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# Radiative and Convective Heat-Transfer in the Atmosphere: Some Basic Laboratory Studies

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## Abstract

This study uses a specialized laboratory configuration to examine how strongly convection can influence atmospheric radiation effects and to what extent greenhouse gases are causing warming or cooling under controlled conditions. A cylindrical apparatus is used, containing a heated, blackened aluminum plate that represents the Earth's surface. This plate can be positioned either below or above the cooler cylinder wall, thereby enabling or suppressing convection. Adding controlled concentrations of the test gases HCG (hydrocarbon gas, a propane/isobutane mixture), CO<sub>2</sub>, and argon, the interaction of radiation emitted by the plate with the gases and the resulting feedback to the plate is investigated. The results vary noticeably depending on the plate's position and measurement duration. With the plate at the bottom, initially a strong temperature increase is observed. This is often falsely interpreted as greenhouse effect but is actually caused by temporarily suppressed convection due to the added gases. It is also demonstrated that the prerequisite for an atmospheric greenhouse effect – whether warming or cooling – is the presence of a temperature gradient along the radiation path. Although the experimental setup can only demonstrate part of the competing heat fluxes in the atmosphere, the results already show how these fluxes can relativize the influence of infrared-active gases.

**Keywords:** Greenhouse effect; radiative transfer; convection; infrared-active gases.

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## 1. Introduction

To get an idea of the Greenhouse Effect (GHE), one usually starts with the question: What would the Earth's temperature be without Greenhouse Gases (GHGs)? Under somewhat contradictory assumptions – on the one hand considering clouds, which shouldn't exist at all without water vapor as the strongest greenhouse gas, and on the other hand, neglecting their significant influence on the GHE – the answer is -18 °C. And the difference of about 34 °C to the actual (but also disputed) average Earth temperature of approximately +16 °C then would be the GHE?

Whether these figures are right or wrong will not be discussed here, but rather a fundamental misunderstanding has to be addressed. The real question about the magnitude of the GHE should refer to a planet without an atmosphere, and therefore without clouds and aerosols, without water evaporation and no biosphere, but with an average surface albedo of about 12%, comparable to the Moon. An average temperature of about -4 °C would be expected, resulting in a greenhouse or better atmospheric effect (see also Koutsoyiannis & Tsakalias, 2025 [1]) of only about 20 °C, which is 14 °C less than is often attributed solely to GHGs.

All the unique characteristics of the blue water planet are responsible for the fact that the Earth's average temperature differs significantly from that of other planets without an atmosphere, allowing life to develop on Earth in the way we know it.

The atmosphere is also what regulates the limitations, meaning that only about half of the solar radiation can reach the Earth's surface, but also the infrared (IR) radiation emitted by the surface and atmosphere is more strongly retained. Due to this insulating effect, a large portion of the energy is shifted to higher layers and only from there radiated back into space. This heat transport

can occur through thermal radiation, conduction, rising air (convection), and evaporation. The local surface temperature is determined by the duration and intensity of solar radiation, by air currents, by the cloud cover, and by many other factors, but also by the interplay of the four outward-directed heat flows. This raises the fundamental question of how these parallel heat flows influence each other and how the contribution attributed to the thermally active gases is relativized by the other heat flows.

Laboratory experiments cannot truly answer this question, but various experimental setups demonstrate the influence that convection can have on radiation transfer studies, and how this can lead to completely contradictory results regarding the magnitude or non-existence of the GHE.

## 2. Experimental Setup

The experimental set-up is shown in Fig. 1 and has already been used in a slightly modified form to demonstrate the GHE (Harde & Schnell 2022) [2] and the negative or reverse GHE (Harde & Schnell 2025) [3]. The apparatus consists of an upright cylinder with a polished aluminum inner lining, which forms an efficient radiation channel for the IR radiation. The gases to be analyzed are poured into the cylinder with a special pump, while gas in the compartment can escape through a small hole, also when the gas mixture is heating up and expanding.

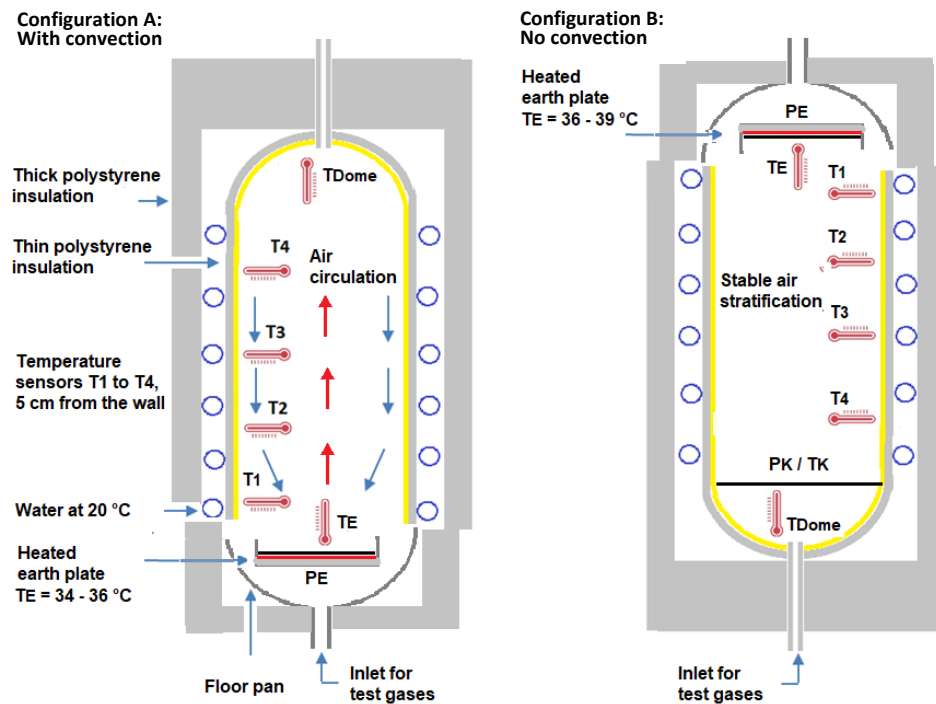


Fig. 1: Experimental setup with a heatable PE-plate. Configuration A simulates radiation propagation with convection, configuration B (apparatus rotated  $180^{\circ}$ ) without convection. The PK plate is only used for the studies "Thermally generated back radiation", Chapter 5.

To specifically investigate the influence of radiation and convection, only one heated plate – representing the Earth's surface and thus called earth plate (PE) – is used. This plate is positioned either in the lower position (Fig. 1A) or in the upper position (Fig. 1B). A second, cooled plate, which would allow for a defined, higher temperature gradient across the cylinder as necessary for demonstrating the atmospheric GHE, is omitted here (see also Section 5).

Instead, the radiation emitted by the earth plate and reflected by the opposite dome, is used to measure the impact of convection on the radiation. The earth plate acts both as transmitter and sensor for the radiation. For comparison, also a measurement with a blackened cover of the dome (plate PK) is carried out and contrasted to an earlier study of the GHE.

The decisive factor for unstable or stable air stratification is the temperature gradient between the warm earth plate PE and the cylinder walls with sensors T1 to T4.

### 3. Radiation Balance with Convection

In position A, the warm earth plate PE is located below the cooler cylinder walls. This creates an unstable air stratification, leading to convection – similar to radiators for room heating. The experiment is divided into three phases:

1. *Heating of the cylinder filled with dried air and waiting for thermal equilibrium (approximately 4 h) at constant heating power of 4.6 W over the full measuring cycle 1 – 3.*

An unusual temperature distribution develops in the cylinder:  $T_{\text{dome}} = T_4 > T_3 > T_2 > T_1$ , caused by convection and observed only in this configuration (see Fig. 2a, right and Appendix, Table A2, Phase 1). The cold, backflowing air from the walls narrows towards the smaller PE plate and flows around sensor T1 (see Fig. 1 A). Therefore, this measuring point shows the lowest temperature  $T_1$ , even though it is located in the immediate vicinity of the warm PE-plate.

2. *Pouring eight liters of the GHGs HCG (hydrocarbon gas, 1:1 mixture of propane and isobutane),  $\text{CO}_2$ , or the noble gas argon into the lower housing (corresponds to 15 vol.%)*

This creates a "gas lake" that floods the PE plate and extends to the T1 measuring point. Since the poured gases have a higher density than air, convection ceases, resulting in an immediate temperature increase at T1 and at the same time a drop at the other points  $T_2$  –  $T_4$  (Fig. 2a). The actual reason of this  $T_1$ -increase is not the GHE, as has been repeatedly postulated by some authors when presenting their demonstration experiments (e.g., v. Ditfurth [4]), but rather the lack of heat dissipation by convection.

This is fully confirmed by measurements with argon as an IR-inactive noble gas, which causes the same temperature increase of the constantly heated ground plate. Only gradually dissolves this blockage, primarily through diffusion, which also causes the temperatures  $T_2$  –  $T_4$  to temporarily rise (Fig. 2a). The maximum temperature increase of the gas lake is measured and expressed as  $\Delta T_E$  compared to the air temperature after phase 1.

3. *Measurement of radiation changes due to 15 vol.% of the gases HCG and  $\text{CO}_2$*

The average temperatures of the last hour and the temperature changes compared to Phase 1 are recorded and referred to as "homogen" in the Tables and Figures.

After the gas pool dissipates and homogenization occurs, the GHGs HCG and  $\text{CO}_2$  ultimately cause a net cooling of the PE-plate, similar to the so-called "negative GHE".

However, in this case, the cooling does not result from a negative temperature gradient (increasing temperature in upward direction; see Harde & Schnell, 2025 [3]) but is determined by the altered radiation balance for the PE-plate upon addition of a GHG. A significant portion of the radiation emitted by the plate is reflected back to the PE-plate by the mirrored dome and walls, largely independent of their temperatures. With GHGs radiation is absorbed on the spectral transitions, for  $\text{CO}_2$ , e.g., causing an attenuation of 12 % and for HCG about 30 %. This leads to partial thermalization and also remission by the gases, but into all directions and primarily determined by their temperature. The result is a dominating attenuation of the reflected radiation and thus a reduced temperature  $\Delta T_E$  measured at the earth plate, while radiation transfer calculations show that the back-and-forth propagation largely compensates any GHE.

As under these experimental conditions, the reflected radiation essentially represents the upwelling radiation, the measured temperature difference at the plate mirrors the radiation balance as expected at the top of the atmosphere (TOA), not at the Earth's surface.

To demonstrate this effect, relatively high concentrations of 15 vol% of GHGs are required, which also alter the thermal conductivity of the air mixture. But the temperature of the earth plate is only slightly affected by this altered thermal conductivity. This can be seen in a control experiment with argon as an IR-inactive gas, where, in contrast to the GHGs a slight warming is observed in phase 3 (Table 1, Fig. 2c). Argon, like  $\text{CO}_2$ , is a gas with low thermal conductivity ( $\lambda = 0.0179 \text{ W/m}\cdot\text{K}$ ) compared to air ( $\lambda = 0.0262 \text{ W/m}\cdot\text{K}$ ). Since radiation and conduction have opposing effects, the cooling temperatures of HCG and  $\text{CO}_2$  (Table 1) are actually slightly higher than those measured here.

Table 1: Effects of the sample gases on the temperature of the earth plate with and without convection.

Gas	$\Delta T_E =$ difference to phase 1	A: with convection		B: no convection	
		$T_E$ °C	$\Delta T_E$ °C	$T_E$ °C	$\Delta T_E$ °C
air	phase 1 for all measurements average $\pm 0.1$ °C	34.1	-	39.1	-
HCG	gas lake	36.1	2.0	-	-
	homogen	32.8	-1.3	36.7	-2.5
CO <sub>2</sub>	gas lake	36.2	2.1	-	-
	homogen	34.0	-0.1	38.2	-0.8
argon	gas lake	35.8	1.8	-	-
	homogen	34.3	0.3	39.2	0.1

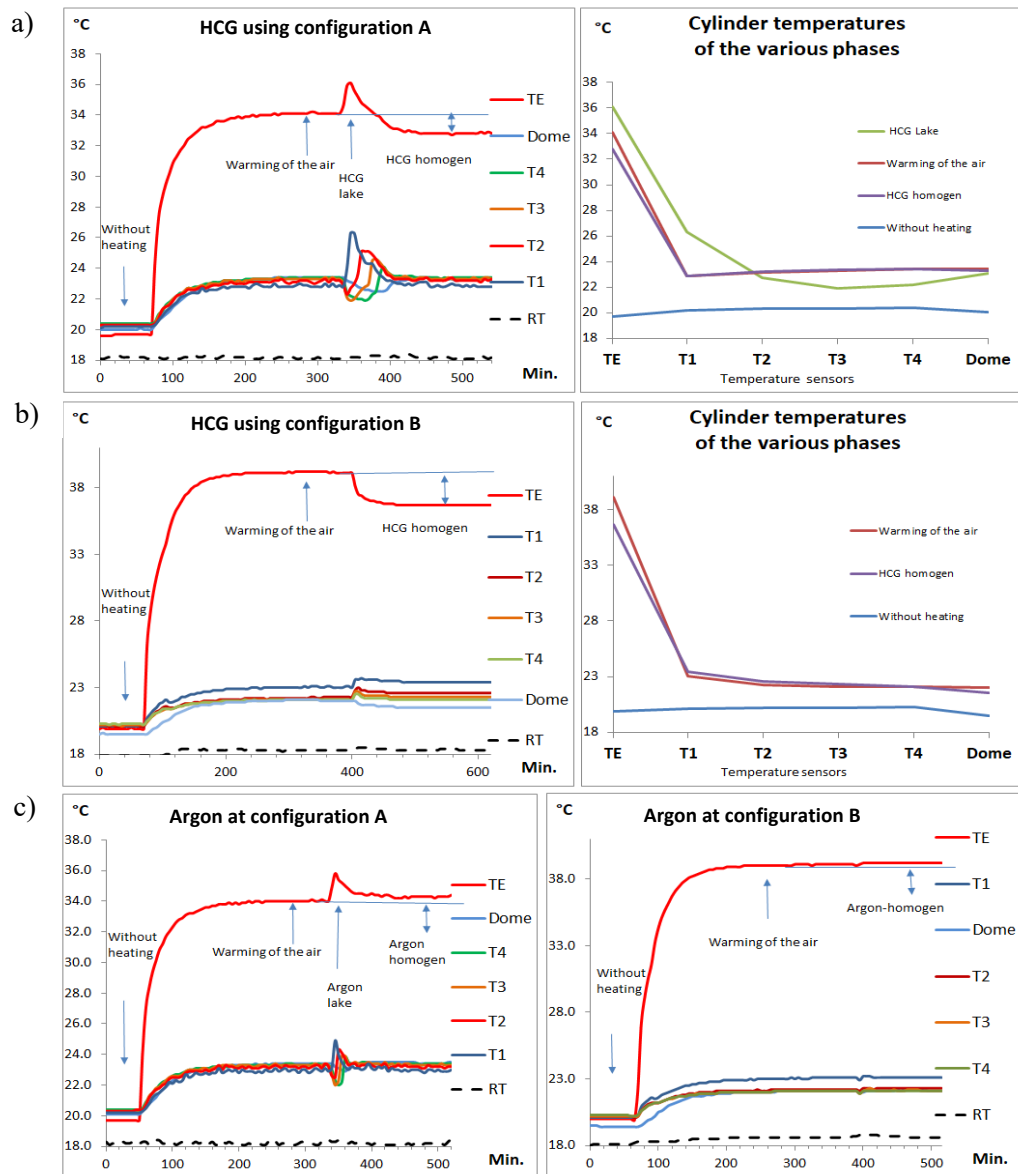


Fig. 2: a) Temperature profiles with convection using the GHG HCG as an example, b) without convection and c) comparative measurements with and without convection for argon.

The properties of the "gas lake" in phase 2 have nothing to do with what happens in the atmosphere. Apart from local variations, CO<sub>2</sub> is evenly distributed in the troposphere. Rather, this primarily concerns experiments or interpretations such as those by v. Dittfurth (1978) [4], Gore &

Guggenheim (2006) [5], or Scorza et al. (2022) [6], who may have inadvertently created a "gas lake" when pouring in pure CO<sub>2</sub> and believed that their experiments demonstrated the atmospheric CO<sub>2</sub> effect. In the most favorable case, these videos confirm the IR absorption of greenhouse gases or their differing thermal conductivity compared to pure air. But these experiments have nothing to do with the greenhouse effect as we know it in our atmosphere (see also: Watts, 2011 [7]; Solheim, 2016 [8]; Schnell, 2020 [9]).

The observed, partly considerable temperature increase (11.3 °C in the Ditzfurth experiment, 2.1 °C in our investigations) is mainly caused by the higher density of CO<sub>2</sub> ( $\rho = 1.98 \text{ kg/m}^3$ ) compared to air ( $\rho = 1.20 \text{ kg/m}^3$ ), which forms a CO<sub>2</sub> pool at the floor even when heated. Like the glass panes in a greenhouse, this layer of heavy gas prevents convection and rising of the heated gas. Only under the influence of diffusion this pool disperses after some time, and the "heavy" gas spreads evenly throughout the tank. Comparison with argon, which produces the same temperature peak when poured in, clearly demonstrates that this is not evidence of the GHE (Fig. 2c).

#### 4. Radiation Balance without Convection

For class B experiments, the entire apparatus is rotated upside-down, so that the earth plate PE is located above the cooler cylinder walls (Fig. 1B). This creates a stable air stratification, warmer at the top and colder at the bottom, which inherently prevents convection. Since the sample gases now only form a temporary gas pool with the dome at the bottom, a thermal insulation of the earth plate is eliminated. Therefore, when performing measurements under these conditions, the experimental procedure is only divided into two phases.

##### 1. Heating of the cylinder filled with dried air and verification of thermal equilibrium.

This procedure is done under the same conditions as in position A, i.e., with a heating power of 4.6 W, and lasts approximately 5 hours. Due to the lack of convection, the temperature of the PE-plate rises by additional 5 °C (Table 1, last column, Phase 1). This already shows that convection has a significant influence on the heating balance of the PE-plate.

##### 2. Pouring in the Sample Gas

When the sample gases are filled in, again initially a gas pool forms in the dome, similar to configuration A. However, in the absence of convection and at a larger distance from the heated plate, this does not cause any heat buildup for this plate. Therefore, with the two greenhouse gases HCG and CO<sub>2</sub>, immediate cooling of the PE plate is observed (Fig. 2b and Appendix, Fig. A1b). This is again due to absorption losses of the back-reflected radiation with the greenhouse gases between the PE-plate and the dome, as already described for configuration A.

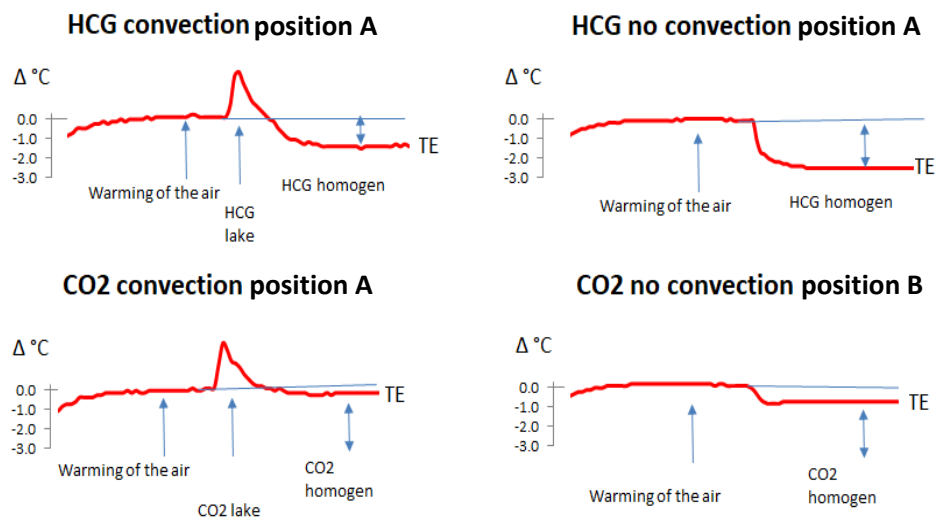


Fig.3: Comparison of measurements for HCG and CO<sub>2</sub> with and without convection.

The crucial difference between positions A and B is the size of the temperature change at plate PE, representing the flux change at TOA. Without convection, HCG causes a cooling of 2.5 °C compared to 1.3 °C with convection, and for CO<sub>2</sub>, the difference is 0.8 °C versus 0.1 °C (Fig 3).

*This experiment confirms that convection, as a competing heat flow, relativizes the effectiveness of GHGs and thereby also the GHE.*

With the potent GHG HCG, a second effect is observed. Despite the temperature drop of  $T_E$ , the temperature  $T_1$  rises. The sensor T1 is in close proximity to the PE-plate and, under stable air stratification according to configuration B, already has the highest temperature of the sensors T1 to T4 without GHGs. When adding HCG, this temperature increases by additional 0.4 °C (Appendix, Table A3). This is explained by the fact that the intensity of the remitted HCG radiation – as explained above – is lower than the radiation absorbed by the gas from the PE-plate, thus contributing to the temperature increase of the air, but not the PE-plate (Appendix, Table A3).

This gas warming is the same as in experiments monitoring only the gas temperature (e.g., Scorza et al. [6]). However, the difference to these measurements is that we register the gas temperature at 5 different positions to observe any temperature changes over the tank and – most important – also changes of the plate temperature. To make this clear, both measurements – observation of the gas temperature or plate temperature – are only tracking the absorption of the gases, not any greenhouse effect, but the changes of the plate also symbolize the reduced upwelling radiation to space and can much better be used to study the impact of convection on radiation effects.

However, the hypothesis that the GHE reduces heat transport via IR radiation towards space is experimentally confirmed, as can be seen from the temperature drop of the dome (Appendix Table A3) and even more pronounced with plate-PK (see Section 5 and Table A4). This applies to cloudless skies and is further amplified by clouds, which not only act as IR absorbers but also as emitters and can additionally scatter some part back to the surface.

Slight warming of the air is also observed with CO<sub>2</sub> but is close to the temperature resolution of the sensors with  $\pm 0.1$  °C (Table A3). Given an approximately 400 times lower CO<sub>2</sub> concentration in the atmosphere, this warming is likely negligible. This may explain why weather balloons and satellites have so far been unable to detect the supposedly CO<sub>2</sub>-caused atmospheric "hotspot."

The comparative experiment with argon (Fig. 2c and Table A3) shows neither a decrease in the  $T_E$  temperature nor a temperature increase from  $T_1$  to  $T_4$ . A slight increase in  $T_E$  after addition of argon is within the temperature resolution.

## 5. Thermally Generated Backradiation

In the previous experiments, backradiation was caused by the reflection of the emitted earth-plate radiation at the mirrored dome. Covering the dome with a blackened aluminum plate (PK) generates thermally produced back radiation according to its temperature  $T_K$  and the Stefan-Boltzmann law. Since the PK-plate is significantly cooler than the earth-plate, the intensity of the back radiation is correspondingly lower. With this weaker backradiation, only the GHG HCG shows clearly measurable cooling using configuration B (Table 2 and Table A4).

Table 2: Impact of a mirrored dome or a blackened plate PK on the temperature of the earth plate according to configuration B, without convection.

Gas	$\Delta T_E =$ difference to phase 1	reflecting dome		blackened plate P <sub>K</sub>	
		$T_E$ °C	$\Delta T_E$ °C	$T_E$ °C	$\Delta T_E$ °C
air	phase 1 of all experiments average $\pm 0,1$ °C	39.1	-	36.0	-
HCG	homogen	36.7	-2.5	35.2	-0.7
CO <sub>2</sub>	homogen	38.2	-0.8	35.9	-0.1
argon	homogen	39.2	0.3	36.2	0.1

However, not only the earth plate is showing some cooling, but there is even a greater temperature loss at the opposing plate PK: 1.2 °C for HCG and 0.4 °C for CO<sub>2</sub>, while the gas temperatures  $T_1$  to  $T_4$  are slightly increasing (see Table A4).

Under these conditions an almost uniform air temperature is adjusting in the cylinder, and different to the changing temperatures over the atmosphere it works as a single, isolated layer. GHGs are causing an attenuation and partial thermalization of the backradiation, resulting in this unusual temperature pattern.

However, significantly different conditions in the radiation balance are arising, when the temperature of the cold plate PK is reduced by a cryostat. Fig. 4 shows as an example a measurement with 10% CO<sub>2</sub> in air for a cooled plate of -11.4 °C and a temperature gradient between the plates of 0.37 °C/cm (for further details see Harde & Schnell 2022 [2]).

With an initial temperature of the earth plate of +30 °C, a temperature increase of 1.0 °C can be observed after adding CO<sub>2</sub>, in contrast to the measurements shown previously. Since convection and heat conduction can be ruled out by control experiments, such an increase can be attributed exclusively to the actual GHE, and it can only be observed in the presence of a sufficient temperature gradient along the radiation propagation path.

This measurement is intended as comparison to illustrate the importance of precisely understanding or even eliminating other heat transfer processes in order to make a reliable statement about the true influence of the various GHGs on our climate.

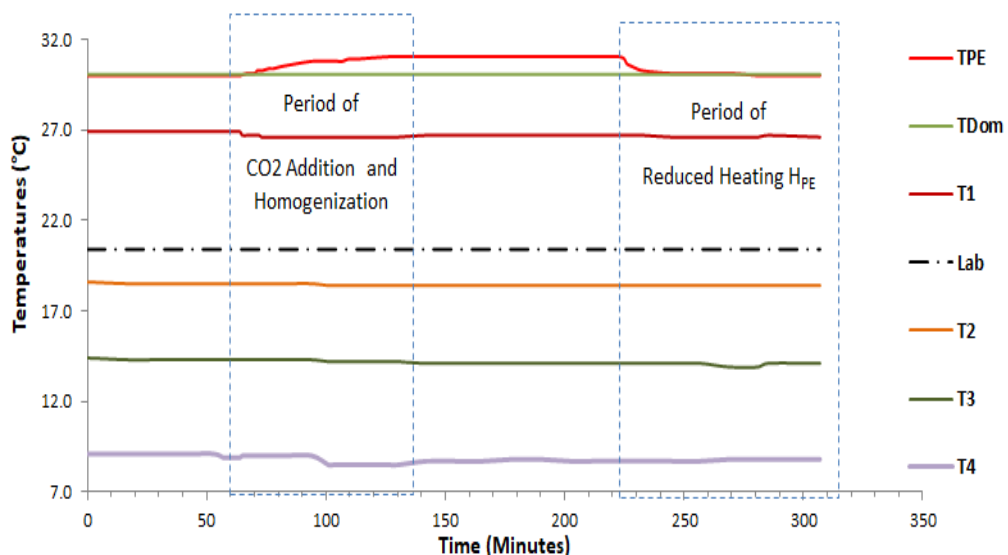


Fig. 4: Measurement for 10% CO<sub>2</sub> in dry air. The temperatures of the earth plate (red), the significantly different gas temperatures at positions  $T_1$ – $T_4$ , and the laboratory temperature (black) were recorded. The ground plate is located on an insulating layer within the thermistor dome.

Experimental set-ups, as previously discussed, in which the heavier sample gases can block convection, also show an increased temperature rise, but this has nothing to do with the GHE. On the other hand, this effect can be superimposed by convection and radiation absorption to such an extent that any warming is compensated for or even reversed. This may be one of the reasons why such differing results have been published from purported demonstration experiments on the GHE. Reliable verification and determination of the influence of the various IR-active gases on our climate therefore requires careful experimental conditions that must be precisely known and adhered to.

The results collected in the laboratory can only be partially applied to the transfer processes in the atmosphere, but they illustrate the strong mutual influence of the heat flows and simultaneously demonstrate the special importance of GHGs for climatic conditions that only made possible life on this planet.

## **6. Conclusion**

In laboratory experiments we have studied the reciprocal influence of heat fluxes as they occur in the atmosphere. In particular, we show how convection affects the effectiveness of IR-active gases. The starting point is to realize that the Earth's surface not only delivers heat through radiation, but also by convection, conduction, and evaporation, and that these mechanisms mutually influence each other. The objective of these studies was to analyze these effects separately and together in a most controllable laboratory experiment.

The setup uses a heated plate to simulate the Earth's surface, which is positioned either below or above the cooled cylinder walls. This results in two clearly distinguishable scenarios: a convective system (plate below, configuration A) and a convection-free system (plate above, configuration B). In both cases, the tank is filled with the GHGs HCG (hydrocarbon gas) and CO<sub>2</sub>, and for comparison argon, so that both, radiation effects of the gases and the influence of a temporarily formed gas layer (gas-lake) of the heavier gases, can be investigated – the latter a phenomenon that has evidently influenced previous demonstration experiments incorrectly.

Temperature measurements of the plate show that with set-up A after adding a sample gas, a significant increase is primarily due to the lower thermal conductivity and higher density of the gases: A spreading gas pool around the earth plate suppresses convection for about 20 minutes, thus warming the plate. This effect occurs with all three gases, including non-IR-active argon, and therefore does not constitute any evidence of a GHE in the physical sense. Only when the gas pool disappears through diffusion, can radiation effects be observed. The temperature drop  $\Delta T_E$  measured at the plate reflects the radiation balance at the top of the atmosphere.

The comparison between configurations A and B is crucial. When convection is allowed, greenhouse gases only slightly reduce the radiation reflected from the dome to the warm plate, causing a slight cooling and, correspondingly, only a slight decrease in the radiation emitted to space. If convection is suppressed, this negative radiation effect is noticeably amplified, respectively the absorbed radiation over the atmosphere and the associated warming at the base.

HCG causes a cooling of 2.5 °C without convection, compared to only 1.3 °C with convection; CO<sub>2</sub> leads to a cooling of 0.8 °C compared to 0.1 °C with convection. This shows that convection is a dominant heat transport mechanism that reduces the radiative effect.

Comparable investigations for the influence of evaporation on radiation could not be carried out with the present experimental setup because too much condensate forms on the walls of the gas cylinder, significantly altering the backradiation.

In summary, the experiments show that the effect of IR-active gases is strongly influenced by convection and that a considerable portion of the warming observed in classical demonstrations is not due to radiative effects, but rather to gas effects that inhibit convection.

For the real atmosphere the interplay of convection and the other mechanical heat fluxes with the GHGs can be understood as lifting warmer air parcels from the lower to the upper troposphere, from where heat can be released more efficiently to space by radiation. Thus, these fluxes prove to be central components in the Earth's heat transport and at the same time relativize the sole significance of IR-active gases as sources for global warming.

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## Appendix

The experimental chamber is thermostatically controlled at  $18\text{ °C} \pm 0.2\text{ °C}$  to eliminate interference from a changing room temperature. The water for cooling the cylinder is generated in a thermal box via a two-point thermostatic control with a hysteresis of  $\pm 0.1\text{ °C}$  and pumped to the cylinder through PVC tubing. To establish stable conditions, the room temperature control and the cooling water are switched on 5 hours before data recording, and the air in the tank is circulated through solid sodium hydroxide solution for drying.

The electric heater is set to 4.00 volts, which fluctuates between 4.6 and 4.7 watts due to the temperature dependence of the resistance heating of the ground plate (Table A1).

Table A1: Technical Data

Component	Length/Hight	Ø:
alu-cylinder	L=57 cm	33 cm
dome	H=13 cm	33
alu plate PE	D=0.8 mm	22 cm
alu plate PK	D=0.8 mm	33 cm
PI-Polyamide foil heater	DC24V, 180 W	22 cm
P <sub>E</sub> support plate	H=2 cm	25 cm
plate spacing P <sub>E</sub> -P <sub>K</sub>	57 cm	
cooling hose	L=25 m	8x12 mm
Styrofoam top	H=15 cm	50 cm
Styrofoam wall	H=65 cm	50 cm
Styrofoam bottom	H=10 cm	50 cm
data logger	Elitech RC4	
thermostat	ES-10 $\pm 0,1\text{ °C}$	
power supply	Korad ka3005d	0-30 V
heating power	4,00 V	4,6 - 4,7 W

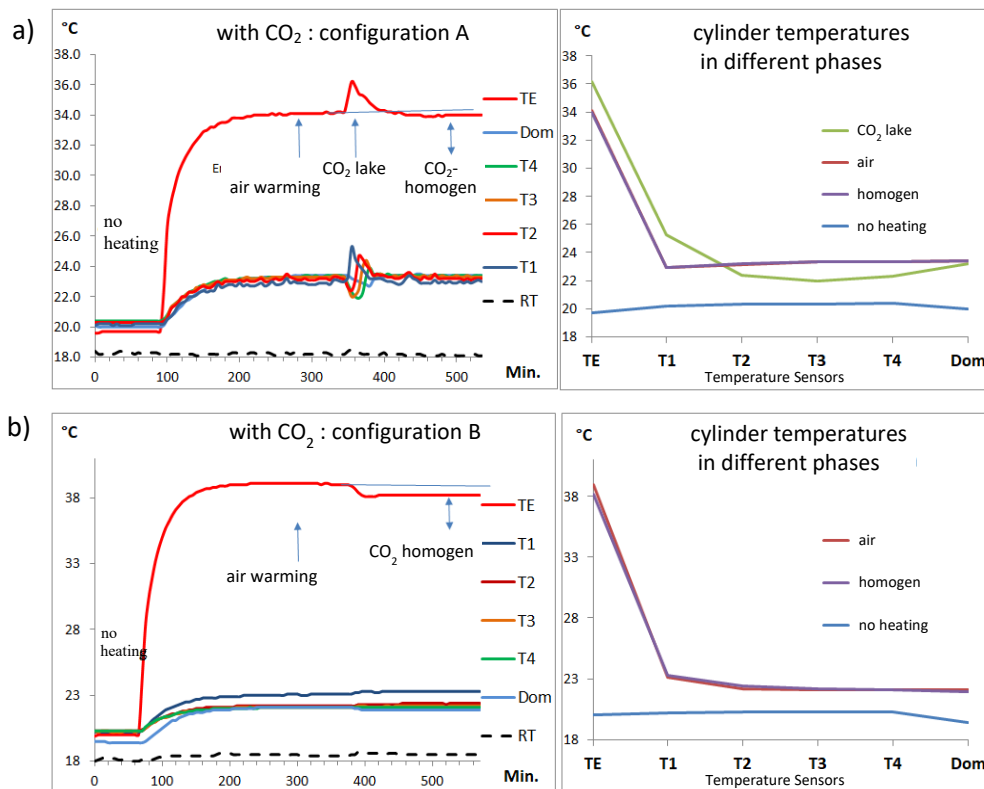


Fig. A1: a) Temperature profiles for CO<sub>2</sub> with convection, b) without convection.

Phase 1 of Tables A2 and A3 shows the temperatures of all sensors after switching on the PE heater. "Start" represents the temperature increase caused by switching on the heater. The "homogen" phases refer to the temperatures and their changes that ultimately result after the addition of the sample gases, compared to the dried air. The "gas-lake" phase in Table A2 is a snapshot at the highest sample temperature reached immediately after the addition of the sample gases.

Some data exhibit a wave-like pattern caused by the thermostat's temperature control. These fluctuations are smoothed out by averaging over a longer period.

Table A2: Configuration A, with convection. Temperatures of the different sensors after addition of 8 liters of a sample gas.

gas	phase	$T_E$ °C	$T_1$ °C	$T_2$ °C	$T_3$ °C	$T_4$ °C	$T_{dome}$ °C
air	1. heating	34.1	22.9	23.2	23.3	23.4	23.4
	$\Delta T$ vs. start	14.4	2.7	2.9	3.0	3.0	3.4
HCG	2. gas-lake	36.1	26.3	22.7	21.9	22.2	23.1
	$\Delta T$ vs. air	2.0	3.4	-0.5	-1.4	-1.2	-0.3
	3. homogen	32.8	22.9	23.2	23.3	23.4	23.3
	$\Delta T$ vs. air	-1.3	0.0	0.1	0.0	0.0	-0.1
air	1. heating	34.1	22.9	23.2	23.3	23.4	23.4
	$\Delta T$ vs. start	14.4	2.8	2.9	3.0	3.0	3.4
CO <sub>2</sub>	2. gas-lake	36.2	25.3	22.4	22.0	22.3	23.2
	$\Delta T$ vs. air	2.1	2.4	-0.8	-1.3	-1.1	-0.2
	3. homogen	34.0	23.0	23.2	23.3	23.4	23.4
	$\Delta T$ vs. air	-0.1	0.0	0.0	0.0	0.0	0.0
air	1. heating	34.0	23.0	23.2	23.3	23.3	23.4
	$\Delta T$ vs. start	14.3	2.8	2.9	3.0	2.9	3.3
argon	2. gas-lake	35.8	24.9	22.5	22.0	22.3	23.2
	$\Delta T$ vs. air	1.8	1.9	-0.7	-1.3	-1.0	-0.2
	3. homogen	34.3	22.9	23.2	23.3	23.4	23.4
	$\Delta T$ vs. air	0.3	0.0	0.0	0.0	0.1	0.0

Table A3: Configuration B, without convection. Temperatures of the various sensors after the addition of 8 liters of a sample gas.

gas	phase	$T_E$ °C	$T_1$ °C	$T_2$ °C	$T_3$ °C	$T_4$ °C	$T_{dome}$ °C
air	1. heating	39.2	23.0	22.3	22.1	22.1	22.0
	$\Delta T$ vs. start	19.3	2.9	2.1	1.9	1.8	2.5
HCG	2. homogen	36.7	23.4	22.6	22.3	22.1	21.5
	$\Delta T$ vs. air	-2.5	0.4	0.3	0.2	0.0	-0.5
air	1. heating	39.0	23.1	22.2	22.1	22.1	22.1
	$\Delta T$ vs. start	19.0	2.9	1.9	1.8	1.8	2.7
CO <sub>2</sub>	2. homogen	38.2	23.3	22.4	22.2	22.1	21.9
	$\Delta T$ vs. air	-0.8	0.2	0.2	0.1	0.0	-0.2
air	1. heating	39.1	23.1	22.2	22.1	22.1	22.1
	$\Delta T$ vs. start	19.1	3.0	2.0	1.9	1.8	2.7
argon	2. homogen	39.2	23.1	22.3	22.1	22.1	22.1
	$\Delta T$ vs. air	0.1	0.0	0.1	0.0	0.0	0.0

Table A4: Temperatures of the various sensors according to configuration B, without convection, after the addition of 8 liters of a sample gas but with a blackened plate PK.

gas	phase	$T_E$ °C	$T_1$ °C	$T_2$ °C	$T_3$ °C	$T_4$ °C	$T_K$ °C
HCG	air	35.9	22.8	22.4	22.3	22.4	25.4
	$\Delta T$ vs. start	15.9	2.5	2.1	2.0	2.1	5.4
	2. homogen	35.2	23.2	22.6	22.5	22.5	24.2
	$\Delta T$ vs. air	-0.70	0.40	0.24	0.15	0.06	-1.22
CO <sub>2</sub>	air	36.0	22.8	22.4	22.4	22.5	25.4
	$\Delta T$ vs. start	16.0	2.5	2.0	2.1	2.1	5.4
	2. homogen	35.9	23.1	22.5	22.4	22.6	25.0
	$\Delta T$ vs. air	-0.1	0.3	0.1	0.0	0.1	-0.4
argon	air	36.1	22.8	22.5	22.4	22.5	25.4
	$\Delta T$ vs. start	15.5	2.5	2.1	2.1	2.1	5.4
	2. homogen	36.2	22.9	22.5	22.4	22.6	25.5
	$\Delta T$ vs. air	0.1	0.1	0.0	0.0	0.0	0.1

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