



This is the print version of the [Skeptical Science](http://skepticalscience.com/article/cru-tampered-with-temperature-data/) article '[CRU tampered with temperature data](http://skepticalscience.com/article/cru-tampered-with-temperature-data/)', which can be found at <http://sks.to/tamper>.

The greenhouse effect and the 2nd law of thermodynamics

What The Science Says:

The 2nd law of thermodynamics is consistent with the greenhouse effect which is directly observed.

Climate Myth: 2nd law of thermodynamics contradicts greenhouse theory

"The atmospheric greenhouse effect, an idea that many authors trace back to the traditional works of Fourier 1824, Tyndall 1861, and Arrhenius 1896, and which is still supported in global climatology, essentially describes a fictitious mechanism, in which a planetary atmosphere acts as a heat pump driven by an environment that is radiatively interacting with but radiatively equilibrated to the atmospheric system. According to the second law of thermodynamics such a planetary machine can never exist." ([Gerhard Gerlich](#))

At a glance

Although this topic may have a highly technical feel to it, thermodynamics is a big part of all our everyday lives. So while you are reading, do remember that there are glossary entries available for all thinly underlined terms - just hover your mouse cursor over them for the entry to appear.

Thermodynamics is the branch of physics that describes how energy interacts within systems. That interaction determines, for example, how we stay cosy or freeze to death. You wear less clothing in very hot weather and layer-up or add extra blankets to your bed when it's cold because such things control how energy interacts with your own body and therefore your degree of comfort and, in extreme cases, safety.

The human body and its surroundings and energy transfer between them make up one such system with which we are all familiar. But let's go a lot bigger here and think about heat energy and its transfer between the Sun, Earth's land/ocean surfaces, the atmosphere and the cosmos.

Sunshine hits the top of our atmosphere and some of it makes it down to the surface, where it heats up the ground and the oceans alike. These in turn give off heat in the form of invisible but warming infra-red radiation. But you can see the effects of that radiation - think of the heat-shimmer you see over a tarmac road-surface on a hot sunny day.

A proportion of that radiation goes back up through the atmosphere and escapes to space. But another proportion of it is absorbed by greenhouse gas molecules, such as water vapour, carbon dioxide and methane. Heating up themselves, those molecules then re-emit that heat energy in all directions including downwards. Due to the greenhouse effect, the total loss of that outgoing radiation is avoided and the cooling of Earth's surface is thereby inhibited. Without that extra blanket, Earth's average temperature would be more than thirty degrees Celsius cooler than is currently the case.

That's all in accordance with the laws of Thermodynamics. The First Law of Thermodynamics states that the total energy of an isolated system is constant - while energy can be transformed from one form to another it can be neither created nor destroyed. The Second Law does not state that the only flow of energy is from hot to cold - but instead that the net sum of the energy flows will be from hot to cold. That qualifier term, 'net', is the important one here. The Earth alone is not a "closed system", but is part of a constant, net energy flow

from the Sun, to Earth and back out to space. Greenhouse gases simply inhibit part of that net flow, by returning some of the outgoing energy back towards Earth's surface.

The myth that the greenhouse effect is contrary to the second law of thermodynamics is mostly based on a very long 2009 paper by two German scientists (not climate scientists), Gerlich and Tseuschner (G&T). In its title, the paper claimed to take down the theory that heat being trapped by our atmosphere keeps us warm. That's a huge claim to make – akin to stating there is no gravity.

The G&T paper has been the subject of many detailed rebuttals over the years since its publication. That's because one thing that makes the scientific community sit up and take notice is when something making big claims is published but which is so blatantly incorrect. To fully deal with every mistake contained in the paper, this rebuttal would have to be thousands of words long. A shorter riposte, posted in a discussion on the topic at the Quora website, was as follows: "...I might add that if G&T were correct they used dozens of rambling pages to prove that blankets can't keep you warm at night."

If the Second Law of Thermodynamics is true - something we can safely assume – then, "blankets can't keep you warm at night", must be false. And - as you'll know from your own experiences - that is of course the case!

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Further details

Among the junk-science themes promoted by climate science deniers is the claim that the explanation for global warming contradicts the second law of thermodynamics. Does it? Of course not (Halpern et al. 2010), but let's explore. Firstly, we need to know how thermal energy transfer works with particular regard to Earth's atmosphere. Then, we need to know what the second law of thermodynamics is, and how it applies to global warming.

Thermal energy is transferred through systems in five main ways: conduction, convection, advection, latent heat and, last but not least, radiation. We'll take them one by one.

Conduction is important in some solids – think of how a cold metal spoon placed in a pot of boiling water can become too hot to touch. In many fluids and gases, conduction is much less important. There are a few exceptions, such as mercury, a metal whose melting point is so low it exists as a liquid above -38 degrees Celsius, making it a handy temperature-marker in thermometers. But air's thermal conductivity is so low we can more or less count it out from this discussion.

Convection



Figure 1: Severe thunderstorm developing over the Welsh countryside one evening in August 2020. This excellent example of convection had stroonal Meteorological Office. As a “test case”, the Review did obtain data directly from the Japanese NMO.

The Review makes the following criticism of CRU:

CRU should have made available an unambiguous list of the stations used in each of the versions of [CRUTEM] at the time of publication. We find that CRU's responses to reasonable requests for information were unhelpful and defensive. [1.3.1]

The inquiry also briefly dealt with the allegation “that Jones was complicit in malpractice in failing to respond appropriately to allegations of fraud made against [...] Professor Wei-Chyung Wang”, whose data Jones cited in a 1990 paper on the urban heat island effect. The allegedly “fabricated” claim was that few if any of a certain selection of Chinese weather stations had moved over time. Wang’s university investigated and rejected the accusation of fraud. Meanwhile, Jones responded within one year with a peer-reviewed analysis confirming the original conclusions. In any case, this was only one paper and [does not change anything](#) we know about the [urban heat island effect](#).

The overall implication of the allegations was to cast doubt on the extent to which CRU's work in this area could be trusted and should be relied upon and we find no evidence to support that implication. [1.3.1]

Despite being heralded as [“the final nail in the coffin of anthropogenic global warming”](#), Climategate has not even invalidated CRU's results, let alone the conclusions of the climate science community. In any case, the entire work of CRU comprises only a small part of the [large body of evidence](#) for [anthropogenic global warming](#). That mountain of evidence cannot be explained away by the behaviour of a few individuals.



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Skeptical Science explains the science of global warming and examines climate misinformation through the lens of peer-reviewed research. The website won the Australian Museum 2011 Eureka Prize for the Advancement of Climate Change Knowledge. Members of the Skeptical Science team have authored peer-reviewed papers, a [college textbook on climate change](#) and the book [Climate Change Denial: Heads in the Sand](#). Skeptical Science content has been used in university courses, textbooks, government reports on climate change, television documentaries and numerous books.



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