

## The Greenhouse effect – a high school experiment

Jan-Erik Solheim, Thor Eriksen, and Yngvar Engebretsen  
Oslo, Norway

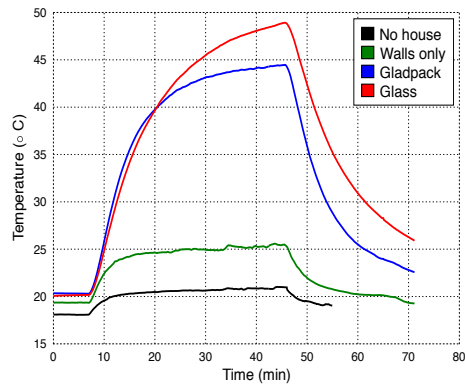
*No amount of experimentation can ever prove me right; a single experiment can prove me wrong. (Albert Einstein)*

The planet Earth has an atmosphere, which keeps us warm. This simple fact is now replaced by the idea that we live in a greenhouse, and the so-called greenhouse-gases keep us warm. This is explained the following way: The Earth receives visible light from the Sun, which heats the surface, which then emits infrared radiation, which is absorbed and re-radiated by the greenhouse-gases in the atmosphere. The more CO<sub>2</sub> we emit - the more radiation is reemitted from the atmosphere, and we will experience a catastrophic warming of our planet.

An extreme and absurd demonstration of the warming effect of CO<sub>2</sub> is presented in a video called "Climate 101", which was produced as part of Al Gore Climate Reality Project (1) and narrated by Bill Nye: *Here you'll be schooled in the scientific fundamentals of climate change in under 5 minutes. The warming effect of CO<sub>2</sub> is demonstrated in a simple lab experiment, which every high school student can easily do: Have two identical glass jars, one with air and one filled with CO<sub>2</sub>, each with a thermometer inside. Shine light from two identical infrared lamps on the top of both glass bottles, and within minutes you will see the temperature in the bottle with the carbon dioxide in it rising faster and higher.* In the video, the thermometer in the CO<sub>2</sub> bottle showed 1.2C warmer than the one in air. The experiment was repeated by Anthony Watts (2), with the same equipment. His conclusion is that the experiment is a hoax, it could never work as advertised, and the scene showing the temperature difference is fabricated.

In order to do this experiment correctly one needs a daylight lamp or the Sun as a light-source, and a box with a glass roof that transmits visual light from the outside and stops IR-radiation from the inside as glass does. This should be compared with box with a roof that transmits IR-radiation. Already in 1909, professor Robert Wood (3) showed by experiment that the reason a greenhouse gets warmer, is that the air inside is trapped by the walls – *the loss of temperature of the ground by radiation is very small in comparison to the loss by convection, in other words that we gain very little from the circumstance that the radiation is trapped.*

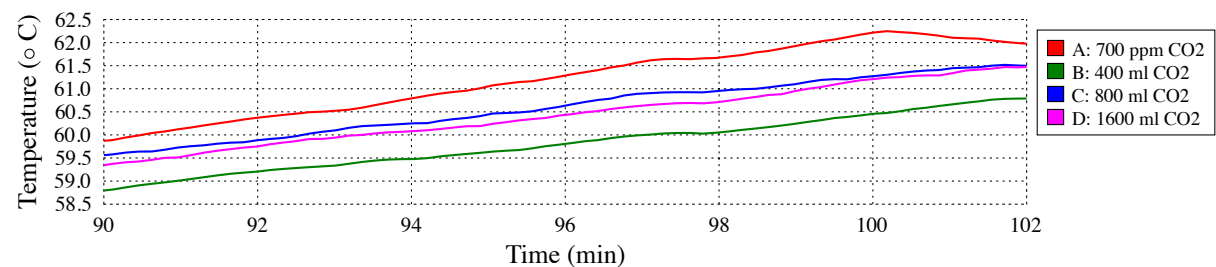




We have done similar experiments at a school in Oslo, Norway. Here we built four small greenhouses as shown in the picture. As roof we used glass or gladpack, which transmits IR-radiation. The figure to the left shows some of our results. The greenhouse effect due to walls and roof that stop convection led to a temperature increase 6-7 times higher than the difference between roof that transmits or stops IR-radiation.

In another experiment we filled one greenhouse with CO<sub>2</sub> – and measured no warming.

Then we tried more realistic increases, from ambient (0.07%) to 4% amount of CO<sub>2</sub> using the Sun as a light source. In this case we observed that the greenhouses with increased CO<sub>2</sub> had less warming than the one with the ambient atmosphere.

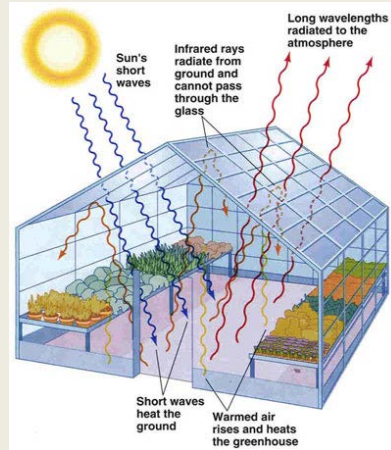


In the figure 400 ml is approximately 1 per cent CO<sub>2</sub> by volume.

Our conclusion is that we were not able to prove that more CO<sub>2</sub> leads to a higher temperature in a greenhouse. The greenhouse effect is due to the air being trapped by the roof and the walls, inhibiting natural cooling by conduction, convection, and evaporation (4).

## References

1. [www.climaterealityproject.org/climate-101](http://www.climaterealityproject.org/climate-101)
2. <https://wattsupwiththat.com/climate-fail-files/gore-and-bill-nye-fail-at-doing-a-simple-co2-experiment/>
3. R.Wood, Note on the Theory of the Grenhouse, Philosophical Magazine, 17, 319 (1909)
4. J.-E. Solheim, T. Eriksen, and Y. Engebretsen, A school experiment with radiation heating of small greenhouses (in Norwegian), Fra Fysikkens Verden (2016), in production



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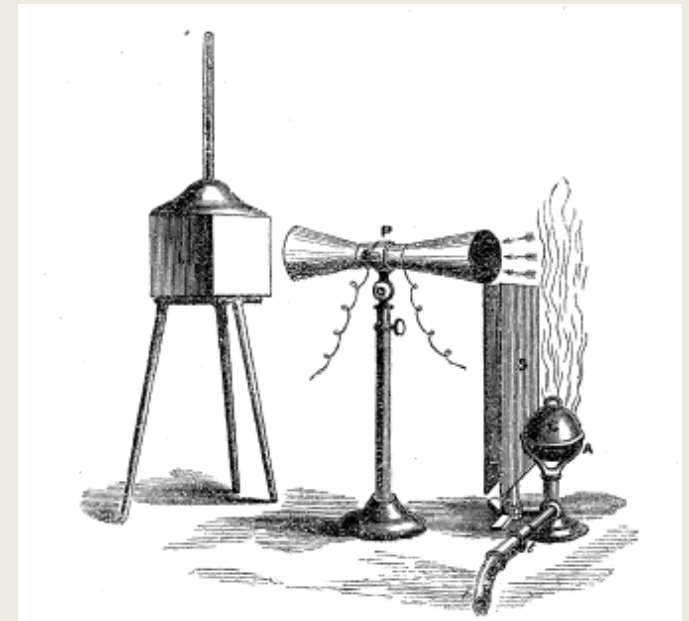
PowerPoint slides for a talk given on  
9 September 2016 at The London  
Conference on Climate Change:  
Science & Geoethics



# John Tyndall: The Bakerian lecture 1871

- Power of absorption of heat:

Air . . . . .	0
Oxygen . . . . .	0
Nitrogen . . . . .	0
Hydrogen . . . . .	0
Carbonic oxide . . . . .	12
Carbonic acid . . . . .	18
Nitrous oxide . . . . .	29





# MÉMOIRE

SUR

LES TEMPÉRATURES DU GLOBE TERRESTRE ET  
DES ESPACES PLANÉTAIRES.

PAR M. FOURIER.

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

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

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

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

1824.

72

1827

THE

LONDON, EDINBURGH, AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.

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

I. Introduction: Observations of Langley on Atmospheric Absorption.

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

\* Extract from a paper presented to the Royal Swedish Academy of Sciences, 11th December, 1895. Communicated by the Author.

† *Heat a Mode of Motion*, 2nd ed. p. 405 (London, 1885).

‡ *Mém. de l'Ac. R. d. Sci. de l'Inst. de France*, t. vii. 1827.

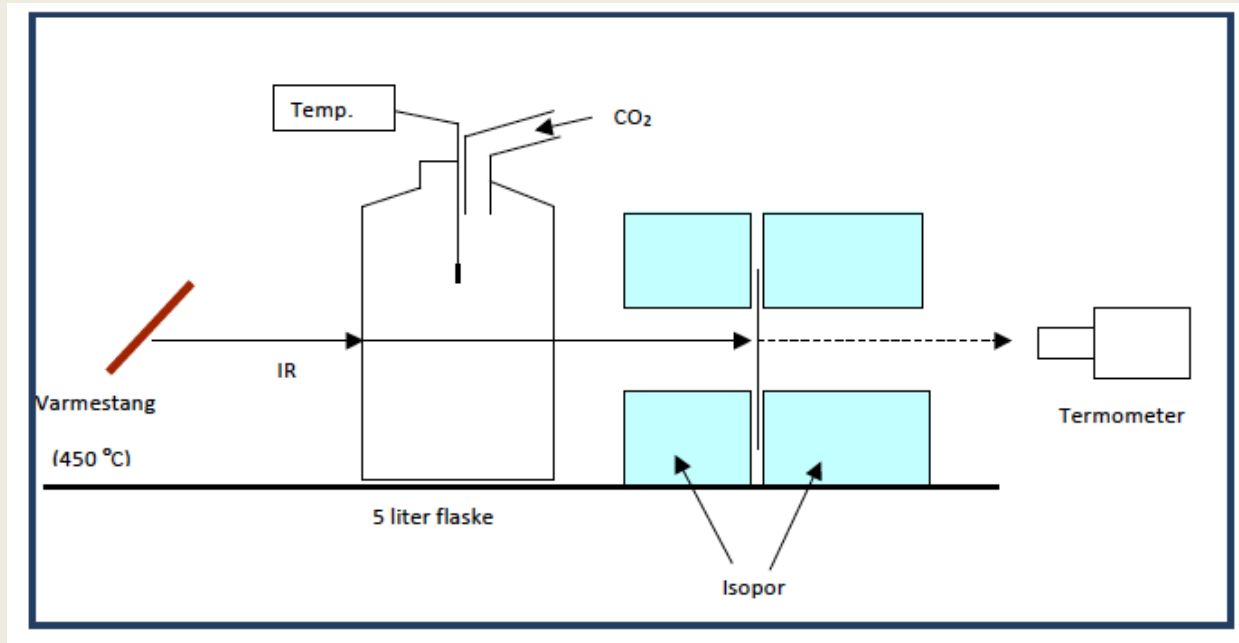
§ *Comptes rendus*, t. vii. p. 41 (1838).

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

S

1896

# Simple experiment: CO<sub>2</sub> absorbs IR-light



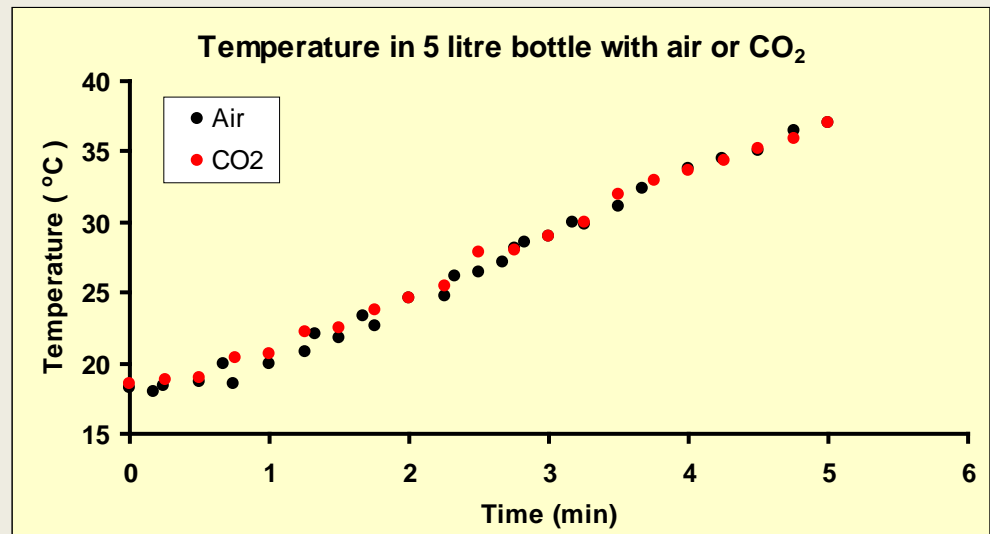
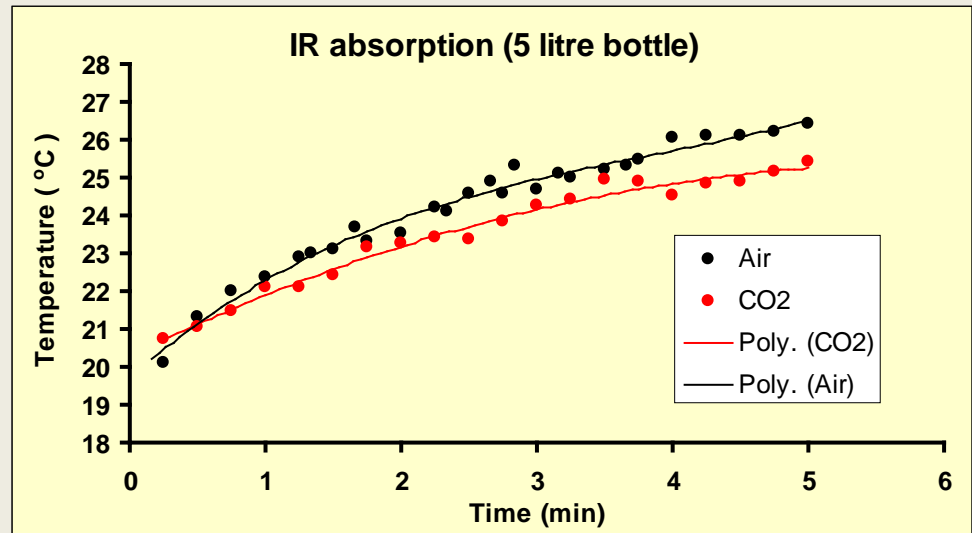
IR-lamp heats the gas in the bottle and a black painted sheet of paper inside a tube with thick styrofoam. Temperature is measured in the bottle and on the back side of the paper (experiment by T. Seim, 2016)

# CO<sub>2</sub> absorbs heat

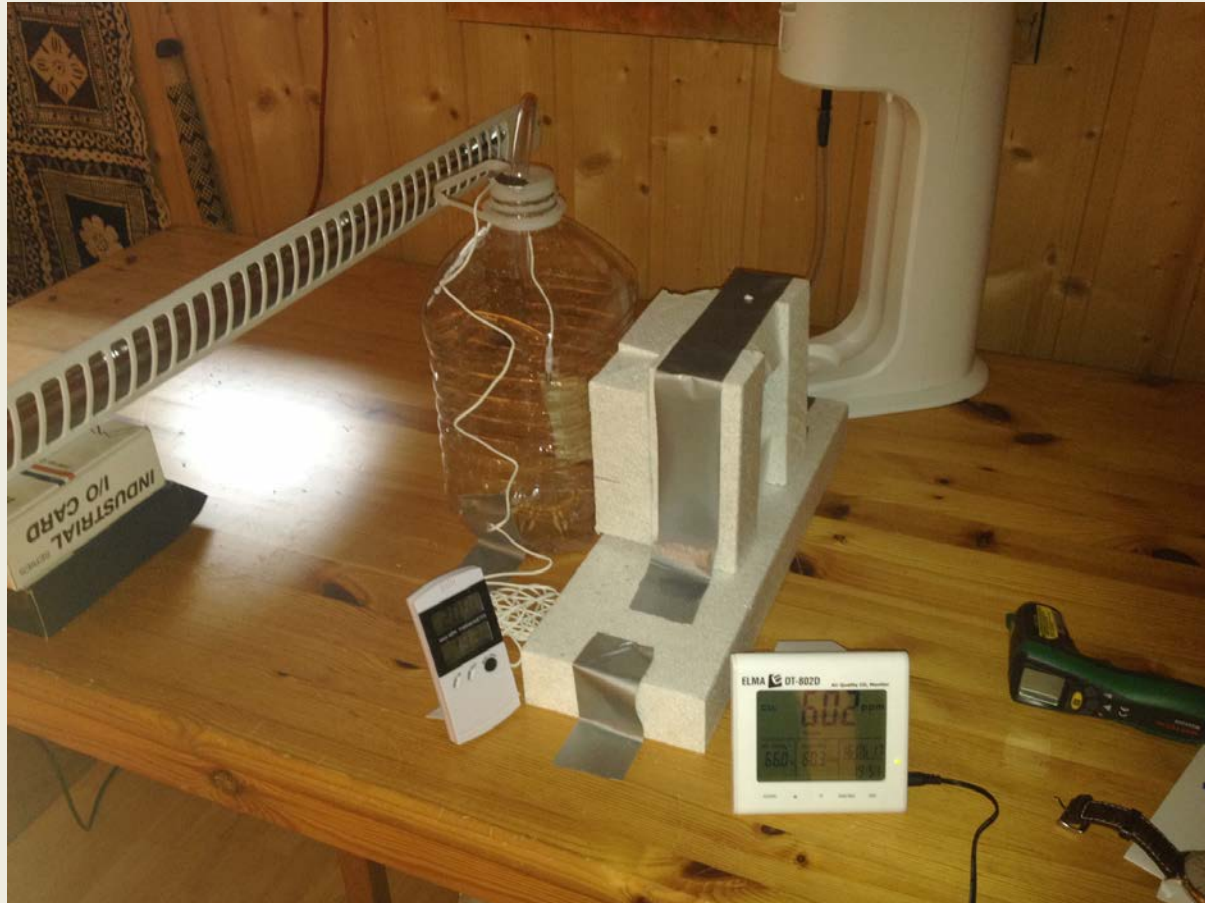
But:

The temperature in the bottle is the same with air and CO<sub>2</sub>

What happens with the missing heat?



(T. Seim, 2016)





# Repeatability of Professor Robert W. Wood's 1909 Experiment on the Theory of the Greenhouse

by  
Prof. Nasif Nahle  
July 5, 2011

PRINCIPIA SCIENTIFIC



# Professor R. Wood, Philosophical Magazine, 1909

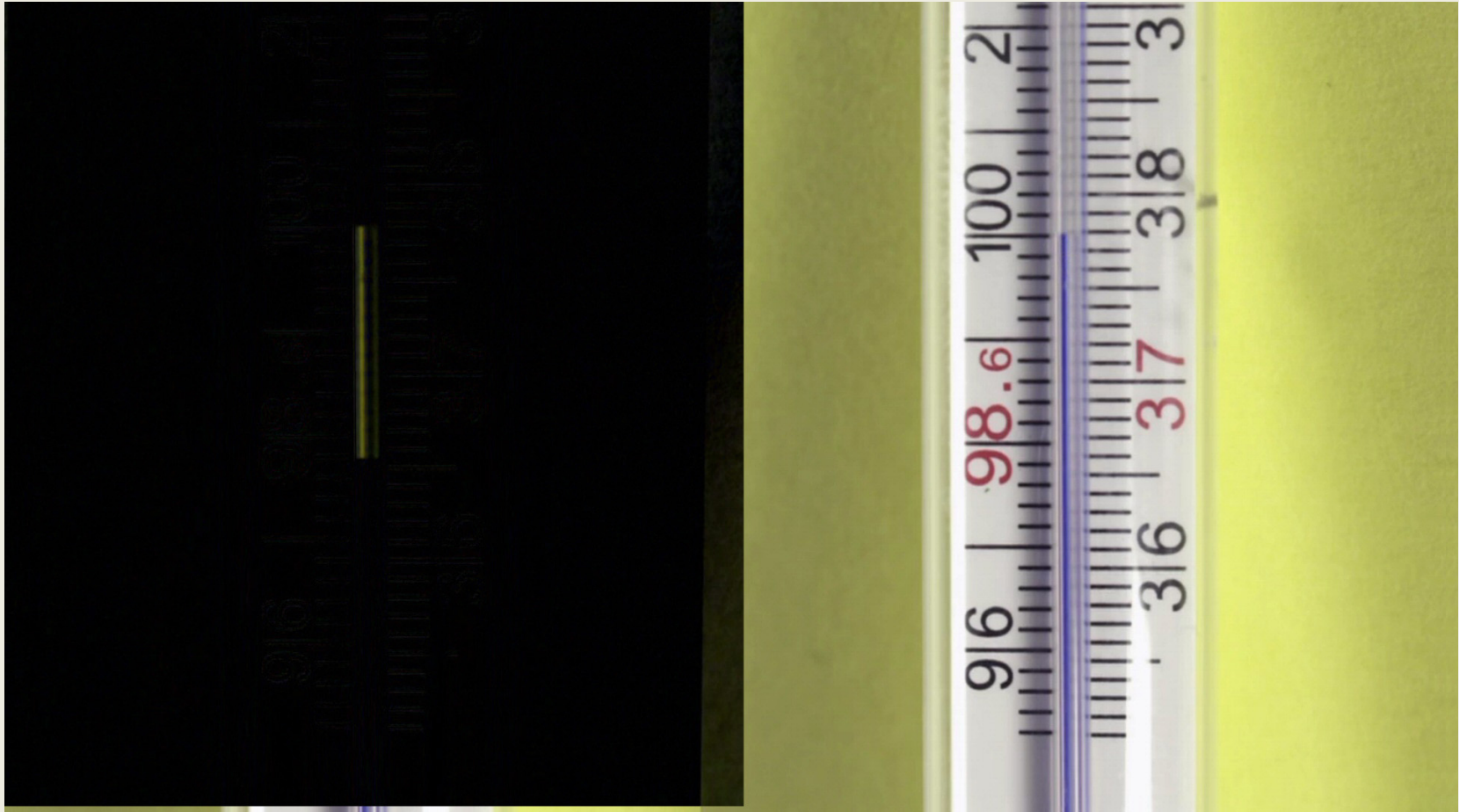
- THERE appears to be a widespread belief that the comparatively high temperature produced within a closed space covered with glass, and exposed to solar radiation, results from a transformation of wave-length, that is, that the heat waves from the sun, which are able to penetrate the glass, fall upon the walls of the enclosure and raise its temperature: the heat energy is re-emitted by the walls in the form of much longer waves, which are unable to penetrate the glass, **the greenhouse acting as a radiation trap.**
- **In fact I am of the opinion that a greenhouse made of a glass transparent to waves of every possible length would show a temperature nearly, if not quite, as high as that observed in a glass house.**
- To test the matter I constructed two enclosures of dead black cardboard, one covered with a glass plate, the other with a plate of rock-salt of equal thickness.
- When exposed to sunlight the temperature rose gradually to 65 °C., the enclosure covered with the salt plate keeping a little ahead of the other, owing to the fact that it transmitted the longer waves from the sun, which were stopped by the glass. In order to eliminate this action the sunlight was first passed through a glass plate.
- **There was now scarcely a difference of one degree between the temperatures of the two enclosures.**
- **I do not pretend to have gone very deeply into the matter, and publish this note merely to draw attention to the fact that trapped radiation appears to play but a very small part in the actual cases with which we are familiar.**

# Al Gore 101 Climate 101

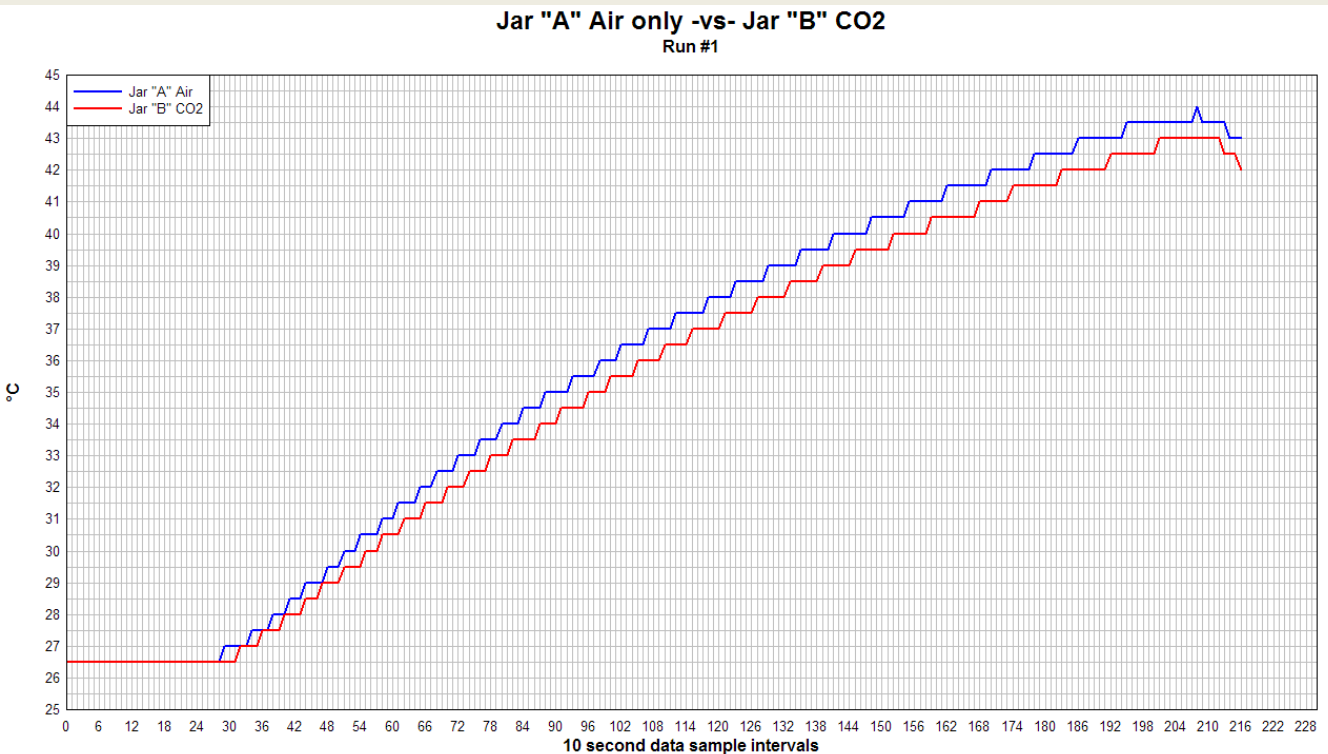


# Al Gore Climate 101 is a fraud

<http://wattsupwiththat.com/2011/10/18/replicating-al-gores-climate-101-video-experiment-shows-that-his-high-school-physics-could-never-work-as-advertised/>



# Gore's experiment repeated with remote temperature readout



(whatsupwiththat.com)

What Mr  
Gore's  
experiment  
demonstrates;  
Air is a better  
heat conductor  
than CO<sub>2</sub>

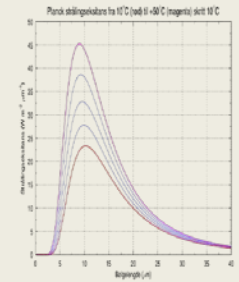
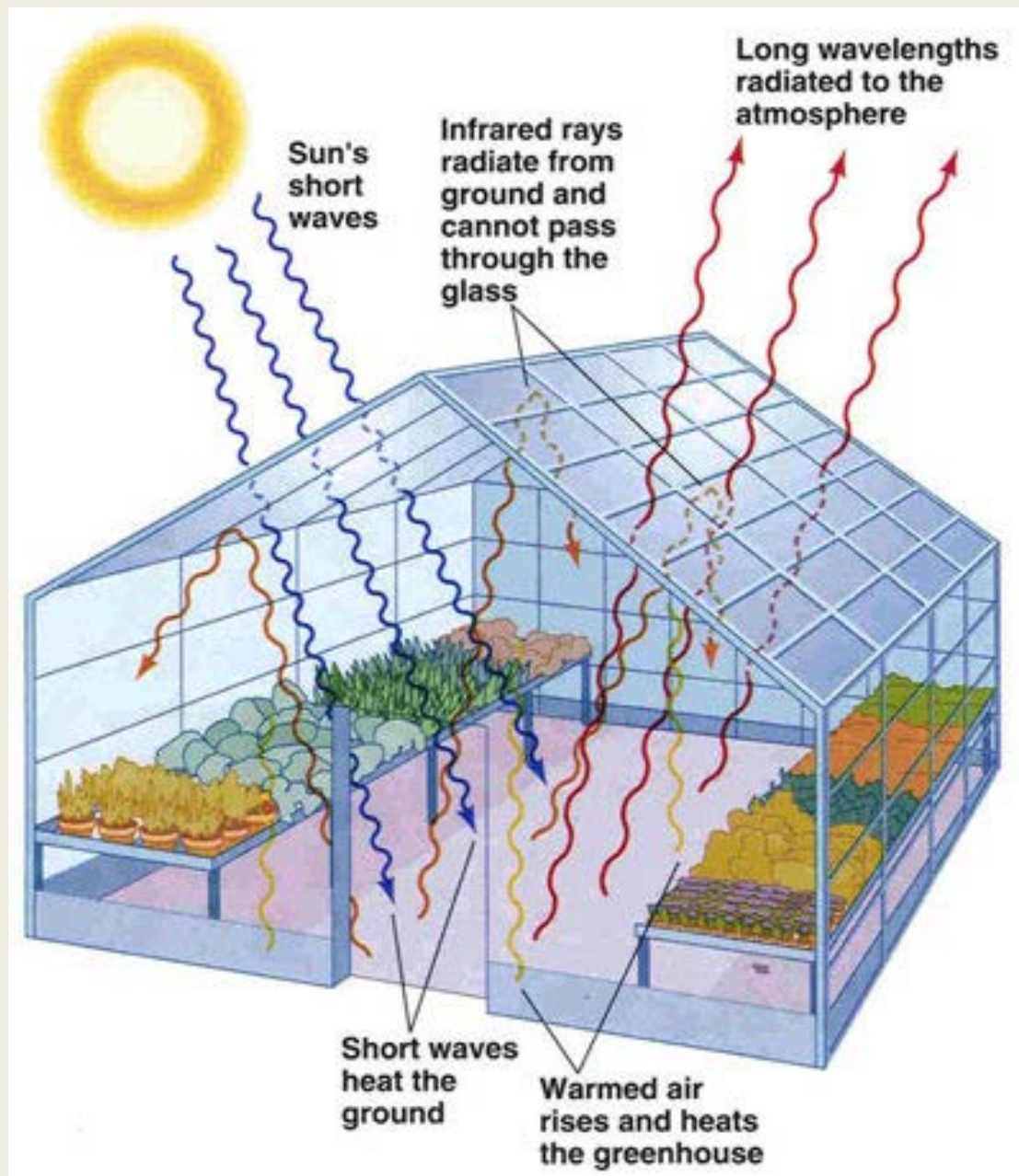
Conductivity

Air: 26

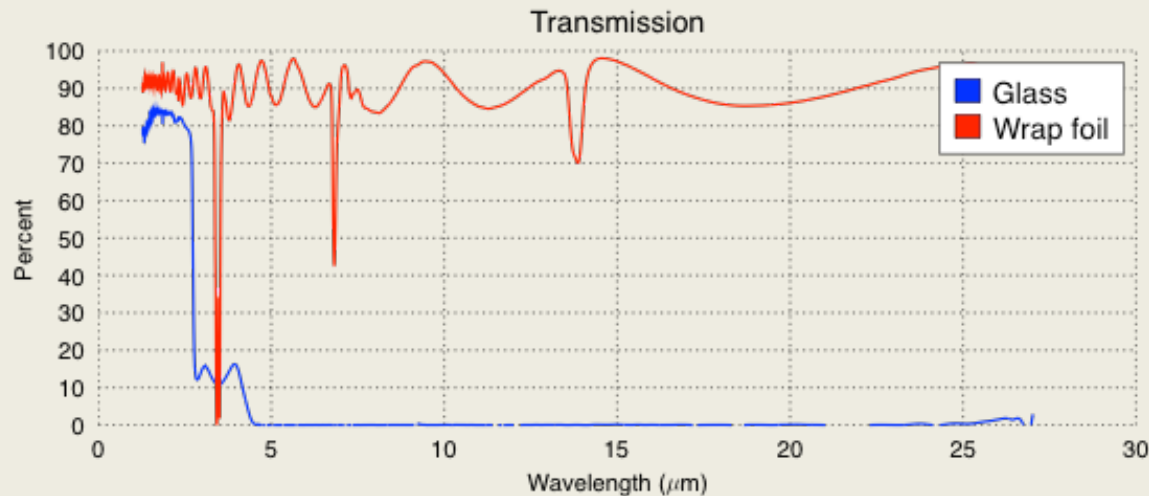
CO<sub>2</sub>: 17

mW/m\*K





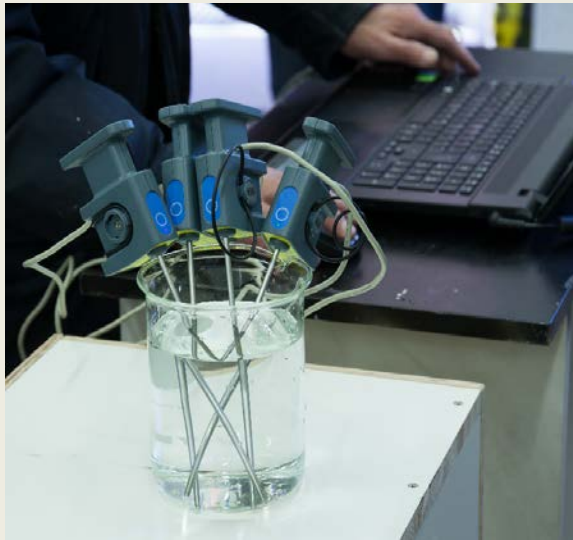
# Transmission through glass and cling film (plastic wrap)



# Equipment



# Calibration and readout



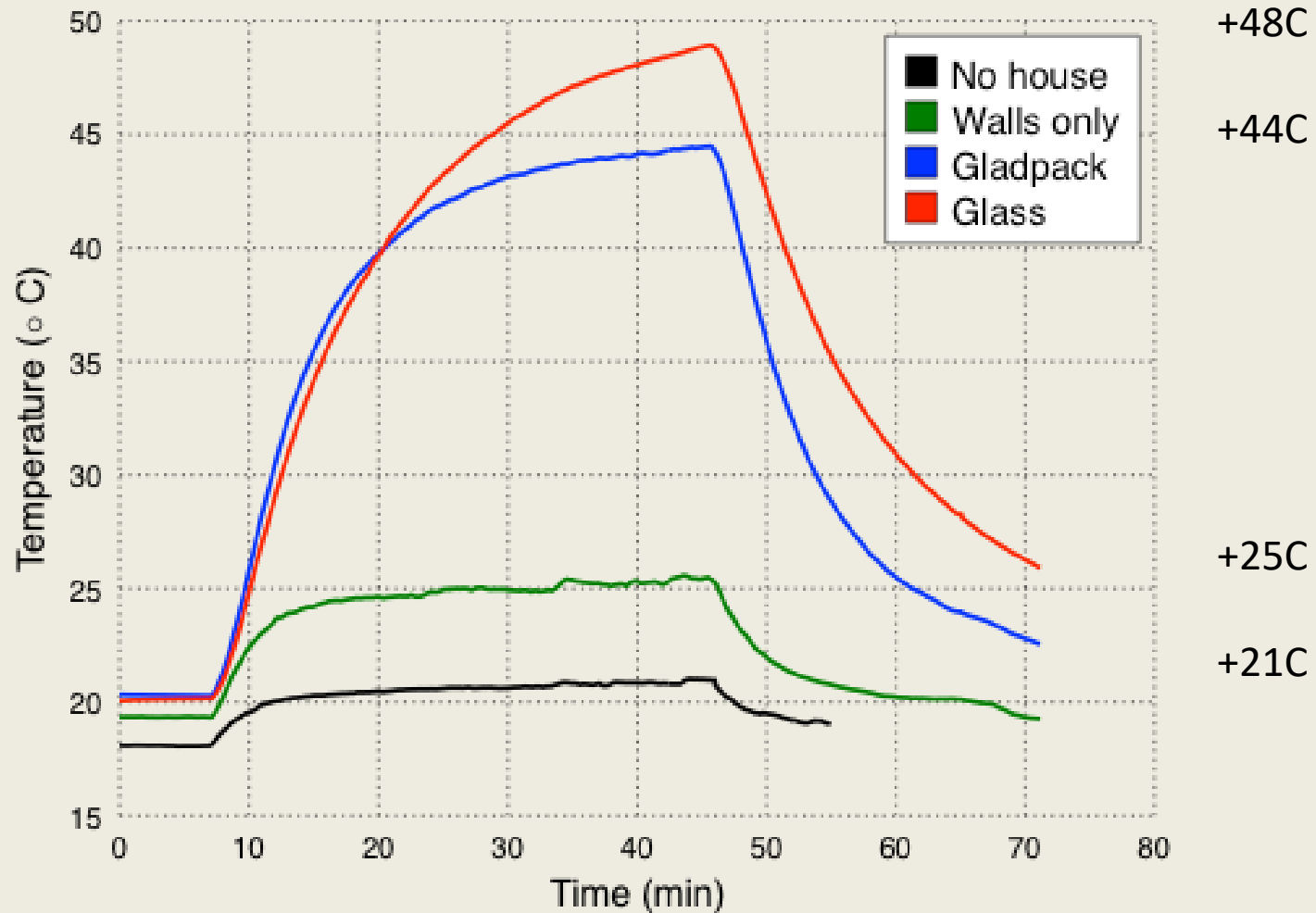


# Indoors experiment with halogen lamps

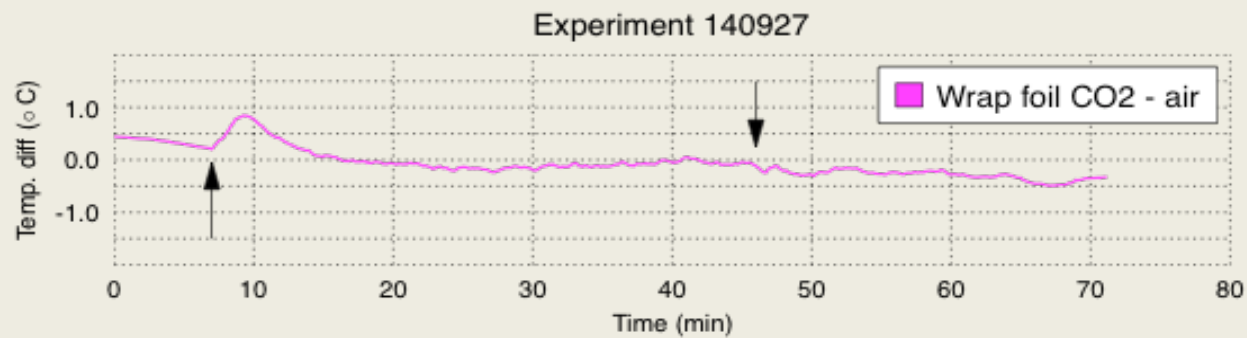
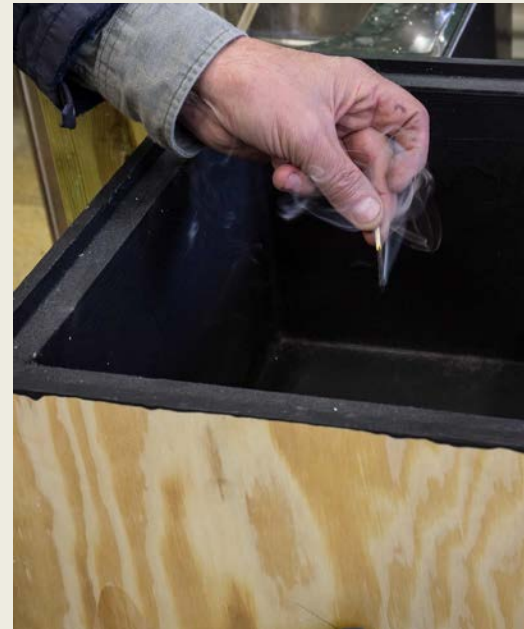




# Result: Indoors with lamps



## Experiment 2: 100% CO<sub>2</sub>



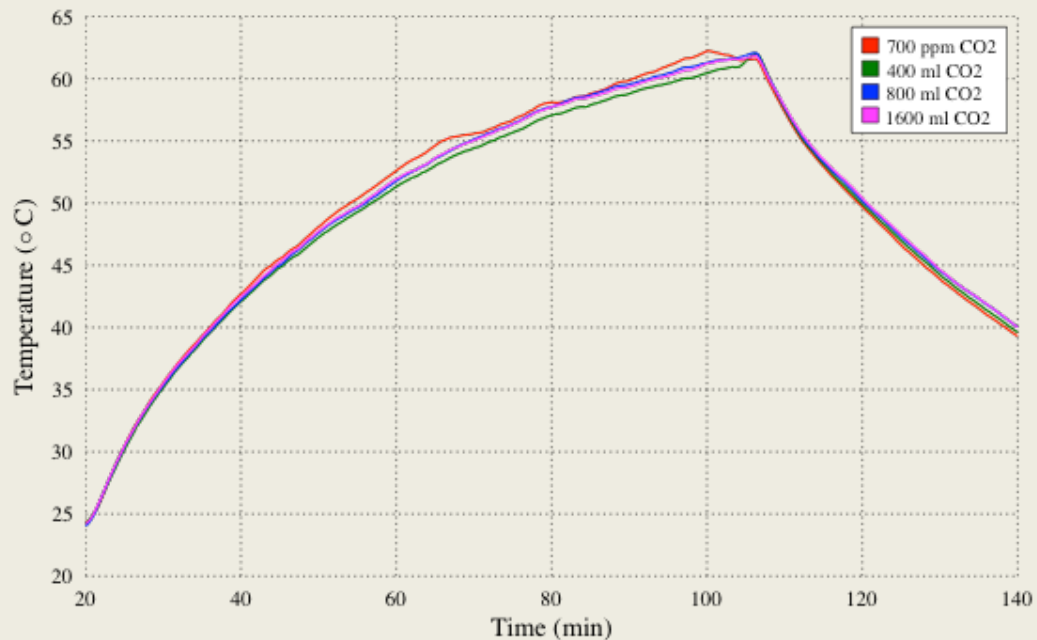
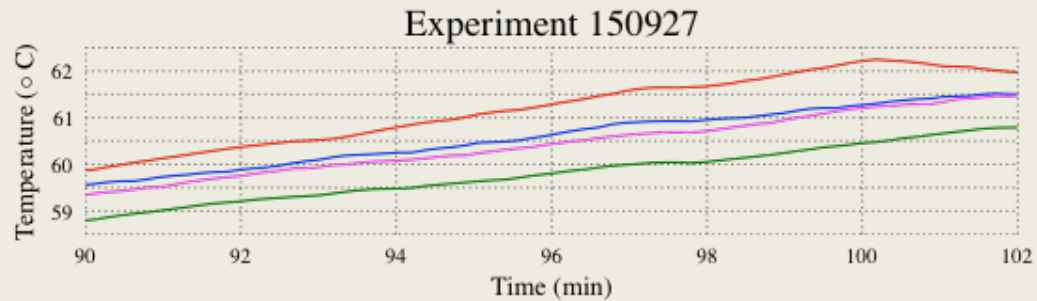
# Sun as a light source

## Can we measure the climate sensitivity?

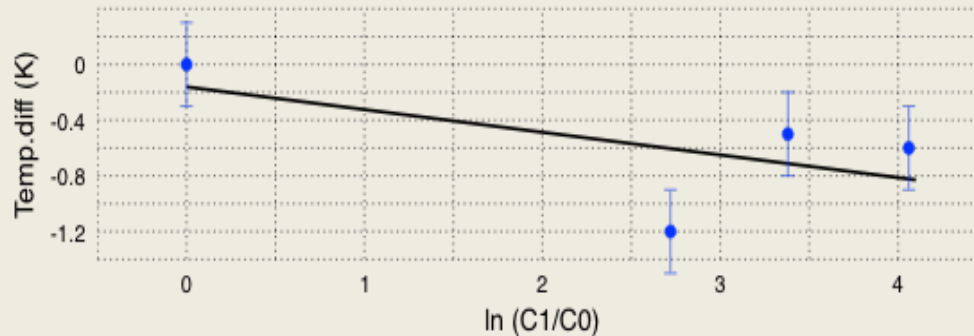


# Result

## Sunlight: doubling and redoubling of CO<sub>2</sub>



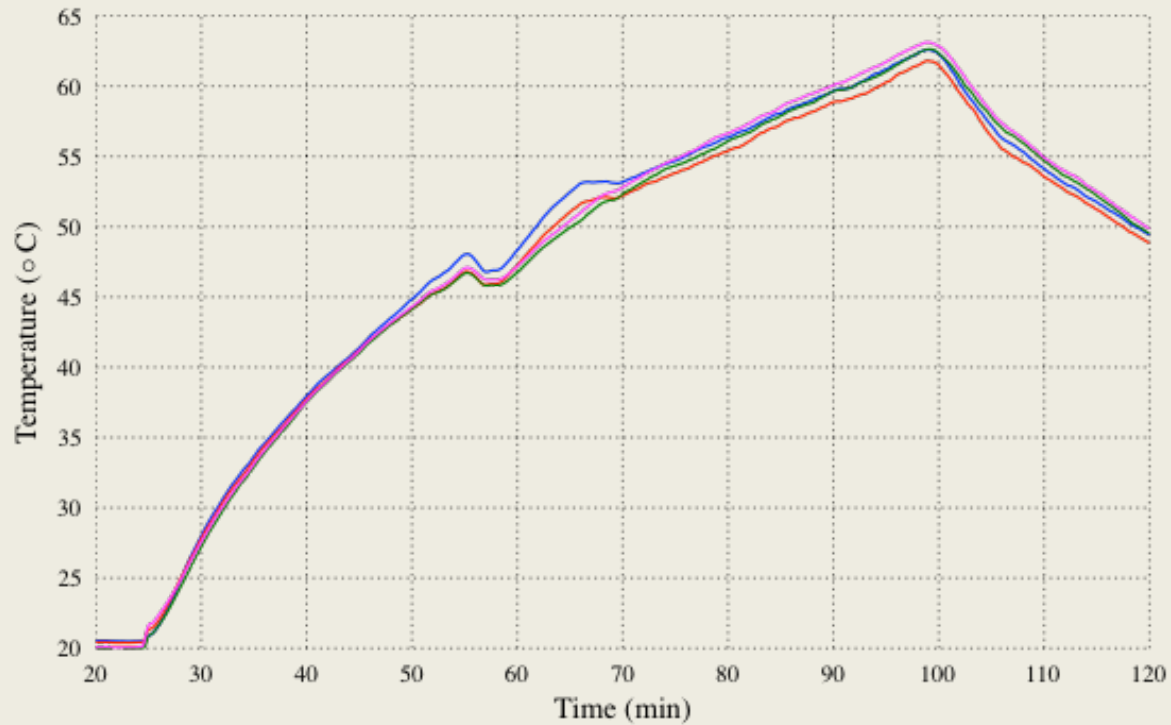
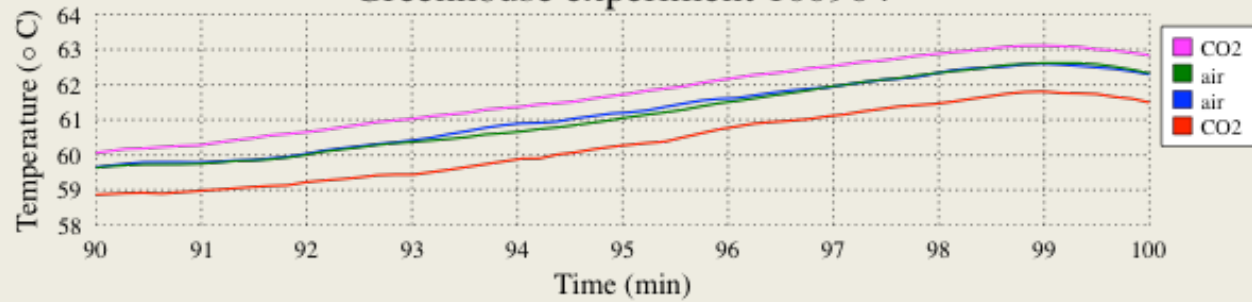
# Determination of Climate Sensitivity in small Greenhouses



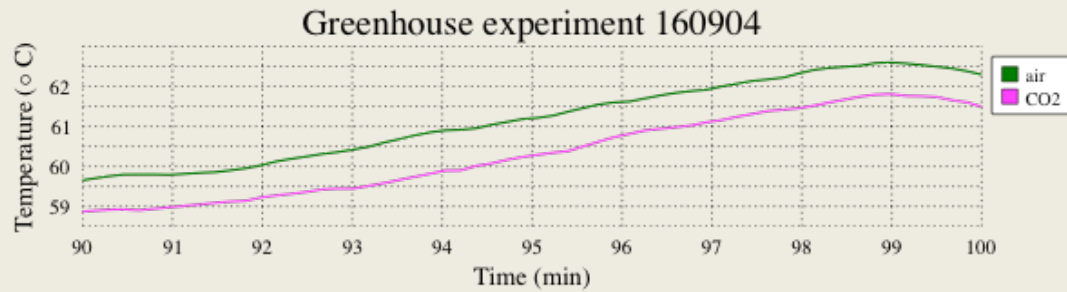
- $\Delta T (K) = (-0.16 \pm 0.16) \ln(C_1/C_0)$
- Climate Sensitivity:  $-0.11 \pm 0.11$  °C (doubling of CO<sub>2</sub>)
- In IPCC terminology: [-0.33:0.11]



### Greenhouse experiment 160904



# A final check



# Conclusions

- The Greenhouse with glass walls and roof, gets warmer. First of all, because roof and walls stops natural cooling by inhibiting heat transport by convection and evaporation
- Increase of CO<sub>2</sub> in small Greenhouses has not resulted in higher temperatures
- An experiment with doubling and redoubling of the CO<sub>2</sub> content gave a 2 $\sigma$ -limit: [-0,3 : 0,1] for the climate sensitivity
- In a Greenhouse filled with CO<sub>2</sub>, the temperature reached the same or a lower level than in a Greenhouse with air.

# References

- [www.climaterealityproject.org/climate-101](http://www.climaterealityproject.org/climate-101)
- <https://wattsupwiththat.com/climate-fail-files/gore-and-bill-nye-fail-at-doing-a-simple-co2-experiment/>
- R.Wood, Note on the Theory of the Greenhouse, Philosophical Magazine, 17, 319 (1909)
- N. Nahle, Repeatability of Professor Robert W. Wood's 1909 Experiment on the Theory of the Greenhouse, Principia Scientific Int. (2011)
- J.-E. Solheim, T. Eriksen, and Y. Engebretsen, A school experiment with radiation heating of small greenhouses (in Norwegian), Fra Fysikkens Verden (2016), in production