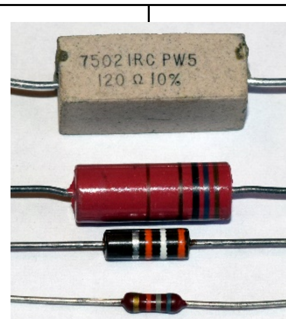
The Energy Advocate

A monthly newsletter promoting energy and technology

January 2018 (Vol. 22, No. 6) P.O. Box 7609, Pueblo West, CO 81007

Power Dissipation

Electrical resistors have long been manufactured and sold with three specifications: the electrical resistance, the tolerance, and the power dissipation rating. We are concerned here only with the power rating. In the photograph, the largest resistor is marked at 120 Ω ± 10%, and 5 watts. The next resistor down is a 2-watt resistor, the next is a ½-watt resistor, and the bottom is rated at ¼-watt.



The power rating is determined primarily by size, but also to some extent by the materials. The 5-watt resistor is packaged in ceramic.

We're not proposing a review of electronics here, but rather discussing power dissipation. Electrical current through resistors adds heat to them. They, in turn, lose heat to the environment by the three usual mechanisms: conduction (through the metal wires), convection (via moving air), and radiation (in the infrared).

We will now propose a new kind of resistor made from NoSuchThingium. It has the ability to operate under conditions of extreme cold, extreme heat, and extreme pressure. All of the device is at one uniform temperature. We feed current through it so that under all conditions, it consumes one watt. We will now consider three different hypothetical conditions under which that resistor is used.

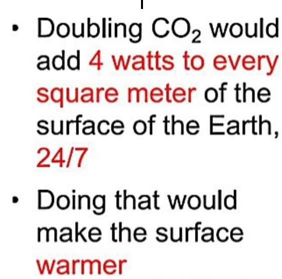
Our first condition is that we place the resistor at the bottom of the ocean, where the temperature is 4 ºC (39 ºF), the temperature of the densest water. After a million years there, the temperature of the resistor remains at 4 ºC, being controlled by massive amounts of water.

Our second condition is that the resistor be in an electronic circuit in a laboratory. The temperature will rise until the heat lost to the surroundings is equal to 1 watt. That temperature might be 30 ºC-50 ºC. These are rough estimates based on touching them with fingers, but engineers who design the circuits actually account mathematically for the heat losses and calculate the expected temperature.

The third condition is ridiculous, but there is a reason for discussing it. Here, we place the resistor inside a perfect thermal insulator made of UnObtainium, that lets no heat pass through its walls whatsoever. If we continuously feed in one watt of electrical power, the resistor gets inexorably hotter and hotter; indeed, the theoretical limit is infinity.

Now, we pose a question: If we feed 1 watt of power into a resistor, how much does the temperature rise? Answer: somewhere between zero and infinity, depending on the mechanism of heat loss.

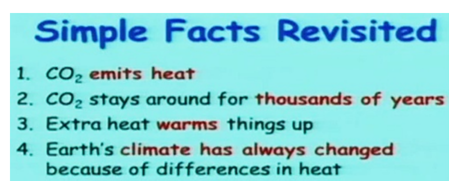
Let us turn our attention to the climate. In a recent debate [1,2] with Yours Truly, Scott Denning claimed that doubling CO_2 concentration would add 4 watts to every square meter on the earth. The premises are highly suspect, but we would still have to ask how much the temperature would rise, and the answer would depend on the heat-loss mechanisms, about which Denning said nothing.



Scott Denning 12/02/2017

Ultimately, of course, the earth can lose heat only by infrared radiation (IR), but the simple-minded notion that the IR heading to outer space comes from the ground is mistaken. Also, the 4-W/m² figure is an overestimate. We will discuss that aspect a bit later.

For now, we'll just note a fact often missed by climate alarmists: the CO_2 is in the sky, not on the surface. The surface emits IR in amounts depending on the temperature (Stefan-Boltzmann radiation law), and some of the IR is in a wavelength band absorbed by CO_2. In other words, IR transfers heat from the surface to CO_2 in the atmosphere. *CO_2 is not a source of heat*; it briefly holds energy delivered to it by IR or by collisions with other molecules, and then shares that energy with other molecules. To say that "CO_2 emits heat" is laughably far from the truth.



Scott Denning, 2011 ICCC6

Worse yet, to emphasize that somehow CO_2 "adds heat" without specifying how the earth sheds heat is to build a case around part of an equation. Under these non-specific conditions, it is *mathematically impossible* to determine how much, if any, the temperature would rise.

[1] http://www.efn-usa.org/environment/item/1615-climate-change-simple-serious-solvable-scott-denning-usofa

[2] http://www.efn-usa.org/environment/item/1635-global-climate-howard-cork-hayden-usofa

IR Absorption

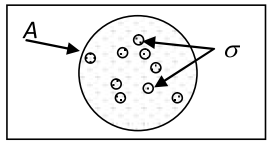
The common conception about the greenhouse effect is that IR emitted by the surface of the earth is absorbed by greenhouse gases (GHGs), mostly H_2O and CO_2, and re-emitted toward the surface. Make no mistake about it. H_2O and CO_2 do absorb IR, and the atmosphere does emit IR toward the surface, but it is important to understand some mechanisms before assaulting CO_2 as the climate-controlling villain.

The likelihood that molecules absorb IR depends upon four things: the intensity of the IR, the number of molecules per unit volume, the wavelength of the IR, and the cross-sectional area σ (called the *cross-section,* described below) of the molecules for absorbing that wavelength.

But absorbing IR is not quite the same as heating the surface. If the molecule immediately emits IR of the same wavelength, the local effect on the atmosphere is nil, zero, naught. The more likely process is that collisions with other molecules cause that absorbed energy to be shared with other molecules, raising the temperature somewhat of the local atmosphere.

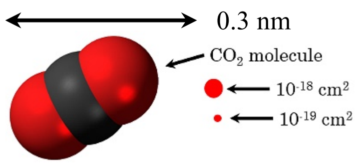
Cross-Sections

In the sketch at the right, you are looking up a short tube whose cross-sectional area is A, at a number N of molecules, of cross-section σ.



The probability that IR is absorbed in the tube is $N\sigma/A$. For a longer tube, where molecules can be lined up one behind another, the mathematics is more complicated; we will not bore you with the details.

Figure 1 shows the IR absorption cross-section that CO_2 has for infrared, in units of 10^{-18} cm^2, versus IR wavelength in micrometers. The cross-sections are minuscule compared to the size of the molecule as one would infer from the density of dry ice (solid CO_2), but be assured that *all* of the IR emitted from the surface between 14 micrometers (μm) and 16 μm is absorbed very near the surface, because there are about 10^{16} molecules of CO_2 in every cubic centimeter of air.



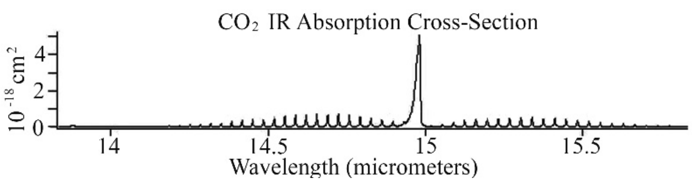
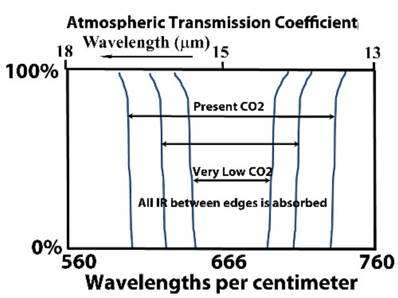


Figure 1: CO_2 IR absorption cross-section. Vertical scale is 0 to 5×10^{-18} cm^2.

The absorption spectrum of CO_2 extends beyond the 14-μm and 16-μm limits of Figure 1, but the cross-sections get smaller and smaller—by numerous factors of ten. As more CO_2 is added to the atmosphere, the density becomes high enough so that some more IR is absorbed. The schematic drawing at the right shows that as more CO_2 is added to the atmosphere, the added absorption occurs out in the wings. With the current concentration of about 400 parts per million, the additional absorption occurs near wavelengths of 17 μm and 13.5 μm. Out there in the far wings of the spectrum, the cross-sections are so small that a large fraction of the IR at those wavelengths reaches outer space. That is, most IR of those wavelengths travels many kilometers before being captured, if at all.



There are two important consequences of the long mean free path of the IR in the far wings of the spectrum. The first is that the majority of the energy is absorbed well above a kilometer in elevation. In other words, heat is added high in the atmosphere, not at the surface. If the molecules immediately re-radiated that radiation, the downward-directed IR would heat the surface, but instead, the incoming IR winds up heating the atmosphere far from the surface.

The other important consequence of IR's being absorbed high in the atmosphere is that the amount of absorption is considerably less than climate scientists have imagined. We now look at the phenomenon called pressure broadening.

Pressure Broadening

Look again at Figure 1, paying attention to the sharp peak at about 15-micrometers wavelength. The sharpness is an indication that the cross-sections were measured at fairly low pressure. Higher pressures cause more frequent collisions between molecules, and the collisions perturb the energy level of the molecules. Therefore, the IR absorbed may have a bit longer or shorter wavelength than at the peak. This phenomenon is called pressure broadening.

The absorption cross-sections in Figure 1 are in some sense huge. They can be measured in a conventional laboratory at low pressure, and the absorption is enough to measure easily. To obtain realistic absorption probabilities all across the wavelength band, climate scientists have used large amounts of CO_2 (5%, or 50,000 ppmv) in air at atmospheric pressure. Those measurements, many over a century old, have resulted in the equation for "forcing" F (IR energy captured per unit area per unit time) which is,

$$F = A\frac{\mathrm{W}}{\mathrm{m}^2}\ln\left(\frac{C}{C_0}\right) \qquad (1)$$

In Equation 1, the coefficient A is usually taken to be 5.35 W/m^2, the starting concentration of C is C_0. When $C = 2C_0$ (i.e., a doubling of the concentration), we have ln(2)=0.69315…, and the forcing is 3.7 W/m^2.

A rather standard routine is to use the Stefan-Boltzmann radiation law to calculate what the temperature rise of the Earth would be if the CO_2 concentration doubled. The result is that if the surface were to have an additional 3.7 watts added to every square meter, the temperature of the surface would rise by 1.1 ºC. The calculation assumes that the *surface* receives 3.7 W/m^2, but the heating actually takes place in the *atmosphere*, and most of it well above an elevation of a kilometer.

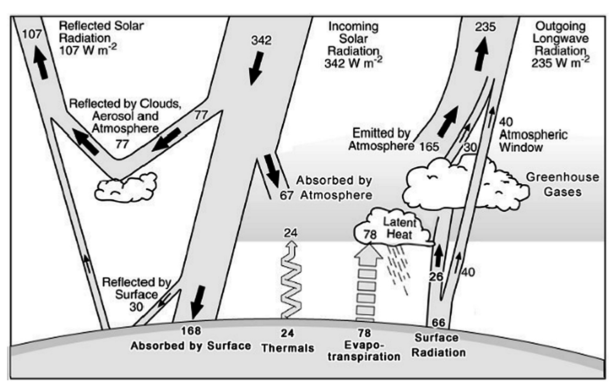


Figure 2: Heat transfer mechanisms, with back-radiation subtracted. (From Kehr: *The Inconvenient Skeptic*)

As shown in Figure 2, the worldwide average IR radiation to space is 235 W/m^2, of which 83% comes from the *atmosphere* (13% from greenhouse gases). The data in Figure 2 are taken entirely from IPCC reports. Just as the radiation to and from a kettle in a hot stove plays no part in net heat transfer, Kehr subtracted out the back radiation toward the surface.

Therefore, the premise that the *surface* receives the 3.7 W/m² is in error. The IR is absorbed by the atmosphere, which is responsible for 83% of the radiation to space.

Yet another problem arises. Equation 1 has been derived on the basis of IR absorption data taken at sea-level pressure, a pressure that is inappropriate for the high altitudes where the IR is actually absorbed.

Figure 3 shows the pressure effect on the IR absorption cross-sections, as calculated by Will Happer, a specialist in atomic, molecular, and optical physics. The horizontal scale is in inverse centimeters (the number of wavelengths per centimeter) as is common in spectroscopy. The wavelength in micrometers is shown in the top scale, reading right to left.

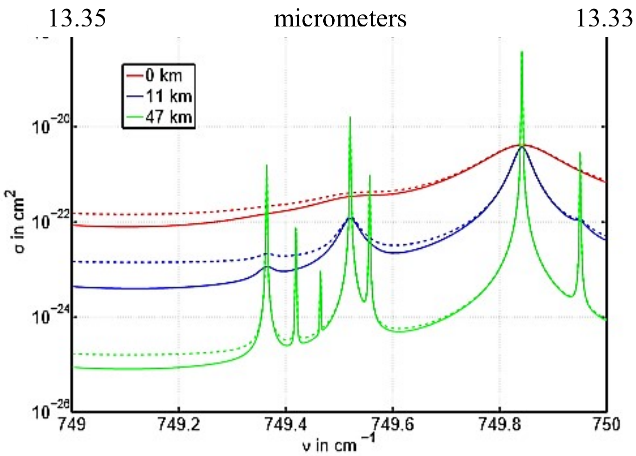


Figure 3: CO_2 IR absorption cross-section in one wing of the spectrum, on a logarithmic scale. The markings on the axis are a factor of 100 apart. The red lines come in at 10^{-22} cm², which is smaller than the big peak in Figure 1 by a factor of 20,000. The next scale marking down (10^{-24}) is smaller by yet another factor of 100. The graph is courtesy of Will Happer, Cyrus Fogg Professor of Physics at Princeton.

At sea level, the cross-section is somewhat flat across the 13.33 to 13.35 micrometer range; By 11 km altitude, the cross-section is reduced by a factor of about 50, and at 47 km altitude, absorption is strictly limited to a few sharp peaks. As a result, the forcing equation (Eq.1) is an overestimate by several tens of a percent.

That coefficient of 5.35 W/m² in Equation 1 is not sacred. It was 6.3 W/m² until 1988 (G. Myhre, E.J. Highwood, K.P. Shine and F. Stordal, "New estimates of radiative forcing due to well-mixed greenhouse gases," *Geophys. Res. Lett.* **25** (1998) 2715–2718), after which it became 5.35 W/m². Now, the CMIP5 models have it at 5.05 W/m². After the climate scientists learn something about molecular spectroscopy, it will drop again, probably to about 3.5 to 4 W/m². The forcing calculated from those coefficients is 4.4, 3.7, and 2.5 W/m², respectively, rounded off to 4 W/m² by Denning.

Summary

Climate Change:
Simple, Serious, Solvable

Scott Denning maintains that climate change is simple, serious, and solvable. Well, it is simple if your model is one that adds 4 W/m² of heat to every square meter of the Earth's surface, and you ignore entirely any mechanisms for heat to escape. The temperature will rise inexorably to infinity. That makes climate change serious.

To put it fairly, but bluntly, there is huge difference between adding 3.7 W/m² to the surface and absorbing 2.5 W/m² of IR at the elevation of Mount Everest.

How serious the problem is depends upon how much the temperature rises. We have shown repeatedly in TEA that the climate models (why do they need more than one if the science is settled?) disagree with measurements.

Denning's solution to the problem is the standard fare—sunbeams, breezes, and "other" (yet to be determined). As a reminder, the only new source of energy discovered in the last couple of centuries is nuclear energy.

Data

Denning enumerates the times that the satellite data have been adjusted. Originally, Roy Spencer and John Christy (University of Alabama-Huntsville, UAH) did not realize that atmospheric drag would have an effect on their average temperature. When it was pointed out to them, they got busy and corrected their calculations to account for the different field of view. Then another problem arose: the satellites were speeding up, and each day they were looking slightly east of where they looked the day before. There were other, more subtle problems that they corrected in due time. Now, they have one satellite that uses thrusters occasionally to stay in the same orbit.

In any case, I gathered some data published by UAH in 2006, and data they published in 2017 (but covering the same time period) and graphed them, Figure 4 shows that, though there small random differences, the data and trends are basically identical.

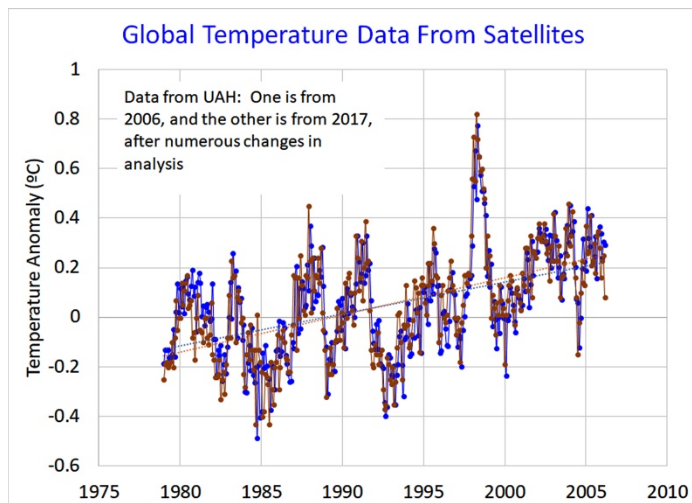
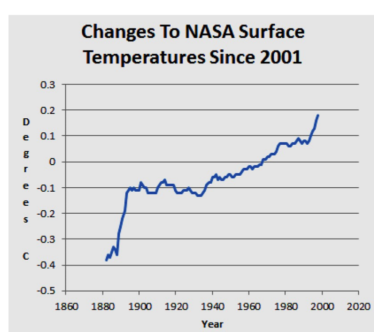


Figure 4: Satellite data of the lower troposphere taken in 2006 and from 2017, with somewhat different means of averaging. The trends are barely distinguishable.



By way of comparison, the surface data published by NASA-GISS show *systematic*—not *random*—reduction of previous temperatures, thereby artificially increasing the temperature trend. The figure to the left shows the modifications to past data. Somehow, the average temperature in 1880 dropped by 0.6 ºC with respect to present temperatures.

Of course, it is the duty of a scientist to correct past errors. If, for example, climate scientists removed thermometers from these louvered Stevenson Screens that were used for weather stations for about a century, and found that they all read a bit high—well, a little less high as decades passed—there might be some justification for the systematic reduction of past temperature averages.

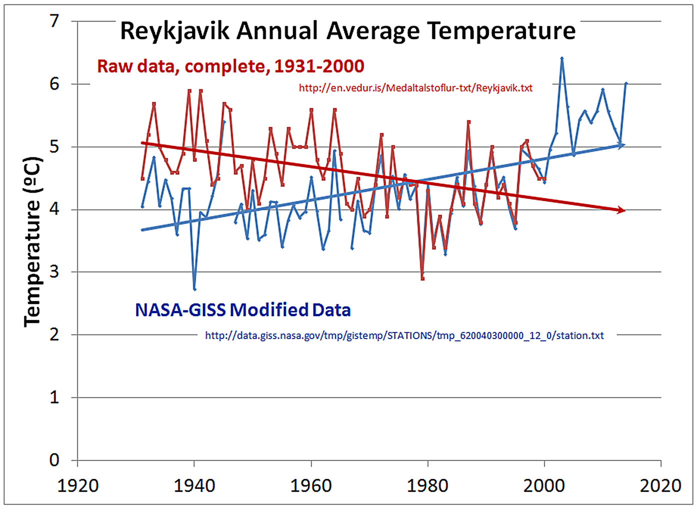


Figure 5: NASA-GISS modifications to *raw data!* (Thanks to Steve Goddard.)

Alternatively, NASA-GISS could conceivable have found that their method of calculating averages was incorrect, and therefore used a better averaging technique. But there is no excuse whatsoever for changing *raw data*. Figure 5 shows blatant data manipulation by NASA-GISS.

Volcanoes

A March 2017 article at *Smithsonianmag.com* presents recent evidence showing that the life of Vikings in Greenland was not what has been historically believed. This very interesting article [3] shows that the Vikings did not live a life of hardship, but rather thrived.

Our interest in the article, however, relates to climate. It tells of the eruption of a volcano in Indonesia in 1258 [3]:

> Then, in the 13th century, after three centuries, their world changed profoundly. First, the climate cooled because of the volcanic eruption in Indonesia. Sea ice increased, and so did ocean storms—ice cores from that period contain more salt from oceanic winds that blew over the ice sheet.

It would be curious indeed if a volcano in Indonesia changed the climate only in the North Atlantic; clearly, the Little Ice Age, which began at that time, was worldwide. Indeed, an article in *Geophysical Research Letters* [4] makes it clear that volcanism was indeed responsible for the Little Ice Age that Michael Mann's hockey stick caused to disappear along with the Medieval Warm Period. In the less hysterical times of 1997, the Washington Post ran an excellent news story about the Little Ice Age [5]:

> By about 1400, the climate had cooled to temperatures comparable to today. Over the next century or two, the world would cool still further, bringing on the Little Ice Age. Unlike many earlier climate swings, the Little Ice Age was abundantly documented by human observers. Records include the first readings from meteorological instruments such as rain gauges and thermometers. … The prices of wheat and other grains in a given year sometimes are used to estimate the size of the harvest and, by another step in logic, the favorableness of the weather that year. … Native American tribes such as the Iroquois relocated their villages to escape the cold. … Although it often is claimed that global air temperatures are the warmest ever and that a warming trend in the last 20 years is unprecedented, climatologists know better.

[3] Tim Folger, "Why Did Greenland's Vikings Vanish?", *Smithsonian Magazine*, March 2017.

[4] Gifford H. Miller, *et* al, "Abrupt onset of the Little Ice Age triggered by volcanism and sustained by sea-ice/ocean feedbacks," *Geophys. Res. Letts.*, 31 January, 2012 at http://onlinelibrary.wiley.com/doi/10.1029/2011GL050168/full

[5] Alan Cutler, "The Little Ice Age," *Washington Post*, August 13, 1997

STEM Notes

Stars twinkle because the light from the star is deflected ever so lightly by the atmosphere which is in constant motion. For a long time, astronomers have adjusted controls to keep bright stars in the cross-hairs of telescopes so that their photographs of dimmer stars would be sharp and clear. But for most of the sky, there are no bright stars in the field of view. Will Happer (mentioned earlier) invented a way to use artificial stars to accomplish the same task.

There is a layer of atmosphere 85-105 km in altitude where there is a considerable amount of sodium. A properly adjusted laser beam directed through an astronomical telescope can cause those sodium atoms to emit yellow light. The picture to the right is a time exposure taken at Lick Observatory by Laurie Hatch.

To the astronomer, that disperse column of sodium-yellow light appears like a star. Keeping that artificial star in the crosshairs lets astronomers get clear pictures of all parts of the sky. Astronomers have used the false star concept to devise a new technology called *adaptive optics*, which results in very sharp astronomical photographs.

NatGeo Strikes Again

The poster child for climate alarmists is the polar bear, whose numbers are actually *increasing*. If a deer is lame, weakened by age or illness, or otherwise not fit, predators make short work of it. If you hike in the woods, you don't see disabled deer.

The story for disabled polar bears is different, as they have no predators except man. They get weak and die. Blame it on climate change!

> As temperatures rise, and sea ice melts, polar bears lose access to the main staple of their diet—seals. Starving, and running out of energy, … *National Geographic*, 12/22/17

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Publisher: Vales Lake Publishing, LLC. Editor Howard Hayden, Ph.D., (for identification only) Professor Emeritus of Physics, University of Connecticut. The Energy Advocate, PO Box 7609, Pueblo West, CO 81007. ISSN: 1091-9732. Fax: (719) 547-7819, e-mail: corkhayden@comcast.net. Website: http://www.EnergyAdvocate.com. Subscription $40 for 12 monthly issues. *A Primer on* CO_2 *and Climate 2nd Ed.* $11.00 and *A Primer on Renewable Energy* $16.00 for subscribers. *Bass Ackwards: How Climate Alarmists Confuse Cause with Effect $18. Energy: A Textbook, $25.* (Add $5.00 for Priority Mail) Checks must be drawn on a US bank. *VISA, MasterCard, Discover/NOVUS* accepted.