

A Paradigm Shift to an Old Scheme for Outgoing Longwave Radiation (OLR)

Alastair B. McDonald, BSc (Elect. Eng.), BSc (Hons)(Open) - Independent researcher - Address: 6 Pine Tree Close, Wimborne, Dorset BH21 1BP, U.K. - Tel. +44 1202 886686 - email: abmcdonald33@gmail.com

Horace-Benedict de Saussure & the Hotbox

Horace-Benedict de Saussure FRS, an 18th Century Swiss professor, and his colleague Marc-Auguste Pictet, used two concave mirrors to demonstrate that non-luminous objects radiate heat. They placed a black-hot cannon ball at the focus of one of two facing mirrors and a thermometer at the focus of the other. **The temperature recorded rose, showing the existence of infra-red radiation (IR), a decade before Sir William Herschel.**

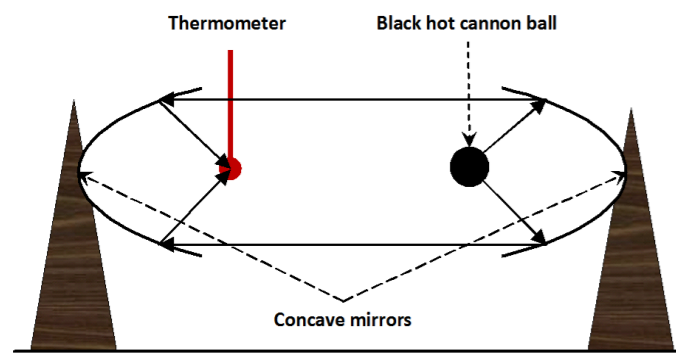


Figure 1 - Apparatus employed by Saussure and Pictet to show IR exists.

Saussure also invented the hot-box solar cooker which works by preventing the conduction of the warm air. He used it as a helio-thermometer to measure solar flux in the atmosphere. Since the temperature it reached on a mountain was only slightly greater than at ~1500 m below, he showed that the air is not heated by solar radiation. **He had discovered the greenhouse effect: that the atmosphere is transparent to solar radiation, but the air near the ground is heated by the absorption of terrestrial IR.**

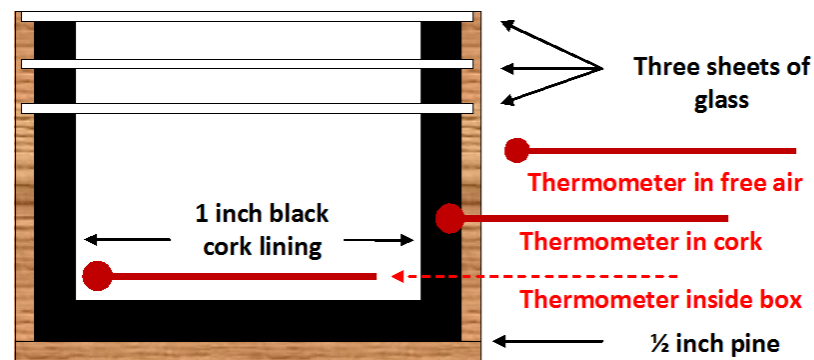


Figure 2 - Diagram illustrating Saussure's helio-thermometer

References

1. Kennedy, J., Morice, C. & Parker, D. Global and regional climate in 2011. *Weather* **67**, 212–218 (2012).
 2. Fourier, J. On the Temperatures of the Terrestrial Sphere and Interplanetary Space. *Translated by Pierrehumbert, R. T.* (2004). <http://www.nature.com/nature/journal/v432/n7018/extref/432677a-s1.pdf>.

The Tropical Lapse Rate Problem

The current climate models predict greater warming in the upper troposphere than is measured by the radiosondes and satellites. **It has been suggested that the theories may be incorrect¹. Here, it is proposed that this is indeed the case!** All the models are ignoring the fact that the absorption of CO₂ is saturated.

Fourier's Scheme of Conducted Radiation

The current scheme for outgoing longwave radiation began with a paper by Jean-Baptiste Joseph Fourier, who invented Fourier analysis. He used it to calculate the conduction of heat in irregular solids. He saw Saussure's hot box, Fig. 2, as a model of the Earth's atmosphere. He believed that the glass in the box impeded the infrared radiation, and **he imagined that the heat emitted by the surface of the Earth passes through the atmosphere in a way similar to that in which heat is conducted through glass².**

But the Radiation is Saturated ...

Based on Fourier's scheme of attenuated radiation reaching the top of the atmosphere, Svante Arrhenius built the first mathematical model of the greenhouse effect in an attempt to show that the Great Ice Age was caused by less CO₂ in the atmosphere. However, Karl Angstrom and John Koch showed that CO₂ absorption is saturated³. **Arrhenius agreed the model was wrong, and the idea that CO₂ causes climate change was abandoned at the turn of the 19th Century.**

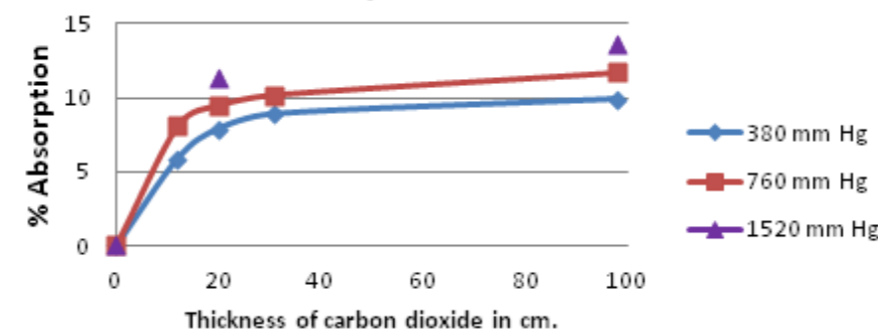


Figure 3 - CO₂ Absorption at ~100°C showing saturation. Data from Koch(1901)⁴.

3. Very, F.W. & C.A. Knut Angstrom on Atmospheric Absorption. *Monthly Weather Review* **1901**, 268 (1901).
 4. Koch, J. Beiträge zur Kenntnis der Wärmeabsorption in Kohlensäure. *Öfvers. Svenska Vet. Akad. Forh.* **58**, 475 – 488 (1901).

... Radiation Escaping from the Sun is Not!

In 1906, the astronomer Karl Schwarzschild proposed an equation describing the flow of radiation escaping to space from the Sun's interior which assumes that Kirchhoff's law for black body radiation applies there. **Schwarzschild's equation is now used to model OLR in the Earth's atmosphere despite the fact that greenhouse gases emit line radiation.** Moreover, under Kirchhoff's law there is no net absorption, although some absorption does occur in models of the Earth's atmosphere because convective adjustment leads to a fixed lapse rate.

This results in a system where the absorption by CO₂ is distributed throughout the entire troposphere, and the emission to space is from the altitude at which the air is at the effective temperature. Fig. 4 shows how an increase in the amount of CO₂ causes the lapse rate to shift to the right, but the radiosondes and satellites do not report this temperature rise.

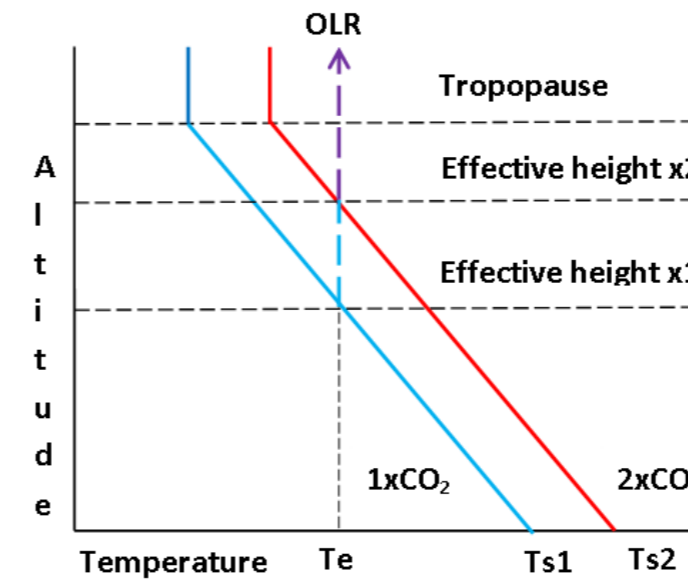


Figure 4 - Temperature versus altitude for a doubling of CO₂ under current scheme. Adapted from Held & Soden (2000)⁵.

It is argued that since the OLR at the top of the atmosphere must equal the incoming solar radiation, then the OLR radiation must be originate from an altitude where a blackbody would have that intensity. **But the TOA ~215K brightness temperature of CO₂ is far less than the effective temperature and so the CO₂ would not emit from the effective height in any case!**

5. Held, I. M. & Soden, B. J. Water vapor feedback and global warming. *Annual Review of Environment and Resources* **25**, 441 (2000).
 6. Philipona, R., Dürr, B., Ohmura, A. & Ruckstuhl, C. Anthropogenic greenhouse forcing and strong water vapor feedback increase temperature in Europe. *Geophys. Res. Lett.* **32**, L19809 (2005).

Tropical Lapse Rate Problem etc. Solved

It follows from the work of Saussure that during the day the air is warmed by radiation from the ground, and because the radiation obeys the Bouguer, Lambert, Beer law, the warming decreases exponentially with height. In this old paradigm it is only the boundary layer which is warmed by radiation from the surface. **Here it is proposed that a paradigm shift back to Saussure's scheme, may resolve many of the climate model problems.**

First, it explains the tropical lapse rate problem, since with this old scheme only the boundary layer warms. See Fig. 5. This scheme is also consistent with the excess warming in eastern Europe being caused by water vapour close to the surface⁶, and may also explain why there are difficulties in closing the surface radiation balance⁷ since **the Microscopic equation of radiative transfer⁹ should be used instead Schwarzschild's equation.**

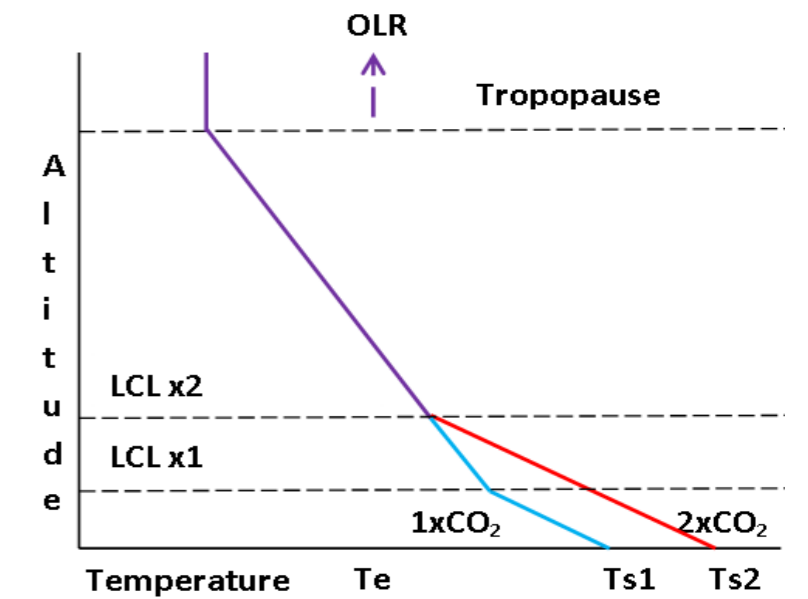


Figure 5 - Temperature versus altitude for a doubling of CO₂ under the old scheme. LCL is the top of the boundary layer. Compare with Fig. 4.

Moreover, since the absorption of CO₂ is saturated, it has little influence on the TOA balance. That is maintained by changes to albedo, e.g. clouds and ice sheets. An increase in surface temperature raises the snow line in altitude and latitude, as is happening with the retreat of glaciers and Arctic sea ice. **The CO₂ affect on the climate is indirect via the global albedo.**

7. Wild, M. *et al.* The global energy balance from a surface perspective. *Clim Dyn* **40**, 3107–3134 (2013).
 8. White, J. W. C. *et al.* Abrupt Impacts of Climate Change: Anticipating Surprises. in **16**, 17028 (2014).
 9. Thomas, G. E. & Stamnes, K. *Radiative Transfer in the Atmosphere and Ocean.* (Cambridge University Press, 2002).