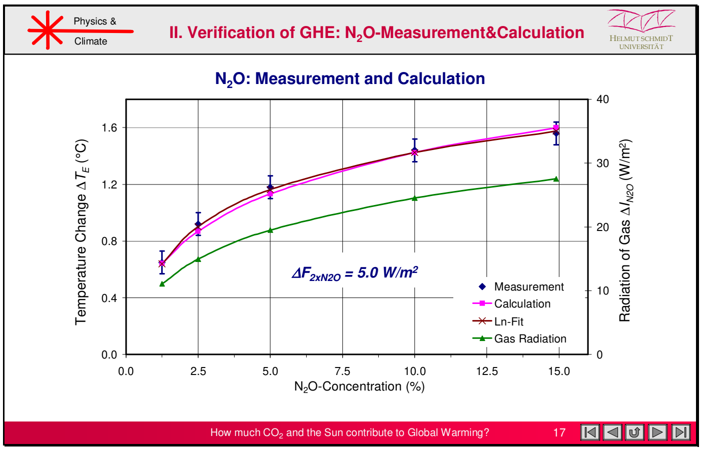
Similar measurements were performed for CH_4 and N_2O.

Also for CH_4 we see clear saturation with increasing concentration under these conditions and good agreement with the calculation.

The radiative forcing at doubled concentration is 2.75 W/m^2 and only 65% of CO_2 in contradiction to the radiative efficiency of CH_4 which is classified to be 25x larger than that of CO_2.

In this context we have to point to an often found misinterpretation concerning the global warming potential of methane. So, the radiative efficiency of CH_4 with 3.7x10^{-4} W/m^2/ppb is classified to be 25x larger than that of CO_2 with 1.4x10^{-5} W/m^2/ppb. Such values are derived when comparing the gases under completely different conditions: CH_4 at a concentration of 1.8 ppm and CO_2 at a 200x larger concentration, when it is already strongly saturated. Also the interference with other green-house gases, particularly with water vapor, is for both gases completely different.

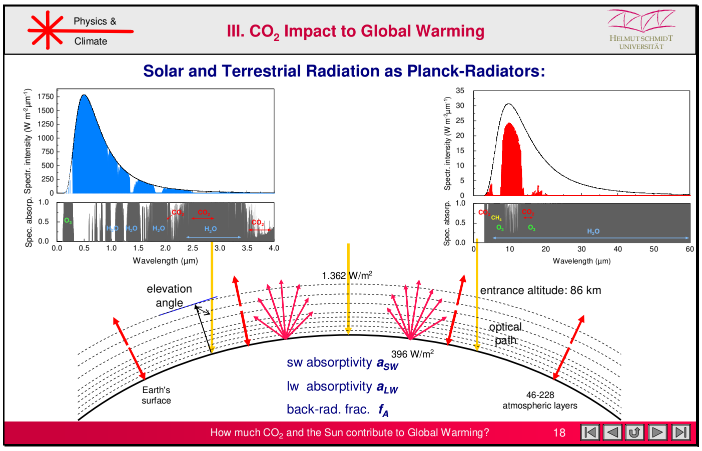
A more realistic consideration supposing a doubling each of the actual CH_4 and CO_2 concentrations shows that CH_4 does not contribute more than about 2% to global warming relative to CO_2 (see also hharde.de).



For N_2O we derive from measurement and calculation a radiative forcing at doubled concentration of 5.0 W/m^2, which is about 1.4x larger than CO_2.

At a concentration of 0.3 ppm in the atmosphere this contributes only about 1% relative to CO_2 to global warming.

So, as we see that the GHE is no Fata Morgana, it remains the decisive question: **How much can this effect contribute to global warming of the Earth?**

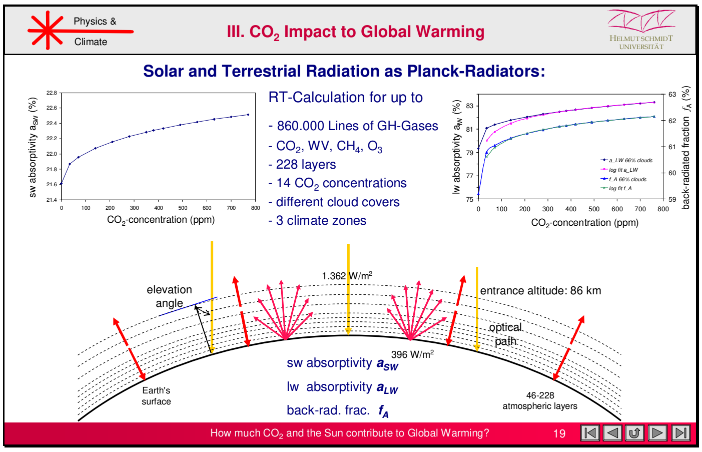


Section III

To answer this question requires to look closer to the specific features of the atmosphere. This means on the one hand we have to consider the incident solar radiation, which is absorbed by the GH-gases, and on the other hand what is absorbed from the terrestrial radiation.

These absorptions have to be calculated as sw and lw absorptivities (integral of spectral absorptivities – see plots) specified in % of the incident radiation which are both assumed as Planck-radiators (dashed lines) [4].

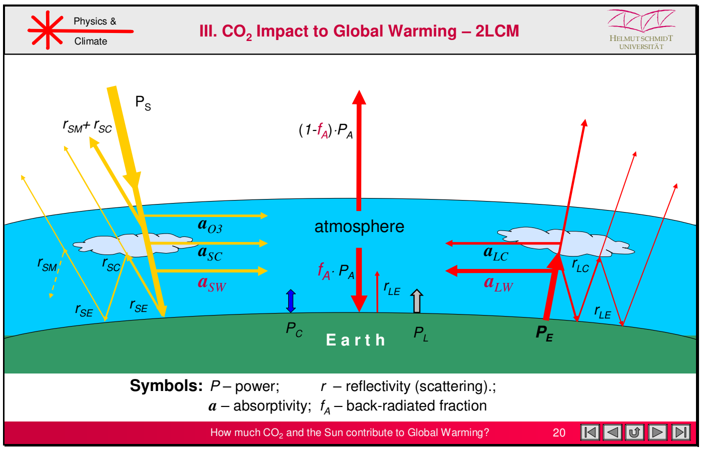
But important is also to know, what the atmosphere itself is reradiating from the absorbed power in upward and backward direction, which can be expressed as back-radiated fraction f_A.



This requires RT-calculations for up to 860,000 lines of the gases CO_2, WV, CH_4 and O_3, this for up to 228 layers due to the changing concentration, pressure and temperature and the propagation path through the atmosphere, this for 14 different CO_2 concentrations, for different cloud covers and 3 climate zones.

The sw and lw absorptivities as well as the back-radiated fraction are displayed as a function of the CO_2 concentration, all showing strong saturation, which can be well represented by logarithmic curves.

These are the key parameters, which determine the whole energy and radiation balance of the Earth-Atmosphere-System as a function of the CO_2 impact.

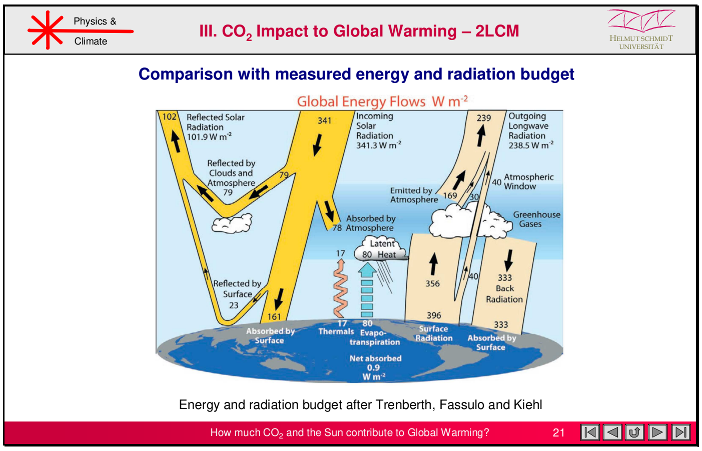


For this energy and radiation balance I use such a Two-Layer Climate Model (2LCM) consisting of the Earth's surface and the atmosphere with the sublayers to calculate the influence of an increasing CO_2 concentration and also the impact of solar variations on the climate.

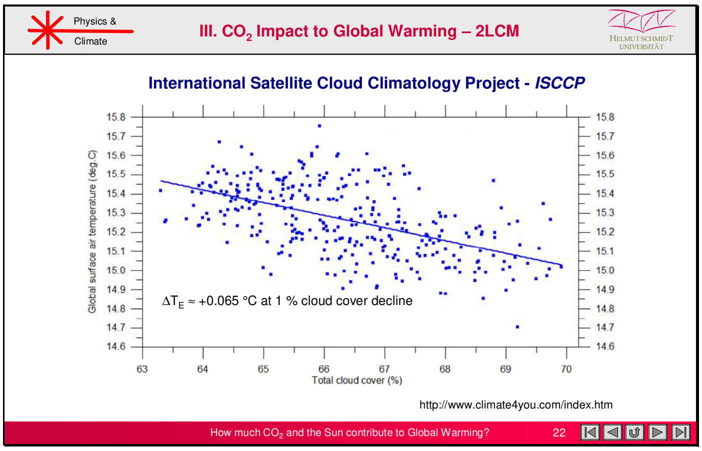
And different to some lavish Atmosphere-Ocean General Circulation Models or Earth-System-Models apparently it doesn't fail to prognosticate the actual temperature progression, as I'll demonstrate.

Additionally to the atmosphere also the Earth acts as absorber for sw and lw radiation and at the same time as source for lw radiation. At equilibrium both layers release as much power as they suck up from the Sun and the neighbouring layer. This gives a coupled balance equation system, which can be solved for the radiated power P_E of the surface and the emitted power P_A of the atmosphere. And with Stefan-Boltzmann the global mean temperatures at the surface, T_E, and of the atmosphere, T_A, are derived [2, 4].

The key parameters controlling the fluxes are indicated as red.

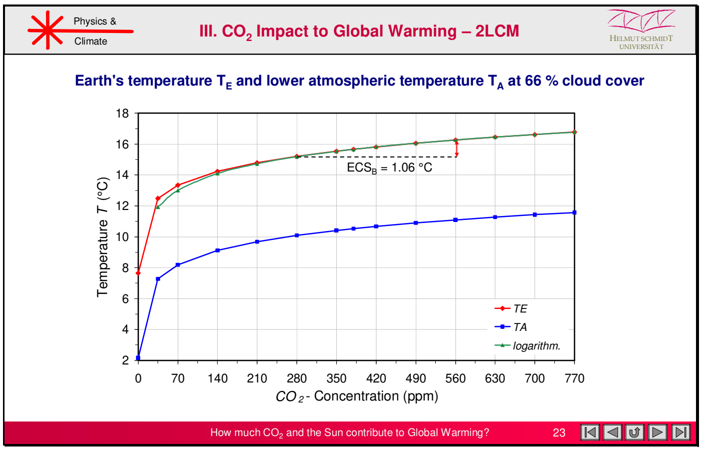


Some other parameters like scattering and absorption at clouds can be chosen within some bounds to calibrate the model to the widely accepted energy and radiation budget scheme of Trenberth, Fassulo and Kiehl.



In addition is the model adapted to the global temperature increase at reduced cloudiness as observed within the International Satellite Cloud Climatology Project (ISCCP) over the 80s and 90s of the last century (see also climate4you).

These data are used as a working or reference point, around which changes caused by CO_2 or the Sun are considered.

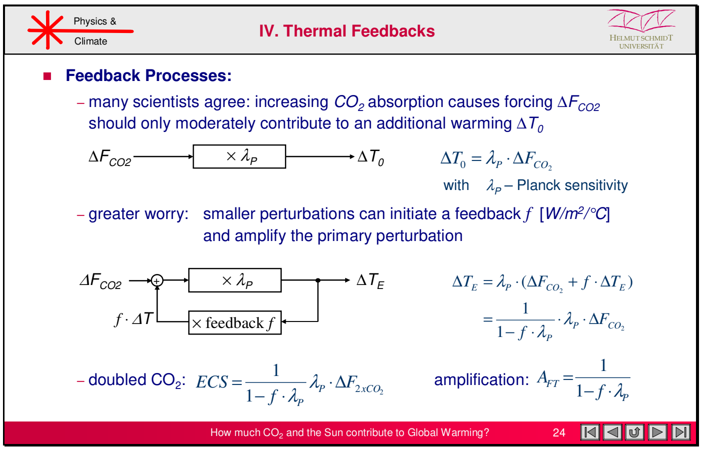


With this adapted two-layer model the direct influence of a changing CO_2 concentration on global warming can be simulated. The red graph represents the surface temperature and the blue the atmospheric temperature in about 800 m height. This is a calculation for a mean cloud cover of 66%.

These curves directly reflect the strong saturating behavior of CO_2 and the overlap particularly with WV lines at increasing CO_2 concentrations, which at higher concentrations can again well be represented by a logarithmic graph.

Doubling of the CO_2 concentration from 280 to 560 ppm gives the so called basic Equilibrium Climate Sensitivity as an important parameter to characterize the impact of CO_2 on global warming. From the 2LCM I get an ECS_B of 1.06°C, which is identical with the Coupled Model Intercomparison Project Phase 5 (CMIP5), although I'm using a significantly different accounting scheme.

In some way this is a direct confirmation of the correct own spectral calculations and their implementation in the 2LCM, and also a confirmation for a realistic ECS_B used by CMIP5. But from where are coming the unrealistically high values specified by the IPCC in their Assessment Reports 5 and 6 (AR5 and AR6)?



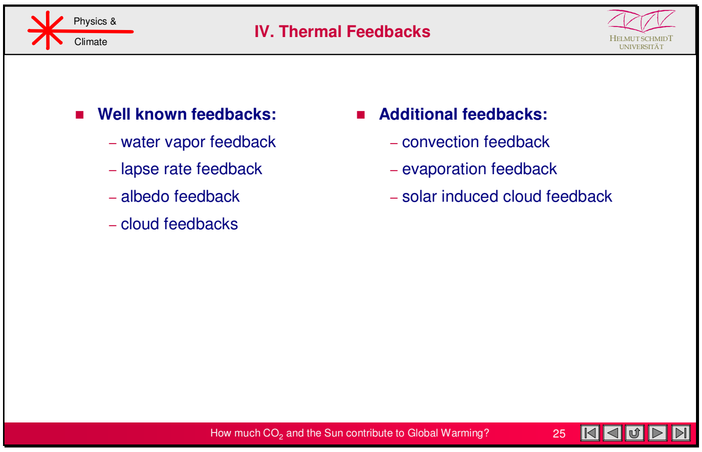
Section IV

Indeed, most of the climate scientists agree (see dashes), that an increasing CO2 absorption, causing a radiative forcing ΔF_{CO2}, alone would only moderately contribute to an additional warming ΔT_0, where λ_P is the Planck sensitivity or the climate sensitivity parameter.

The greater worry is that already smaller perturbations can initiate a feedback f (in units of $W/m^2/°C$), which significantly amplifies the primary perturbation, as represented by the lower block diagram and the relevant equation, which after transposition can be represented by an amplification factor A_{FT} and the basic forcing.

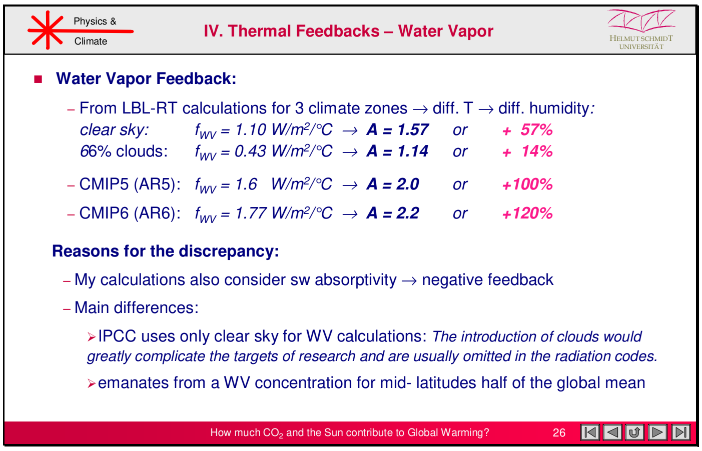
With the forcing for doubled CO_2 this gives the general equilibrium climate sensitivity *ECS* as the basic value times an amplification factor A_{FT} for thermal feedback [2, 4].

Indeed, the *ECS* is one of the most important but also most controversially discussed measures for the CO_2 influence, for which respective calculations diverge by more than a factor of 20 from about 0.4 up to more than 8°C. So, it's reasonable to look a bit closer to this quantity and from where these differences are coming from.



Well known feedback processes are the water vapor, lapse rate, albedo and cloud feedbacks.

Additionally I consider some phenomena, which are even not mentioned in the IPCC assessment reports or in most of the climate literature. These are convection, evaporation and solar induced cloud feedbacks.



Let's briefly look to WV feedback.

From detailed LBL radiation transfer calculations for different climate zones and thus different temperatures and humidity I calculate a water vapor amplification at clear sky of 1.57 and at average overcast of only 1.14 or +14%, much smaller than the values used in CMIP5 with an amplification of 2, or +100%, and in CMIP6 with even 120%.

The reasons for this discrepancy are threefold:

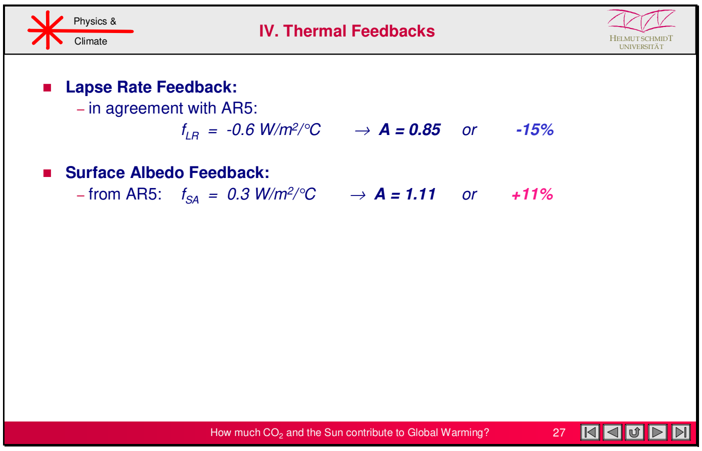
My calculations also consider the sw absorptivity, which causes a negative feedback and apparently is not considered in the other models.

The main differences, however, go back to determine changes of the lw absorptivity with temperature and humidity.

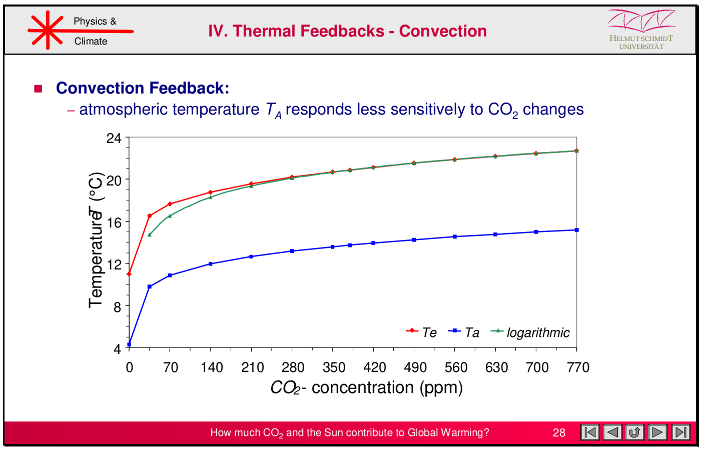
So, the IPCC calculations are for clear sky. In AR5 we can read: *The introduction of clouds would greatly complicate the targets of research and are usually omitted in the radiation codes*.

And these models emanate from a WV concentration for mid-latitudes, which is half of the global mean.

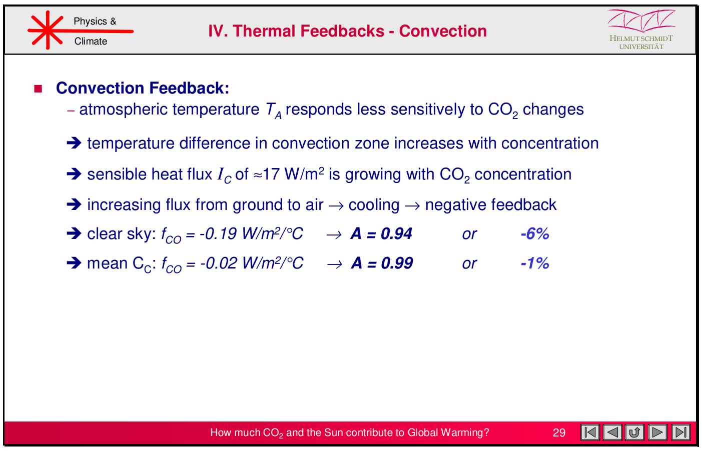
Both contribute to a lower saturation on the WV lines and therefore a much larger variation with the WV concentration and temperature.



For the lapse rate and albedo feedback - one slightly negative, the other slightly positive - I use the data published in literature with these numbers.



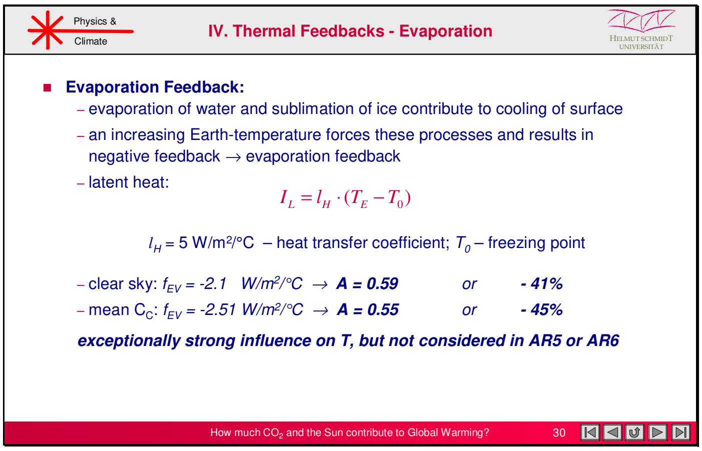
In addition to these standard effects we see from our simulations that the air temperature is less sensitively responding to CO_2 concentration changes than the Earth temperature.



Therefore, the temperature difference in the convection zone is further growing with ascending CO_2 concentration.

Thus, also the sensible heat flux is growing with the concentration, which altogether results in a negative feedback.

A more detailed consideration shows that this feedback is larger for clear sky and almost vanishes at mean cloud cover.

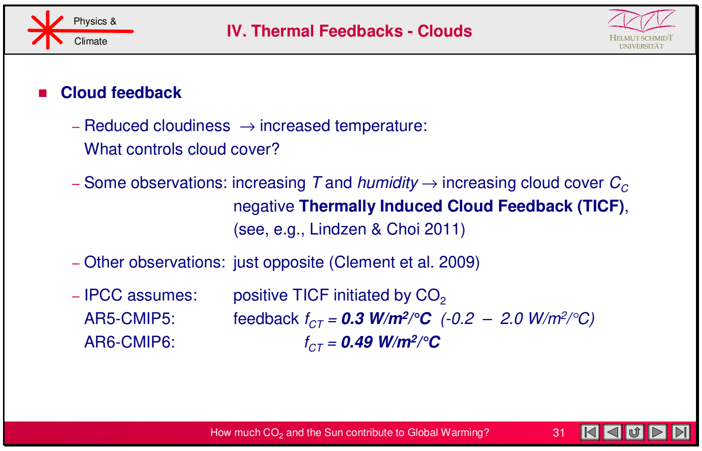


Similar to convection also evaporation of water and sublimation of ice contribute to cooling of the surface.

Since an increasing Earth temperature further forces these processes, they also result in a negative feedback, which we call evaporation feedback.

In first order the latent heat flux is proportional to the difference of the Earth-temperature to the freezing point T_0 (Kirchhoff-equation). With a heat transfer coefficient of 5 W/m^2/K this contributes to significant negative feedback of 45%.

Although this feedback has an exceptionally strong influence on the adjusting temperature levels, it is not considered or mentioned in AR5 or AR6.



Finally we have to look to the influence of clouds on global warming.

As we saw, reduced cloudiness increases the temperature. But this gives no answer, why the cloud cover is changing over some time period.

Some observations report (see dashes) that with increasing temperature and humidity also the cloud cover increases and then contributes to negative cloud feedback, this particularly in tropical areas (see, e.g., Lindzen & Choi 2011).

Other observations just report the opposite (Clement et al. 2009).

So, this feedback constitutes by far the primary source of spread. The IPCC assumes that it is driven by CO_2 induced temperature changes and specifies this feedback within extremely wide margins from -0.2 to 2.0 W/m^2/°C. CMIP5 uses a model mean of 0.3 W/m^2/°C, while CMIP6 further increased it to 0.49 W/m^2/°C.

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IV. Thermal Feedbacks

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	CMIP5			CMIP6			2LCM		
λ_P (°C/W·m^2)	0.313			0.311			0.319		
ΔF_{2xCO2} (W/m²)	3.39			3.93			3.32		
ECS_B (°C)	1.06			1.22			1.06		
feedbacks	f_k W/m²/°C	A_k	ΔT_k °C	f_k W/m²/°C	A_k	ΔT_k °C	f_k W/m²/°C	A_k	ΔT_k °C
water vapor f_{WV}	1.6	2.0	1.06	1.77	2.22	1.5	0.38	1.14	0.14
lapse rate f_{LR}	–0.6	0.84	–0.17	–0.50	0.87	–0.16	–0.6	0.84	–0.17
surf. albedo f_{SA}	0.3	1.10	0.11	0.35	1.12	0.15	0.3	1.11	0.11
clouds therm f_{TC}	0.3	1.10	0.11	0.49	1.18	0.22	0.3	1.11	0.11
convection f_{CO}							–0.02	0.99	–0.01
evaporation f_{EV}							–2.51	0.55	–0.47
total feedbacks by CO_2	f_{TG} W/m²/°C	A_{FT}	*ECS* °C	f_{TG} W/m²/°C	A_{FT}	*ECS* °C	f_{TG} W/m²/°C	A_{FT}	*ECS* °C
	2.14	3.01	**3.2**	2.18	3.10	**3.78**	-1.77	0.64	**0.68**

How much CO_2 and the Sun contribute to Global Warming? 32

Altogether this gives this compilation on the one hand for the Coupled Model Intercomparison Project Phase 5 and 6, on the other hand for the own calculations with the 2LCM at mean cloud cover.

This table is from the SCC paper with the CO_2 and solar radiative forcing and shall not be discussed here in detail, but the yellow fields show the big differences on the one hand between CMIP5 and 6 and on the other hand my own calculations for the 2LCM.

The main discrepancies result from the smaller WV and negative evaporation feedback. At mean cloudiness I get a very moderate *ECS* of only 0.68°C, which is more than 5x smaller than the CMIP6 value.

And there is a principal deficit that the thermally induced cloud feedback cannot explain the observed cloud cover changes measured within the International Satellite Cloud Climatology Project. This would require a cloud feedback of more than 2 W/m²/°C and result in an unrealistically high *ECS* between 15° and 18°C for the CMIP-models, while it would contribute to a moderate *ECS* of 1.2°C for the 2LCM.

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V. Solar Influence

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- **Strong indication for other mechanisms affecting cloud changes**
  - Over last century: Modern Grand Solar Maximum with ΔTSI of ≈ 3 ‰ (e.g. Shapiro et al. 2011, Scafetta&Willson 2014)
  - Observations: The amount of clouds varies over the solar cycle: is an indication that solar activities also modulate the cloud cover
- **Solar Cloud Changes:**
  - **Cosmic Rays** – Henrik Svensmark, Shaviv et al.: Cosmic flux affects formation of water droplets in the lower atmosphere. Increasing solar activity and thus solar magnetic field deflects cosmic flux → increasing TSI reduces cloud formation.
  - **Hyper-sensitivity to UV-Rays** – Joanna Haigh: increased UV-radiation activates ozone production and heat transfer → acts back on cloud formation

How much CO_2 and the Sun contribute to Global Warming? 33

Section V

All this is a strong indication that apparently still some other mechanism has to be made responsible for the observed cloud changes and additional warming, in first position the Sun, which for more than 4 Bill. years controlled the climate.

Dashes:

So, solar observations indicate that over the last solar cycles from 1950-2000 we had a modern grand solar maximum, and over the last century the Total Solar Irradiance (*TSI*) was increasing by about 3 ‰.

From observations we also know that the amount of clouds varies over a solar cycle. This suggest that not only the temperature but also solar activities directly modulate the cloud cover.

One mechanism, proposed by Hendrik Svensmark and colleagues, is that the cosmic flux affects formation of water droplets in the lower atmosphere. So, an increasing solar activity and thus solar magnetic field deflects the cosmic flux, and therefore, an increasing TSI reduces the cloud formation.

Another mechanism, suggested by Joanna Haigh, is that increased UV-radiation activates the ozone production and finally acts back on the tropospheric circulation and cloud formation.

Physics & Climate

V. Solar Influence

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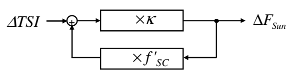
- **Equilibrium Solar Sensitivity *ESS*:**
  - Increase of *TSI* by 1‰ → $ESS_B = \lambda_{Sun} \cdot \Delta TSI = 0.09$°C (basic solar sensitivity)
  - Additionally amplified by solar cloud changes: ⇒ **Solar Induced Cloud Feedback (*SICF*)**



$\Delta F_{Sun} = A_{SC} \cdot \Delta TSI$

↑ solar cloud feedback

- Over 80s and 90s clouds decreased by 4% (ISCC-Project).
- ERBS-data over this interval: $\delta TSI \approx +0.5$ - 1‰ (Willson&Mordvinov, 2003)
- These data inserted in 2LCM gives:

for $\boldsymbol{\delta TSI = 0.5‰ \rightarrow A_{SC} = 5.7 \;\Rightarrow\; ESS = A_{SC} \cdot ESS_B = 0.51°C}$

$\delta TSI = 1‰ \rightarrow A_{SC} = 3.5 \;\Rightarrow\; ESS = A_{SC} \cdot ESS_B = 0.31°C$

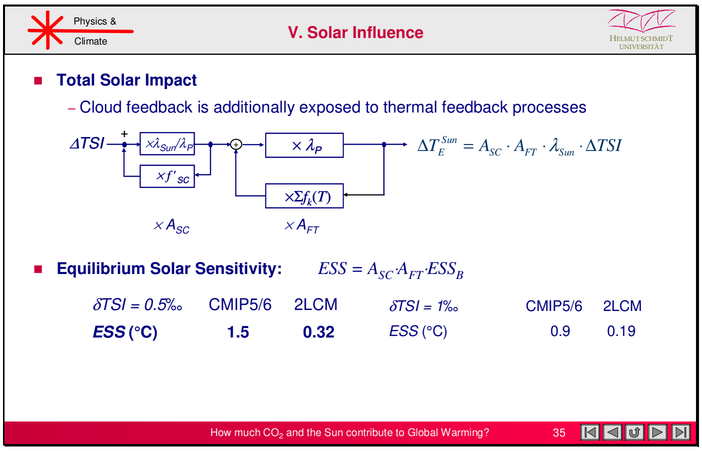
How much CO_2 and the Sun contribute to Global Warming? 34

Similar to the *ECS* we can define an Equilibrium Solar Sensitivity *ESS*. This is the temperature increase, when the *TSI* is rising by 1‰. From the 2LCM we find an increase of 0.09°C and a solar sensitivity parameter λ_{Sun} = 0.065°C/Wm². This defines the basic equilibrium climate sensitivity ESS_B .

Additionally any varying *TSI* can further be amplified by cloud changes. We call this *Solar Induced Cloud Feedback* (SICF) with an amplification A_{SC} of the solar radiative forcing, which determines the Earth heating.

Over the 80s and 90s the clouds decreased by about 4%, and the Earth-Radiation-Budget-Satellite (ERBS) project over this period shows an increasing *TSI* of 0.5 - 1‰.

Inserting these data into the 2LCM we find for δTSI = 0.5‰ an amplification by SICF of *Asc* = 5.7 and an *ESS* = 0.51°C, for δTSI = 1‰ an amplification of *Asc* = 3.5 and an *ESS* = 0.31°C.

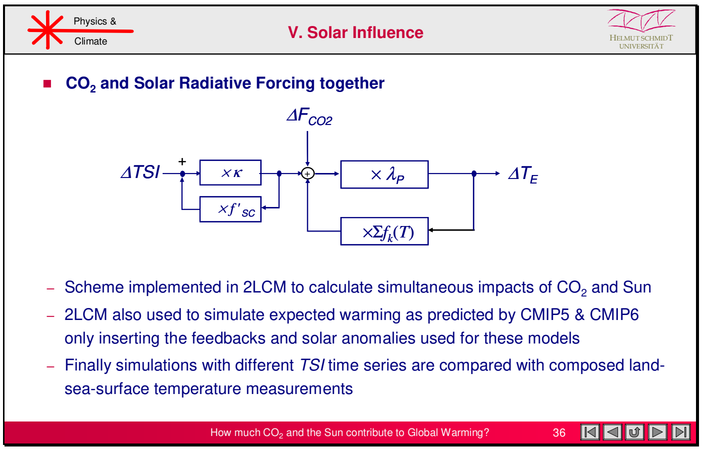


But this solar induced forcing and respective heating is exposed to the same thermal feedbacks as the CO_2 radiative forcing and additionally amplified or attenuated by these processes .

So the respective block diagram represents two successive feedbacks with the amplifications A_{SC} and A_{FT}.

Finally we get an *ESS* as product of these amplifications and the basic ESS_B value, which with δTSI = 0.5‰ gives a temperature increase for the CMIP5/6 models of 1.5°C and for the 2LCM of only 0.32°C, which is one fifth.

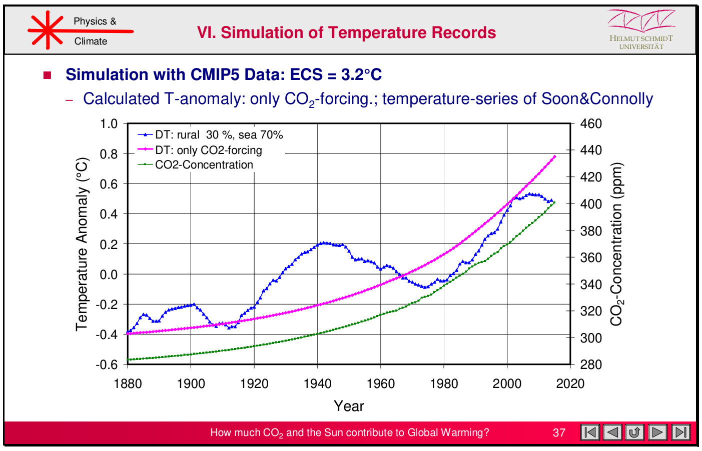
For the larger assumed ERBS-value of 1‰, ESS reduces to 0.9 and 0.19°C.



This diagram shows the combined CO_2 and solar radiative forcing and is implemented in the 2LCM to calculate the simultaneous impacts of the two forcings [2].

The 2LCM can also be used to simulate the expected warming as predicted by the CMIP5 & 6 models, only inserting the respective feedback data. This should work reliably well, all the more the deduced basic ECS was identical with the CMIP5-value.

And finally these simulations with different *TSI* time series are compared with composed land-sea-surface temperature measurements to derive from this comparison the contribution of CO_2 and solar global warming.

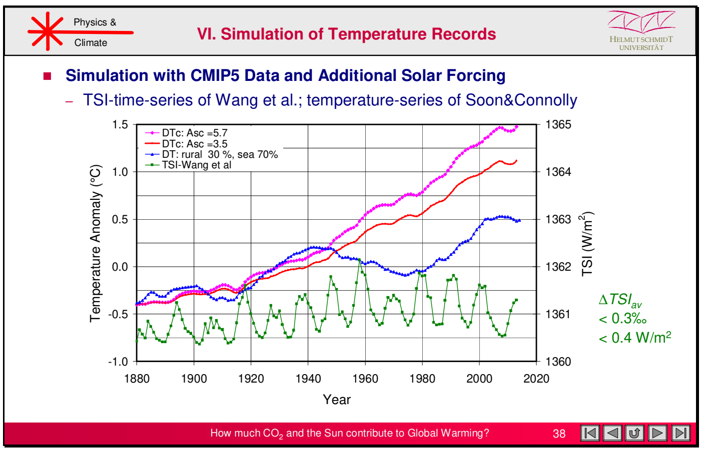


Section VI

First we are looking only to the calculated temperature anomaly caused by CO_2 radiative forcing, as it can be expected from the CMIP5 data but simulated with the 2LCM. This is shown as Magenta Graph.It follows strictly the Green Graph which represents the averaged CO_2 concentration derived from paleontological and Mauna Loa data.

With an equilibrium climate sensitivity of 3.2°C the predicted temperature increase, particularly since 2000, is larger than the composed rural and sea surface temperature series of Soon & Connolly [5], shown as Blue Triangles.

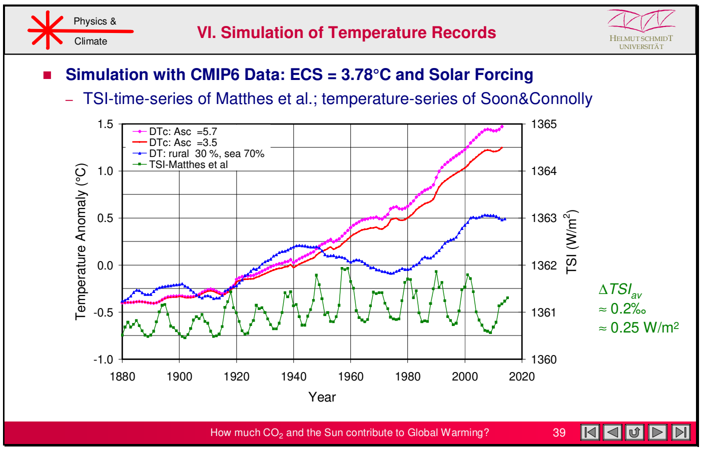
Especially the stronger modulation in the middle of the century and a declining temperature from the 40s to 80s cannot be explained by a purely monotonic CO_2 increase.



Including also solar forcing this discrepancy to observations is even further increasing, although most CMIP5 models only consider the very flat TSI-time-series of Wang et al., shown as Green Graph with a solar variation of less than 0.3‰ (< 0.4 W/m2) after averaging over the Schwabe cycles.

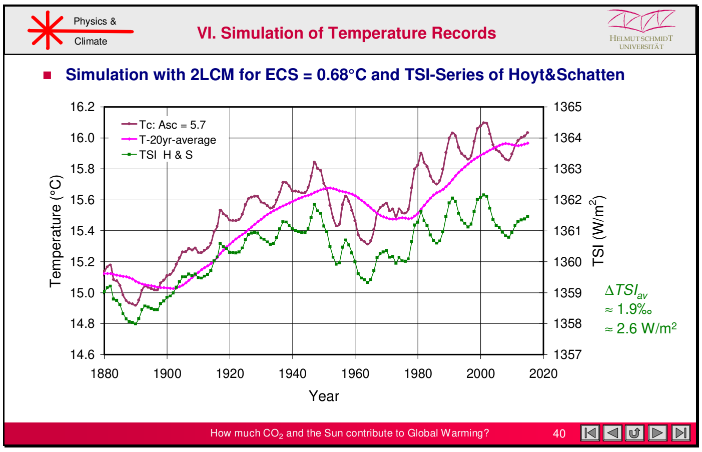
With such a low and flat solar forcing, which shall also explain the cloud changes over the 80s and 90s, this requires at least a solar induced cloud feedback of *Asc* = 5.7, displayed as Magenta Diamonds.

The increasing discrepancy to observations is obvious, even with a smaller cloud feedback of 3.5 as Red Graph.



The analogous simulation for the CMIP6 data with an even larger *ECS* value but a still flatter *TSI*-time-series of Matthes et al. is shown on this slide again as Green Graph. This *TSI*-series was officially recommended for the CMIP6 models, surely to limit the natural impact as far as possible and not to further increase the discrepancy to observations. At the time of the CMIP5 studies this TSI-series was not available. Otherwise it might have been used already for CMIP5.

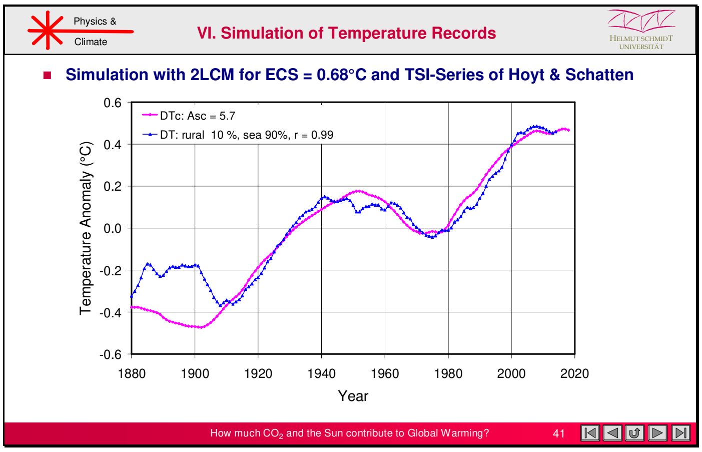
Therefore, the simulation is strongly dominated by the CO_2 forcing with an *ECS* of 3.8°C, while the amplification by solar induced cloud feedback with 3.5 or 5.7 only gives a relatively small correction, and the overall increase is similar to CMIP5.



A completely different situation we find for a simulation with the own thermal feedback data yielding an *ECS* of 0.68°C and using the *TSI* time series of Hoyt & Schatten with a solar variability of about 2.6 W/m^2 over the last century and a pronounced decline over the 40s to 60s.

This series is shown in Green and the calculated temperature, including both forcings is represented in Plum. It displays the non-averaged temperature trend to compare this directly with the *TSI* series and to demonstrate how the calculation closely tracks the solar variations.

Additionally reveals this figure the smoothed data as running average over 20 yrs as Magenta Diamonds, clearly exposing the phase shift mainly expected due to the delayed response by the oceans.



Without any fitting of the parameters, only using the derived *ECS*- and *ESS*-values, this gives this excellent agreement with the observed temperature time series, which is a composition of rural data with a weighting of 10% and of the sea surface data from the Hadley Centre HadSST 4.0 with a weighting of 90%.

A larger deviation is only found at the end of the 19th century and might be explained by an internal oscillation like the Atlantic Multi-Decadal Oscillation.

Comparison from 1910 upward gives a correlation of 99% and different to the CMIP-simulations can well reproduce the temperature drop around 1970 and also the total temperature increase over the last 140 years.

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VI. Simulation of Temperature Records

- **Total Temperature Balance:**
  - **CO_2 warming over last century**:
    82 ppm CO_2 at ECS = 0.68°C → ΔT_{CO2} = **0.24°C** → *30%*
  - **Solar warming over last century**:
    with *ΔTSI = 1.9‰ and ESS = 0.32°C* → $\Delta T_{Sun} = \Delta TSI \times ESS$ = **0.60°C** → *70%*
  - ➢ **Full agreement with observed temperature increase: 0.84°C**
  - ➢ **Full agreement with observed cloud cover changes**
- **Simulations give no evidence for combined CO_2 and solar forcing, but**
  - observations much better reproduced with stronger solar impact
  - thermal feedbacks of CMIP5/6 are too large

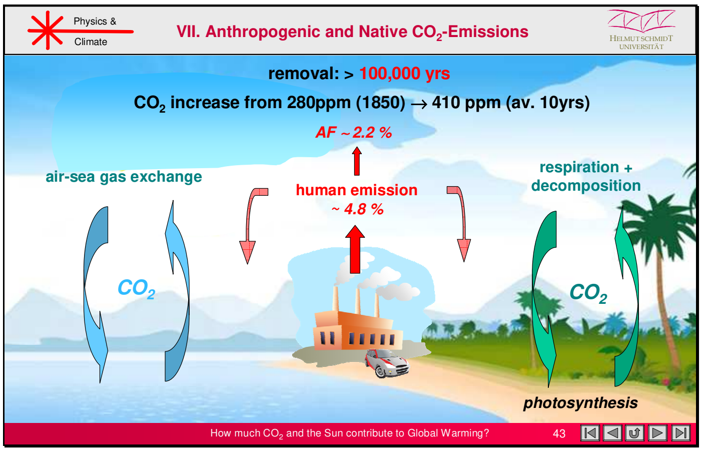
How much CO_2 and the Sun contribute to Global Warming? 42

When we look to the individual contributions to global warming based on this calculation, we find for a CO2 increase of 82 ppm over the last century and with an equilibrium climate sensitivity of 0.68°C a temperature increase of 0.24°C.

For the solar radiative forcing with Δ*TSI* = 1.9‰ and an equilibrium solar sensitivity of 0.32°C this gives additional 0.6°C, together 0.84°C, in full agreement with the observation and cloud cover changes.

So, the Sun contributes to 70% and CO_2 only to 30% to global warming over the last century and in a similar way also over the whole Industrial Era.

Of course, such a simulation is no evidence that the combined CO_2 and solar radiative forcing and its implementation in the 2LCM is the only right explanation for the observed global warming, but it clearly shows that the observed temperature time series can much better be reproduced with this stronger solar influence, and that even without this impact the assumed thermal feedbacks of the CMIP5/6 models are much too large and have no chance to explain the temperature modulation over the mid century (see also Scafetta 2021).



Section VII

After these longer excurses about the climate sensitivity and feedbacks still a few remarks to the IPCC claim, that the observed CO_2 increase is exclusively man-made (see [3]).
The official IPCC version is that the carbon cycle has come out of balance, although humans contribute less than 5 % to the total CO_2 emissions. IPCC assumes that the uptake of anthropogenic emissions is only slightly more than 50%, the rest, the so called Airborne Fraction (AF) cumulates in the atmosphere.

This is made responsible for the rapidly rising atmospheric CO_2 concentrations, which in 1850 were about 280 ppm and over the Industrial Era increased by about 130 ppm.

The removal of this additional *CO_2* from the atmosphere by natural processes is expected to take up to a *few hundred thousand years*, even when anthropogenic emissions could completely be stopped.

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VII. Anthropogenic and Native CO_2-Emissions

- **Some inconsistencies of the IPCC interpretations:**
  - Apparently variations in native emissions (seasonal cycles, volcanic activities, El Niños, permafrost) are neglected or directly compensated, but human emissions are accumulating up to several 100,000 yrs
    ⇒ violation of equivalence principle.
  - Absorption of native emissions happens with residence time $\tau_R \approx 3$ yrs, but anthropogenic emissions require adjustment times up to $\tau_A \approx 1$ Mio yrs
    ⇒ violation of equivalence principle.
  - ≈ 52-55% of human emissions are absorbed, rest remains in atmosphere (AF): but absorption ~ emission, not ~ concentration as in all native processes
    ⇒ contradicts basic physical understanding.
  - Bern-Model considers 5 different decay times, again with absorption ~ emission
    ⇒ violates principle of parallel absorption channels: $1/\tau_R = \alpha_R = \alpha_1 + \alpha_2 + \ldots + \alpha_n$

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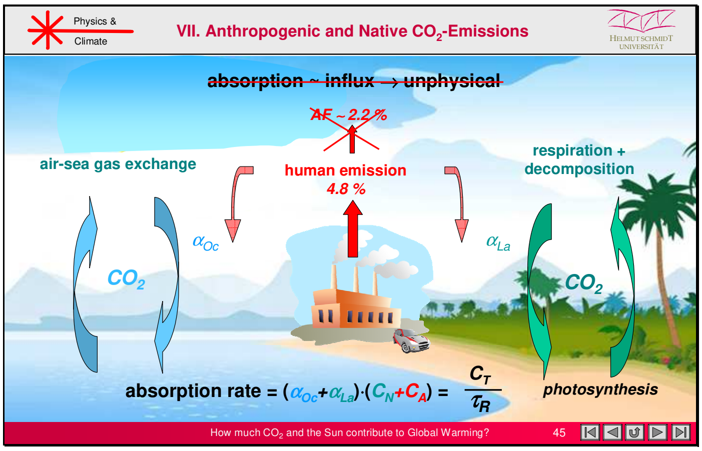
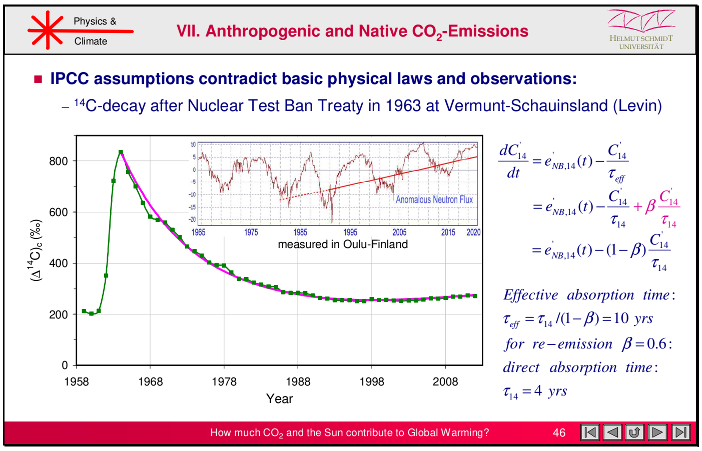
Chart self-explaining



Summarizing again the main differences to the IPCC illusion shows:

- the absorption is not proportional to the influx,
- the same sinks work for native and anthropogenic emissions,
- these sinks work parallel with the respective oceanic and land absorptivities defining one common decay time τ_R,
- the only physical law, which stabilizes the CO_2 content in the atmosphere and makes sure that the system can come to equilibrium, is a first order absorption process, proportional to the CO_2 concentration.

This process worked before 1750 in the same way as over the industrial Era and this with only one single residence time of about 3-4 yr.



The first order absorption process is directly confirmed by measurements of the radiocarbon perturbation after the Nuclear Test Ban Treaty in 1963, here plotted as normalized C14-anomaly at Vermunt-Schauinsland. It indicates that the increased 14C-concentration obeys an almost single exponential decay with an e-folding time τ_{eff} = 10 yrs.

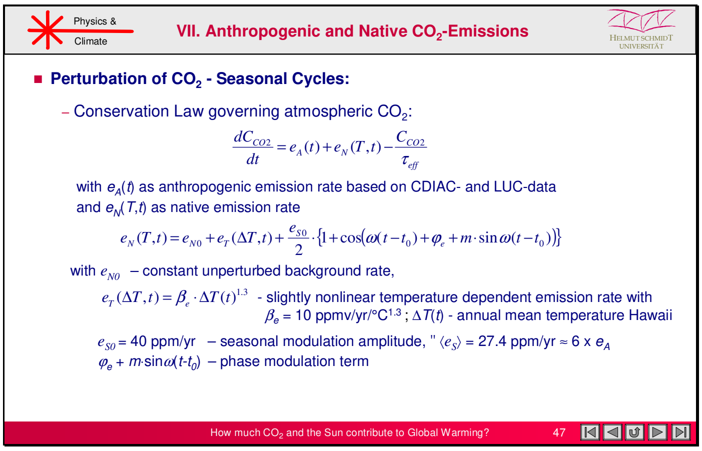
This decay is the result of the balance equation for the C14-concentration, on the one hand with the natural emission rate e_{NB} caused by the cosmic neutron flux converting nitrogen atoms to C14 in the stratosphere, and on the other hand the absorption rate C_{14}/τ_{eff}.

Only with the end 90s we see a slight increase, which can be explained by an increasing cosmic neutron flux, as measured in Oulu, and an inclining C14 production by nuclear power plants.

The effective absorption time already accounts for a partial re-emission of directly absorbed C14 with a time constant τ_{14}. When these molecules are not completely removed from the upper layers, they can still be re-emitted with a fraction β.

Therefore, τ_{eff} is $\tau_{14}/(1-\beta)$, and for 10 yrs and, e.g., β = 0.6 the direct absorption time is only 4 yrs.

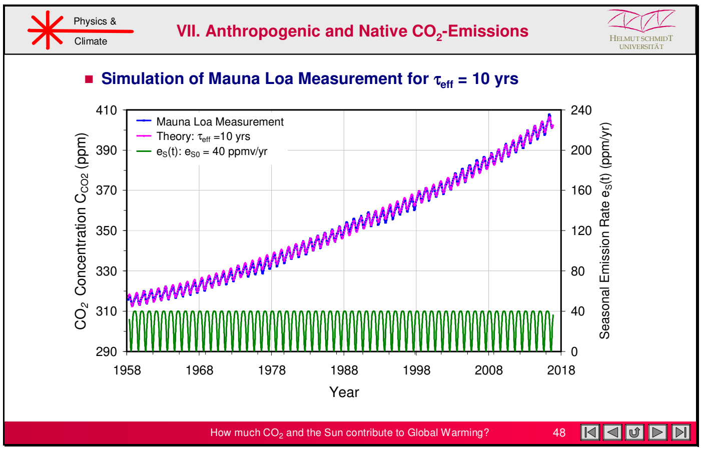
What we find for C14 as tracer also holds for the total CO_2 cycle.



An independent confirmation of the effective and direct absorption time we can derive from the total balance of atmospheric CO_2 , in particular when looking closer to the seasonal cycles.

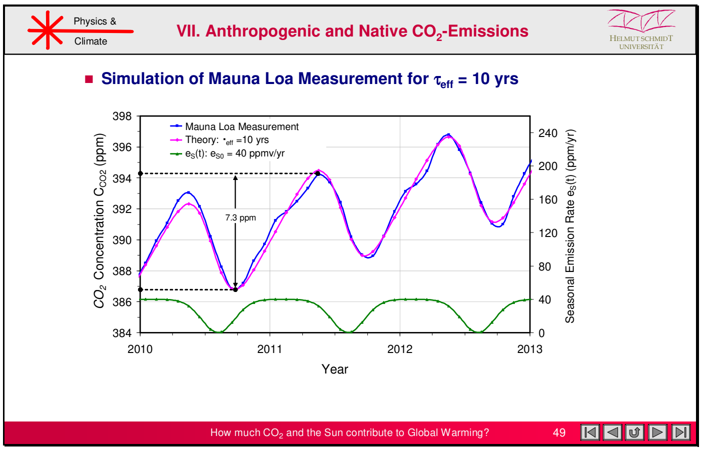
Starting from the Conservation Law for all CO_2 isotopologues in the atmosphere with

- e_A as anthrogogenic emission rate based on the CDIAC-data and Land Use Change and on the other hand the natural emissions e_N with
- a smaller unperturbed background rate e_{N0},
- a slightly nonlinear temperature dependent emission rate with ΔT as the temperature anomaly at Hawaii and
- a seasonal cycle with an amplitude e_{S0}, which due to the asymmetry corresponds to an average emission of 27 ppm/yr. After all, this is even about 6 times the anthropogenic emission rate.
- The asymmetry in the seasonal emission is considered as a phase modulation term.



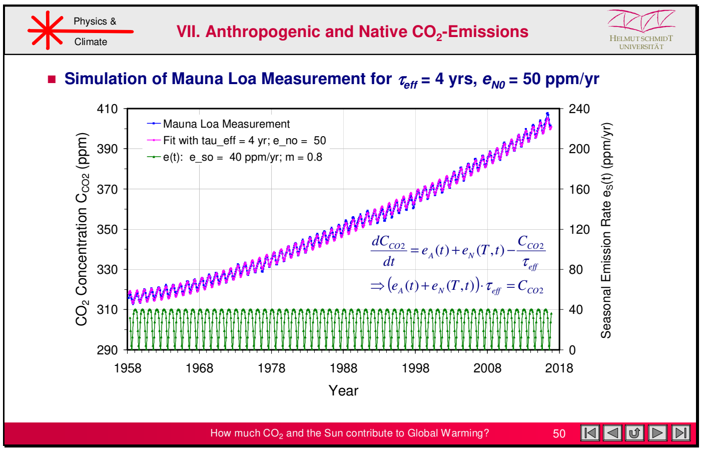
A simulation with these data is shown as Magenta graph and gives this excellent agreement with the Mauna Loa measurement, which is displayed in Blue.

The seasonal emission rate is shown as Green graph.



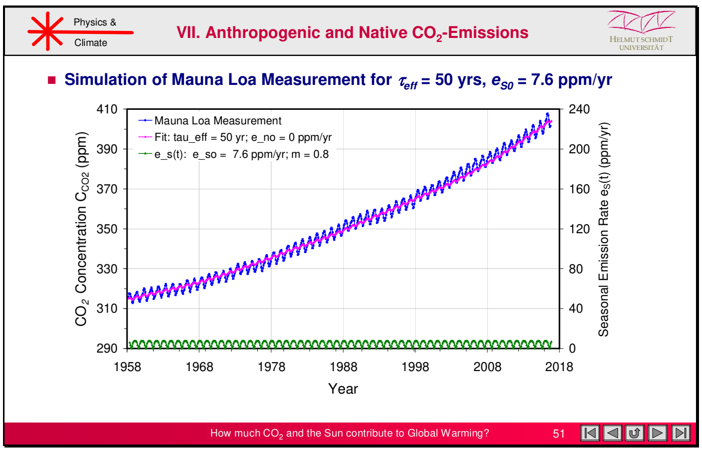
Even on a magnified scale tracts the calculation the measurement well in amplitude and shape, where the latter is controlled by the phase modulation of the seasonal emissions.

Within some bounds this observed evolution on the shorter and longer time scale can also be recovered for other values of the emission rate and absorption time.



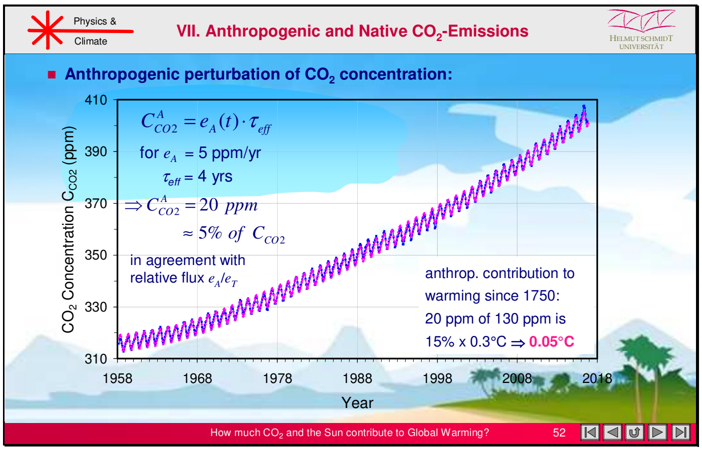
This plot demonstrates a simulation for an effective absorption time of 4 yrs, where a faster decay, mainly of the average seasonal emissions, is essentially compensated by a larger constant back-ground emission e_{NO}, which is increased to 50 ppm/yr, while the modulation amplitude is the same.

This variation within some bonds is a consequence of the fact that the CO_2 concentration at equilibrium is essentially determined by the product of the total emission and the absorption time. A change in one can therefore be compensated by a change in the other.



However, and very important, the observed evolution of CO_2 is recovered only for *τ_{eff} shorter than 10 -11 yrs.* For larger absorption times like here for 50 yrs, either the long time evolution is increasing too rapidly, even for a zero background emission e_{NO}, or when reducing the seasonal amplitude to compensate for the faster overall growth, the seasonal modulation depth gets too small.

So, these simulations represent an independent but consistent possibility to the C14-decay to derive an upper limit for the absorption time, which can only be shorter than 10 years.



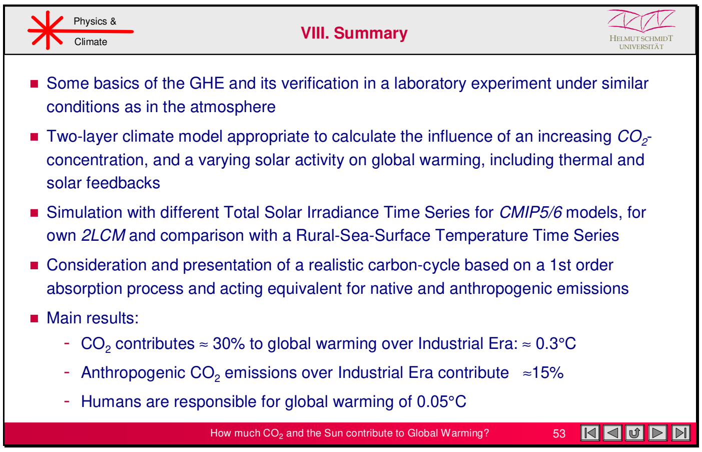
The anthropogenic fraction C^A_{CO2} of the CO_2 concentration at quasi equilibrium conditions is given as the product of the anthropogenic emission rate times the effective absorption time.

For example, for τ_{eff} = 4 yrs, anthropogenic emission, even as great as its recent maximum of 5 ppm/yr, could perturb CO_2 by no more than 20 ppm, which is less than 5% and agrees well with the simple balance that at equilibrium the relative anthropogenic and native contributions in the atmosphere are determined by their relative emissions, independent of the absorption time.

In comparison to a CO_2 increase over the Industrial Era with about 130 ppm the anthropogenic fraction of 20 ppm is not more than 15%.

So, when CO_2 caused a global temperature increase of about 0.3°C over this period and only 15% of this CO_2 is of anthropogenic origin, humans are responsible for a temperature incline of not more than 0.05°C.

And to further reduce this absolutely negligible contribution we endanger a secure energy supply and with this a prospering economy and stable standard of living.



Section VIII

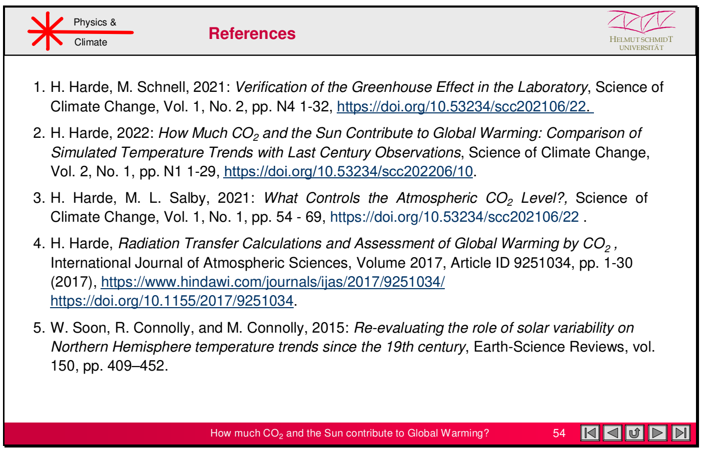
In summary, we have discussed

- some basics of the GHE and presented laboratory experiments under similar conditions as in the atmosphere to verify the GHE.
- I have explained a two-layer climate model appropriate to calculate the influence of an increasing CO_2-concentration, and a varying solar activity on global warming, including thermal and solar feedbacks.
- The simulations with different Total Solar Irradiance Time Series for the CMIP5/6 models and the own 2LCM were compared with a combined Rural-Sea-Surface Temperature Time Series.
- I have presented a realistic carbon-cycle based on a 1st order absorption process which is acting equivalent for native and anthropogenic emissions.

And as main results we can summarize:

- CO_2 contributes ≈ 30% to global warming over Industrial Era, which is ≈ 0.3°C.
- Anthropogenic CO_2 emissions over Industrial Era contribute ≈15%.
- Humans are responsible for global warming of *0.05°C*

The GH-experiments were performed by Michael Schnell. For the carbon-cycle I had a close collaboration with Murry Salby.



References

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Some thoughts for managing easier the journal.