4/16/16

Problems with the Physics of Greenhouse Warming

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Abstract: The world is warming, but are we absolutely sure that greenhouse gases are the culprit? Planck's law shows us that temperature in matter is the result of a very broad continuum of frequencies of oscillation of the bonds holding matter together. Greenhouse gases absorb only very small parts of this continuum. The thermal energy absorbed by greenhouse gases increases the internal energy of the bonds; its effect on the temperature of air has yet to be measured experimentally. Energy in radiation is equal to frequency times a constant meaning ultraviolet-B radiation reaching Earth when ozone is depleted is 48 times more energetic than infrared absorbed most strongly by carbon dioxide. The higher the thermal energy, the higher the temperature to which the absorbing body can be raised. Current climate models assume that energy is additive, overestimating infrared energy and underestimating ultraviolet energy. Ozone depletion provides a much clearer, more direct, and more complete explanation for the details of observed changes in warming since 1945 and throughout Earth history.

Introduction: The world has warmed substantially, especially since 1970, with 2015 being the hottest year recorded by thermometers and the first few months of 2016 continuing to set records. Most climate scientists are convinced, beyond a reasonable doubt, that global warming is caused by increasing concentrations of greenhouse gases. This consensus, crafted by the United Nations Intergovernmental Panel on Climate Change (IPCC), led to an agreement in Paris on December 12, 2015, among 195 nations, that global warming is a serious problem and that nations must work together right now to reduce greenhouse-gas emissions.

In 2006, I discovered an enigma in the science of climate change that caused me to put aside everything else I was doing in retirement so that I could work full time carefully reexamining all the assumptions upon which greenhouse-warming theory is built and carefully reevaluating the best observational data. This paper summarizes several fundamental problems in thermodynamics that cause me to wonder whether greenhouse-warming theory is physically possible.

Unfortunately the IPCC was founded in 1988 to build consensus rather than to question whether greenhouse warming theory provides the best explanation for observed warming. What I have discovered is that the ozone depletion theory of global warming appears to provide a much more direct, clearer, and complete explanation for detailed observations of changes in global warming since 1945 and throughout Earth history (Ward, 2015a; Ward, 2016b). As Max Planck, the father of modern physics explained in 1936: “New scientific ideas never spring from a communal body, however organized, but rather from the head of an individually inspired researcher who struggles with his problems in lonely thought and unites all his thought on one single point, which is his whole world for the moment.” Could I be right?

Thermal energy is oscillations of bonds: Thermal energy in matter is the result of all the normal modes of oscillation of all the degrees of freedom of all the bonds that hold the components of atoms and molecules of matter together. Each oscillation arises because atoms and even components of atoms with similar electric charge repel each other as they are pressed together while atoms and components of atoms with opposite electric charges attract each other as they move apart. The length of the bond, the amplitude of oscillation, moves from minimum length to maximum length and then back to minimum length again trillions of times per second. When matter is heated, both the frequencies and amplitudes of these oscillations are observed to increase, increasing the volume. At absolute zero, there are no oscillations and matter is very dense. At high enough temperature, the bonds come apart, the matter melts into a liquid or vaporizes into a gas. Thermal energy is stored in these oscillations as shown by the fact that the capacity of matter to hold heat (the heat capacity) increases with the number of degrees of freedom available (Grossman, 2014).

These atomic oscillators are frictionless and thus can oscillate for a long period of time. The only way to add or subtract amplitude of oscillation from these atomic oscillators is via resonance, where, at each frequency of oscillation, the oscillator with the greatest amplitude of oscillation shares the difference in amplitude of oscillation with nearby oscillators. Thus thermal energy flows from high amplitude of oscillation to low amplitude of oscillation at each frequency. The jostling of oscillators touching each other in matter can also cause them to share amplitude and frequency of oscillation via conduction helping the body approach thermal equilibrium.

Temperature is a broad spectrum of oscillations: In 1900, Max Planck modified the Wien approximation to develop empirically what is now known as Planck’s law, calculating the spectral radiance observed to be emitted from a black body at thermal equilibrium as a function of temperature (Figure 1). This electromagnetic

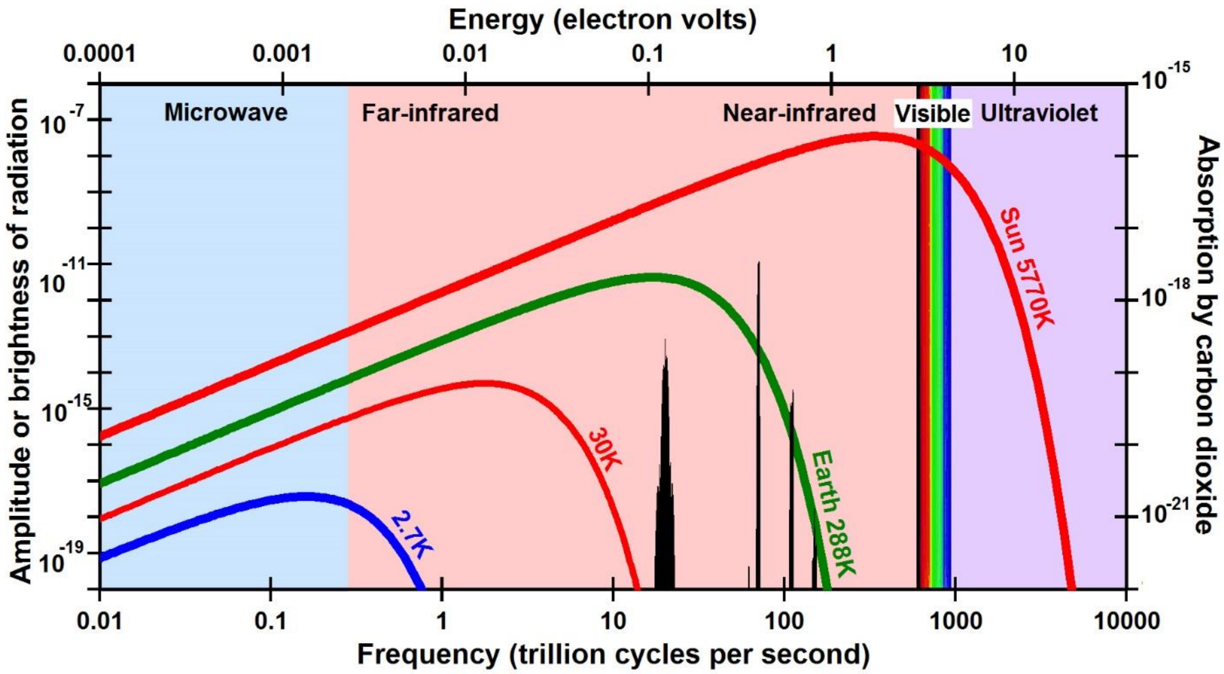

Figure 1. Planck's law shows the amplitude, brightness, or intensity of radiation at each frequency of oscillation as a function of the temperature in Kelvin of a black body at thermal equilibrium. The black lines show the frequencies absorbed by carbon dioxide, which make up a very small percentage of the broad continuum of frequencies that make up temperature. Energy on the upper X-axis is equal to frequency on the lower X-axis times the Planck constant (E=hν).

radiation is emitted, induced in air or in space, by the frequencies and amplitudes of oscillators on the surface of matter. Thus Planck's law defines the relationship between thermal energy and what we perceive and measure as temperature of matter. Each curve, for a given temperature, shows that temperature results from a very broad continuum of frequencies of oscillation extending over many orders of magnitude in frequency. Each frequency is an important ingredient of what we think of as temperature. Each curve specifies the intensity, essentially the natural amplitude of oscillation, at each of these frequencies for the given temperature. The heat transferred via radiation from the emitting body to the absorbing body consists of this very broad continuum of frequencies of oscillation.

Radiation from a body cannot warm the same body: Note in Figure 1 that the curves for different temperatures do not intersect. A warmer body has a higher intensity, a higher amplitude of oscillation, at every frequency and has a higher frequency containing the highest amplitude of oscillation. Thus radiation from any thermal body does not have high enough amplitudes of oscillation at each frequency to warm the emitting body, even if it were radiated back to that body perfectly, without loss. If a body's radiation could warm the radiating body, bodies of matter, under certain circumstances, could spontaneously heat themselves up—something that clearly cannot happen.

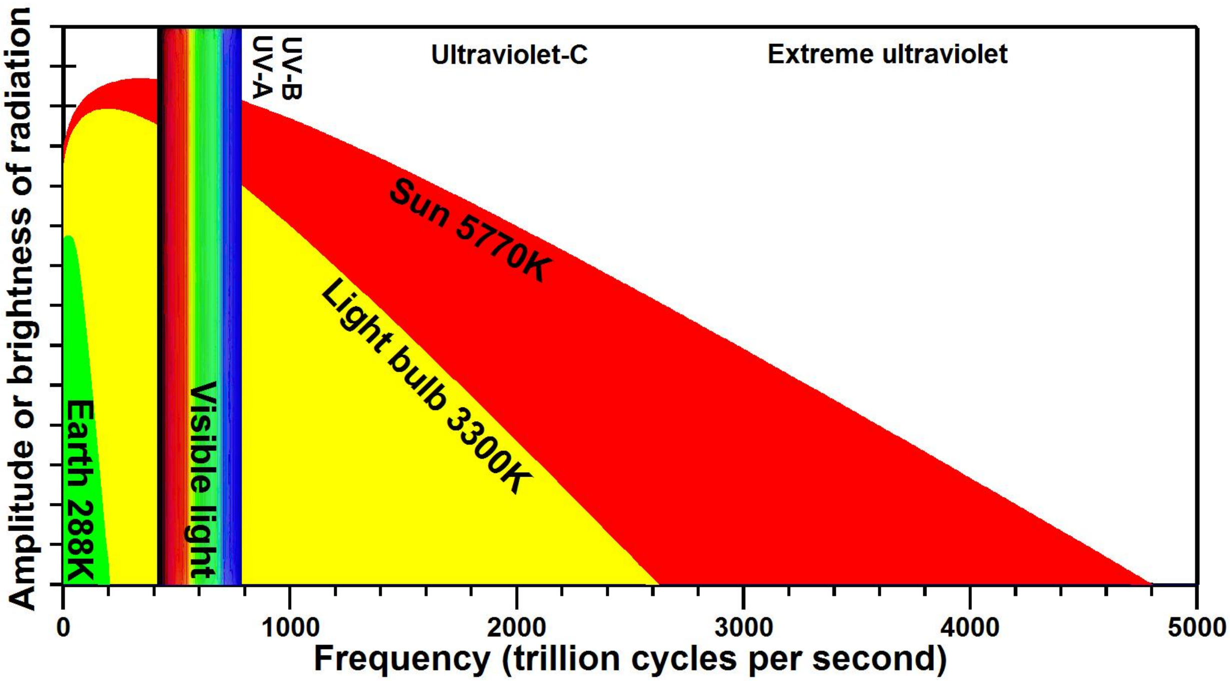

Figure 2. Planck's law plotted with frequency as a linear scale, shows that warmer bodies radiate higher frequencies with higher amplitudes of oscillation.

Figure 2 shows Planck's law with frequency plotted on a linear scale. Note how hotter bodies radiate a lot of higher frequencies with higher amplitudes than cooler bodies. A body of matter can only be warmed by a warmer body containing higher amplitudes of higher frequencies.

What do greenhouse gases radiate? Greenhouse-warming theory assumes that infrared radiation from Earth is absorbed by greenhouse gases and then radiated back to Earth causing Earth to warm. Trenberth and Fasullo (2012), and Wild et al. (2013), for example, calculate that twice as many watts per square meter are radiated by greenhouse gases back to Earth as are radiated to Earth by Sun (Figure 3). This does not make physical sense. Radiation from Sun clearly feels hotter than radiation from Earth. In fact this assumption is physically impossible for many reasons. Air temperatures, for example, decrease with altitude in the troposphere at an average lapse rate of 6.4°C per km. If layers of air radiate thermal energy back to Earth, the amplitudes of oscillation at every frequency within the radiation would be less than the amplitudes of oscillation on the surface of Earth and thus could not warm Earth.

Greenhouse-warming theory also assumes that infrared radiation from Earth absorbed by greenhouse gases, slows the loss of heat from Earth to space. Yet far more heat travels through the troposphere as a result of wind, storms, and convection than by radiation.

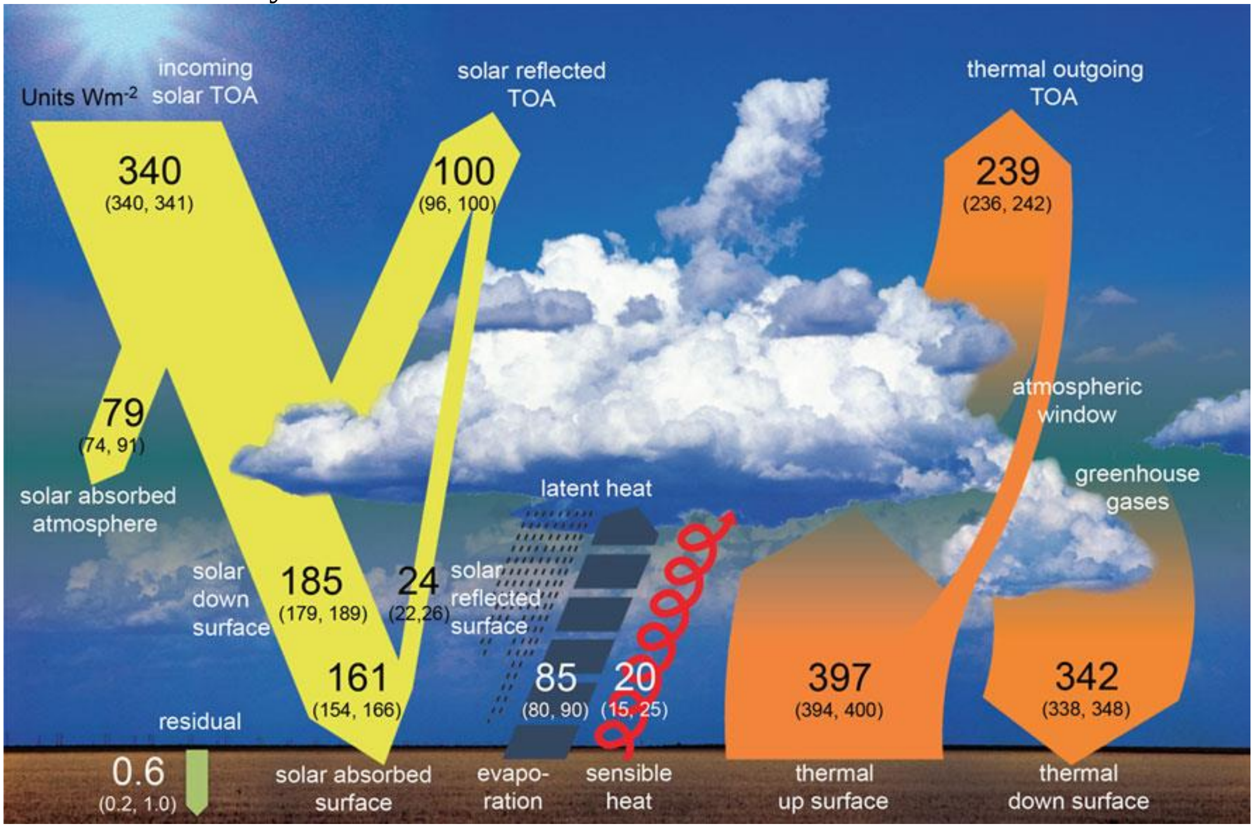

Figure 3. Schematic diagram of the global mean energy balance of the Earth. Numbers indicate best estimates for the magnitudes of the globally averaged energy balance components together with their uncertainty ranges, representing present day climate conditions at the beginning of the twenty first century. Units are in watts per square meter. Figure and caption from Wild et al. (2013).

How much do greenhouse gases warm air when absorbing infrared radiation? Tyndall (1861) observed that carbon dioxide, and certain other gases containing three or more atoms, absorb infrared radiation. He, and most scientists since, have assumed that the temperature of the gas, therefore, must increase substantially based on the law of conservation of energy. Extensive and detailed observations in the laboratory, however, show that the frequencies of thermal energy absorbed by a molecule of carbon dioxide, water vapor, or methane are the frequencies of the normal modes of oscillation of the bonds holding the molecule together (Rothman et al., 2013). Thus the thermal energy absorbed increases the internal energy of the bonds. Temperature of a gas, however, is proportional to the average kinetic energy of all the molecules making up the gas, which is proportional to the average translational velocity of all the molecules squared. One has to assume that internal energy is converted to kinetic energy of translation as the molecules collide with each other. Then one must assume, according to the law of equipartition, that the energy is shared equally among all the degrees of freedom, not just the three involving translational motion. Then this energy, absorbed by only trace amounts of greenhouse gases, must be shared with all the molecules making up the remaining 99.96% of dry air. The efficiency of these conversions does not appear to be high, but it has never been studied in detail.

What is most surprising, is that the sensitivity of air temperature to increasing concentrations of greenhouse gases has never been measured experimentally in the laboratory or in the field. The only experiment that I can find documented in the literature was by Ångström (1900), who showed the effect to be minimal. This is why I issued the Climate Change Challenge on November 12, 2015, offering to pay $10,000 to the first scientist or group of scientists who can demonstrate *experimentally* that a 15% increase in carbon dioxide, such as that observed from 1970 to 1998, can actually cause more warming of Earth than caused by observed contemporaneous depletion of the ozone layer of up to 60% (Ward, 2015b). Current climate theory suggests a doubling of carbon dioxide concentration should cause warming of somewhere between 2.2 and 4.8K (PALAEOSENS Project Members, 2012), assuming all observed warming has been caused only by increased concentrations of greenhouse gases. It should be easy to measure changes of degrees of warming in the laboratory.

Greenhouse-gases absorb very little heat: Carbon dioxide, for example, makes up only 0.04% of the mass of the atmosphere and the frequencies of oscillation absorbed, shown by the vertical black lines in Figure 1, are much less than 10% of all the frequencies whose amplitudes must be increased to warm Earth. Greenhouse gases simply do not absorb enough heat to have a significant effect on the temperature of air and especially on the temperature of Earth, which has much greater heat capacity. These black lines are the spectral lines of absorption (Rothman et al., 2013). The scale is not shown since it is the frequencies that I am emphasizing.

Radiant energy is a function of frequency only: Planck (1914) postulated in 1900 that the energy in radiation (E) is equal to frequency (ν) times a constant (h), now known as the Planck constant: $E=h\nu$ (Figure 4). $E=h\nu$ is also known as the Planck-Einstein relation, commonly thought of as the energy of a photon. It is well known and understood, as shown in the figure, that naturally occurring microwaves have more energy than radio signals, that infrared has more energy than microwaves but not enough energy to power photosynthesis, that visible light powers photosynthesis but cannot cause sunburn, that ultraviolet radiation has enough energy to cause sunburn and photo-dissociation of many molecules, that X-rays have enough energy to penetrate your body and can be used to destroy cancer

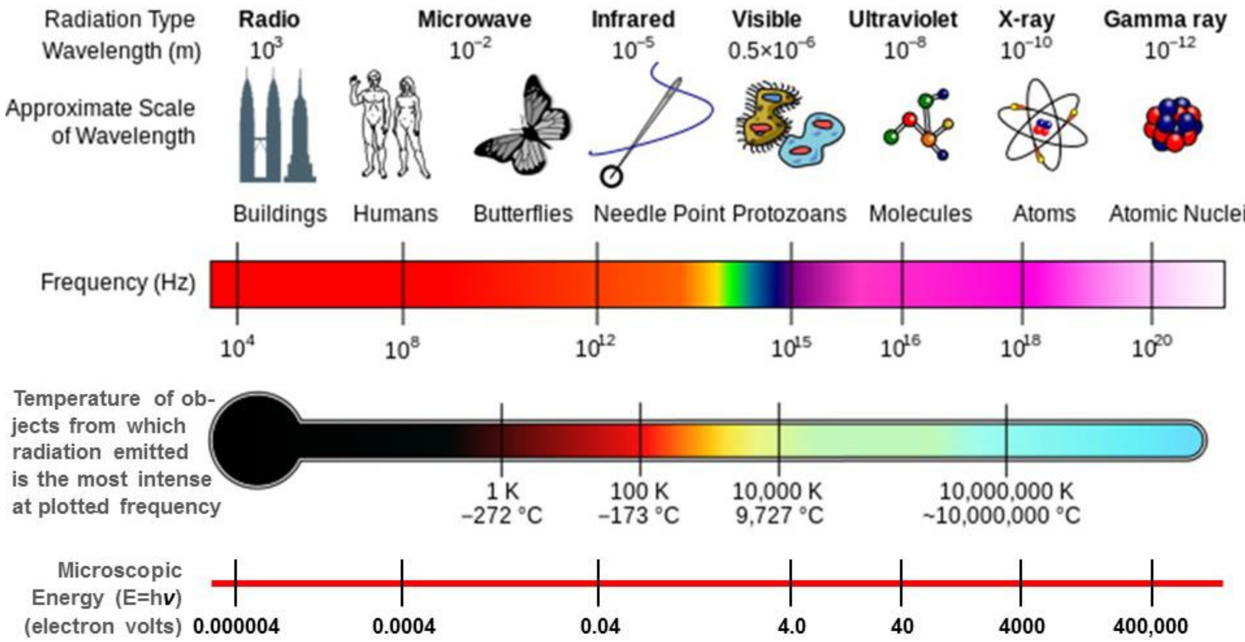

Figure 4. The electromagnetic spectrum is a continuum extending from very low radio frequencies to very high gamma ray frequencies, more than 16 orders of magnitude. Microscopic energy shown is E=hv and thus also ranges over more than 16 orders of magnitude. Temperature is shown for objects whose radiation is most intense at the frequency plotted based on Wien's displacement law.

cells, and that gamma rays (nuclear energy) have enough energy in very small doses to kill you. Thermal (chemical) energy clearly increases with frequency of oscillation.

The frequency of ultraviolet-B radiation, (967 terahertz, commonly specified as a wavelength of 310 nanometers), reaching Earth when ozone is depleted, is 48 times greater than the frequency of infrared radiation that is absorbed most strongly by carbon dioxide (20 terahertz, a wavelength of 14,900 nanometers). Thus, by E=h*v*, the thermal energy of ultraviolet-B radiation is 48 times the thermal energy of infrared radiation at 20 terahertz. The higher the thermal energy, the higher the "temperature" of the radiation, the higher the temperature to which the absorbing body can be raised. There simply is not enough thermal energy absorbed by greenhouse gases to have a significant effect on global temperatures.

Planck sought to fit his law to data measuring the thermal effect of a narrow band of radiation on a small piece of matter, typically a thermopile or a resistor. Therefore spectral radiance, on the y-axis, was defined to include watts, energy per second. If E=h*v*, however, energy is on the x-axis, and the y-axis should be amplitude of oscillation, which is more difficult to measure and will need to be calibrated carefully in the laboratory. This will change the detailed shape of each

Planck curve but will not change the observations about Planck curves made in this paper.

Energy is not additive: The fundamental problem with current greenhouse-warming theory and current climate models, is that they assume thermal energy can be added together to create a higher level of thermal energy. Climate models add up (integrate) energy as a function of bandwidth and add radiative forcing's together. Yet thermal energy is only a function of frequency ($E=h\nu$) and is not a function of bandwidth. Frequency is not additive. You cannot add blue light to red light to get ultraviolet light. Thermal energy is an intensive physical property spread evenly throughout matter at the atomic level and is therefore not additive, as explained in detail by Ward (2016a).

Ozone depletion explains observed global warming clearly, directly, and completely: Ward (2015a) and Ward (2016b) explain in detail how observed increases in ultraviolet-B radiation reaching Earth when the ozone layer is depleted explain all major changes in global warming, clearly, directly, and completely in recent years and throughout Earth history. Current climate models cannot explain the following observations directly. There are hundreds of peer-reviewed papers asserting natural variability and numerous other possible causes, but is this just arm-waving rationalization? Climate models cannot explain directly, without rationalization: (1) why temperatures barely changed from 1945 to 1970, (2) why they rose sharply from 1970 to 1998, (3) why they remained nearly constant from 1998 to 2013, (4) why they began rising even more quickly in 2014, (5) why 2015 is the hottest year on record, (6) why January 2016 is the hottest January on record, (7) why February 2016 is the hottest February on record, (8) why March 2016 is the hottest March on record, (9) why the polar vortex has become a major issue since 2014, and (10) why your risk of sunburn has increased substantially since 1970.

Conclusions: Temperature in matter results from a very broad continuum of frequencies of oscillation of the bonds holding matter together, each with a specific amplitude of oscillation shared via resonance. Radiation from Earth does not have high enough amplitudes at each frequency to warm Earth. Greenhouse gases absorb a very small number of low energy infrared frequencies required to define temperature and heat in matter and therefore cannot have a significant effect on global warming compared to the 48 times higher energy of ultraviolet-B radiation reaching Earth when ozone is depleted. World leaders may be wasting very large amounts of money trying to reduce greenhouse gas emissions.

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