# Correcting Fundamental Mistakes in Radiation Physics Shows How the Middle Atmosphere Plays the Primary Role in Determining How Effectively Earth is Heated by Sun

Planck's empirical law
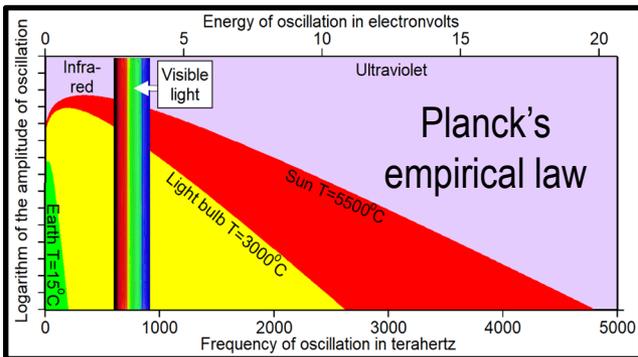
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Asymptotic curves of cooling and of warming
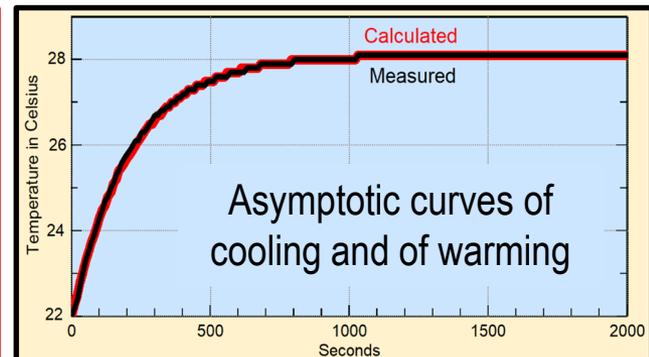
Current mistakes thinking about the physics of radiation

1) That electromagnetic radiation, including visible light, physically is waves, photons, or wave-particle duality.

No. Electromagnetic radiation, light, is well-known physically to be a very broad continuum of frequencies of oscillation ranging from very low frequency radio signals to very high frequency gamma rays.

2) That frequency of electromagnetic radiation is wave frequency, i.e. the velocity of light divided by wavelength.

No. Electromagnetic radiation is a broad spectrum of frequencies of oscillation of all the bonds holding matter together.

3) That electromagnetic radiation travels through air and space as waves or photons.

No. Electromagnetic radiation travels through air and space as frequency by resonance, where amplitudes of oscillation at each frequency of oscillation are averaged or shared.

4) That energy of electromagnetic radiation is the same thing as intensity or brightness.

No. Energy of electromagnetic radiation (E) is well-known to equal the Planck constant (h) times frequency (ν), E=hν. Since frequency is a broad continuum, energy must be a broad continuum.

Radiation Type	Radio	Microwave	Infrared	Visible	Ultraviolet	X-ray	Gamma ray
Approximate length of the oscillator (m)	10^3	10^{-2}	10^{-5}	0.5×10^{-6}	10^{-8}	10^{-10}	10^{-12}
	Buildings	Humans	Butterflies	Needle point	Protozoans	Molecules	Atoms	Atomic nuclei

Frequency (Hz): 10^4, 10^8, 10^{12}, 10^{15}, 10^{16}, 10^{18}, 10^{20}

Temperature of objects at which this radiation is the most intense frequency emitted: 1 K -272 °C, 100 K -173 °C, 10,000 K 9.727 °C, 10,000,000 K ~10,000,000 °C

Energy = hν (electron volts): 0.000004, 0.0004, 0.04, 4.0, 40, 4000, 400,000

Energy of oscillation in electronvolts: 0, 5, 10, 15, 20

Infra-red; Visible light; Ultraviolet

Energy belongs on the x-axis

Planck's law

Energy Wm^{-2}

Earth 15°C

Light bulb T=3

Sun T=5500°C

Y-axis should be intensity, brightness, or amplitude of oscillation

Frequency of oscillation in terahertz: 0, 1000, 2000, 3000, 4000, 5000

5) That flux of electromagnetic radiation can be quantified as a single number or amount of watts per square meter.

No. Energy of electromagnetic radiation (E) equals the Planck constant (h) times frequency (v), $E=hv$. Since frequency is a broad continuum, energy must a broad continuum with a different value of watts per square meter at each frequency.

6) Flux of electromagnetic radiation is proportional to temperature of the emitting body.

No. Flux is proportional to the difference in temperature. This is why all curves of warming or cooling approach the final temperature asymptotically.

7) That energy is additive. That flux is additive. That radiative forcings can be added together.

No. Temperatures are averative. They are averaged together.

8) That thermal energy is some unspecified generic thing that is additive (can be added together).

No. Thermal energy is the simultaneous oscillation of all bonds that hold matter together. The hotter the body of matter, the greater the amplitude of oscillation at each and every frequency and the higher the frequencies with the greatest amplitudes of oscillation.

Asymptotic curves of heating and cooling show flux is proportional to temperature difference
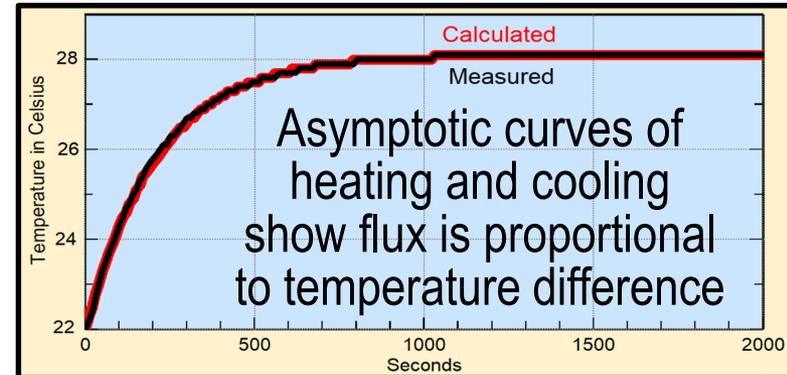
The measured black curve is the warming caused by a picture light shining on a small black piece of metal. The calculated red curve is the temperature calculated by multiplying 4.6% times the average of the existing temperature and the ending temperature of 28 °C at each 10-second interval. The 4.6% has to do with the conductivity per second of heat into the black object and other boundary conditions.

Electromagnetic radiation is a broad continuum of frequencies of oscillation of all the bonds on the surface of matter that hold matter together.

Temperature is a measure of how fast atoms are moving.
# The higher the average velocity of the atoms, the higher the temperature.

Temperature in a gas is a measure of translational kinetic energy $E=1/2mv^2$

High Temperature Low Temperature   Thermal Equilibrium

Heat transfer   Net heat transfer has ceased

CO_2 absorbs terrestrial infrared energy into the bonds holding the molecules together. This does not change the temperature of air!

Logarithm of the amplitude of oscillation

Energy of oscillation in electronvolts
0   5   10   15   20

Infra-red   Visible light   Ultraviolet

Planck's empirical law

Earth T=15°C

Light bulb T=3000°C

Sun T=5500°C

0   1000   2000   3000   4000   5000
Frequency of oscillation in terahertz

Temperature in solid matter is a measure of a broad continuum of internal oscillatory kinetic energy
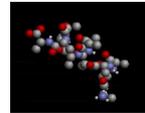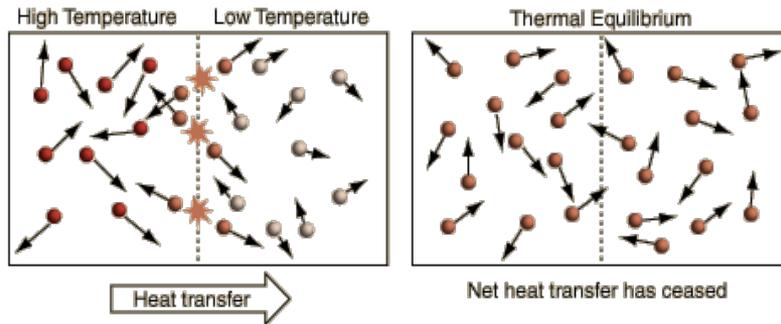
Oscillation of what?
Oscillation of all bonds holding matter together.

Planck's empirical law describes the physical properties of temperature in solid matter as:

1. A broad spectrum or continuum of frequencies of oscillation on the lower x-axis.

2. A broad continuum of energies of oscillation on the upper x-axis since energy equals frequency times a constant (E=hv).

3. Planck's empirical law then calculates a broad continuum of amplitudes or intensities of oscillation on the y-axis.

The higher the temperature, the higher the amplitudes of oscillation at each and every frequency of oscillation and the higher the frequencies with the greatest amplitudes of oscillation.

O_2 absorbs ultraviolet-C into the bonds holding the molecules together, causing dissociation. The two oxygen atoms fly apart at high velocity, converting all bond energy efficiently and completely into air temperature, heating the stratosphere.
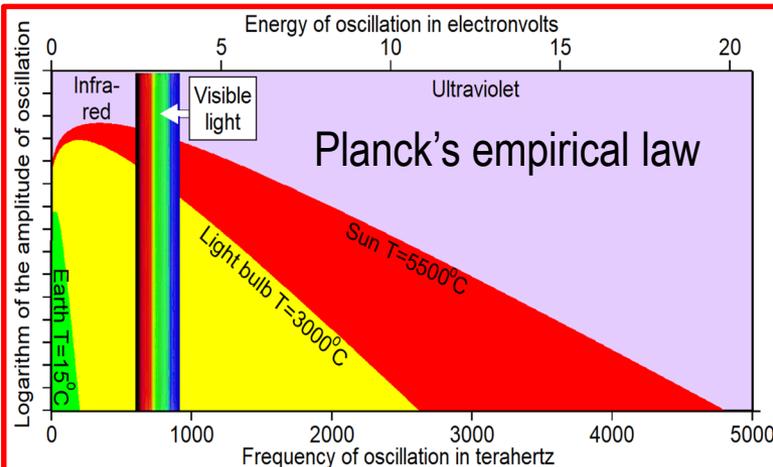
Planck's law says for Earth to increase its temperature, it must absorb increased amplitudes of oscillation primarily at ultraviolet-B frequencies

Most frequencies of oscillation of solar radiation greater than around 1650 terahertz are absorbed in the ionosphere to create ions.

Most frequencies of oscillation of solar radiation between 1650 and 1000 terahertz are absorbed in the stratosphere to dissociate oxygen and other molecules warming the stratosphere.

The highest frequencies of oscillation of solar radiation penetrating the ozone layer are some ultraviolet-B (952 to 1070 Thz), all ultraviolet-A (790 to 952 Thz), and all visible light (405 to 790 Thz).

Thus changes in the intensities (amplitudes of oscillation) of ultraviolet-B solar radiation reaching Earth's surface have <u>THE</u> primary effect on average surface temperatures.
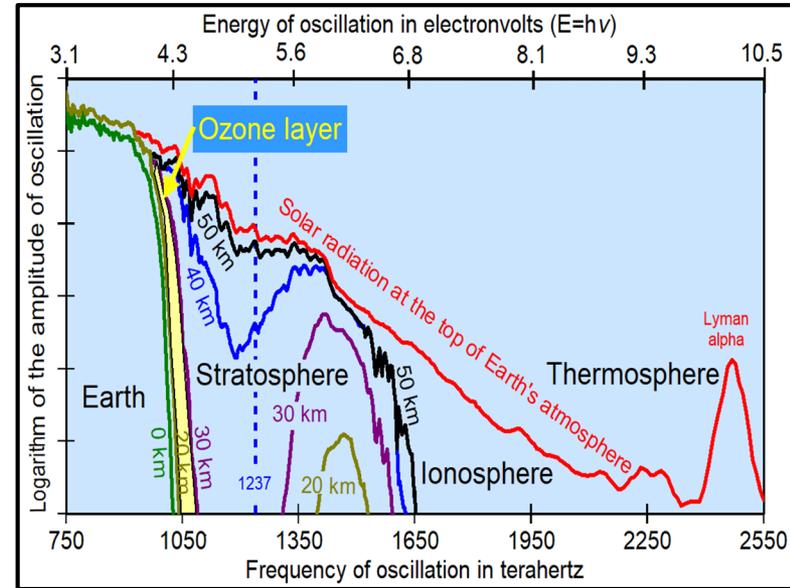
UV-C at 1237 THz dissociates oxygen

UV-B at 967 THz dissociates ozone

The annual average surface temperature of Earth is determined primarily by how much ultraviolet-B solar radiation penetrates the ozone layer and reaches Earth's surface, where it dissociates ground-level ozone depletion warming air and penetrates oceans hundreds of meters, efficiently raising ocean heat content.

When solar radiation is present, the oxygen-ozone cycle continuously dissociates oxygen, heating air and then dissociates ozone, heating air. The average lifetime of an ozone molecule is only around 8.3 days.

Thus, air is warmer wherever there is more ozone.

During winter, less ultraviolet-B reaches the ozone layer in polar regions so that ozone concentrations accumulate.

Ozone depletion is most effective when atoms of chlorine interact on the aqueous surfaces of polar stratospheric clouds formed during the coldest periods of polar winter.

Under these conditions, one atom of chlorine can lead to the destruction of more than 100,000 molecules of ozone.

This is why the greatest effect of ozone depletion is observed to be an increase in winter minimum temperatures.


Ozone molecule + Ultraviolet rays → Oxygen (O_2) + Single atom of oxygen

Single atom of oxygen + Oxygen (O_2) → Ozone molecule

Ozone concentrations
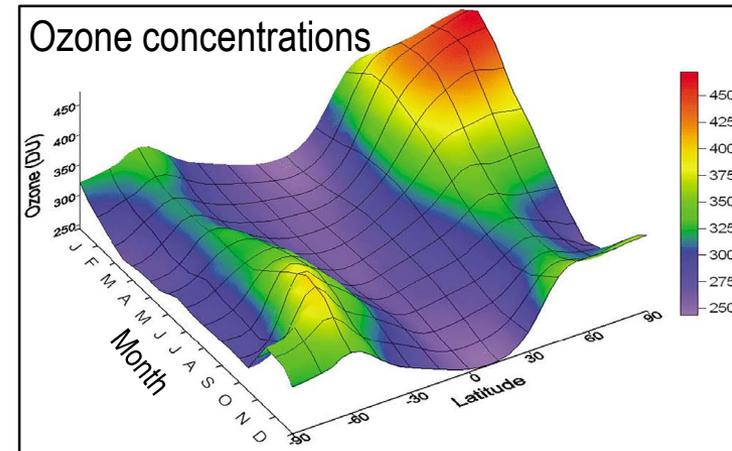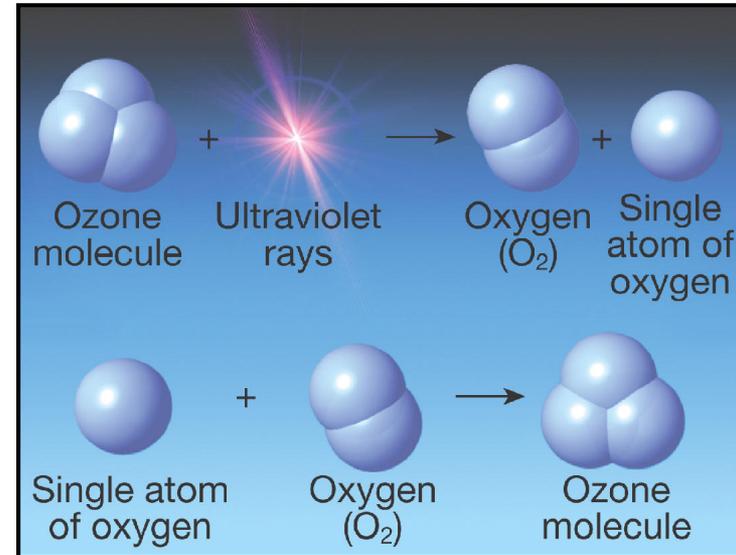
Maps of ozone concentrations vary daily.
Air containing ozone is warmer than surrounding air.

Dobson (1929) showed that maximum positive daily deviations of ozone values from monthly means are generally found to the rear of surface low-pressure areas, while maximum negative deviations are found to the rear of surface highs.
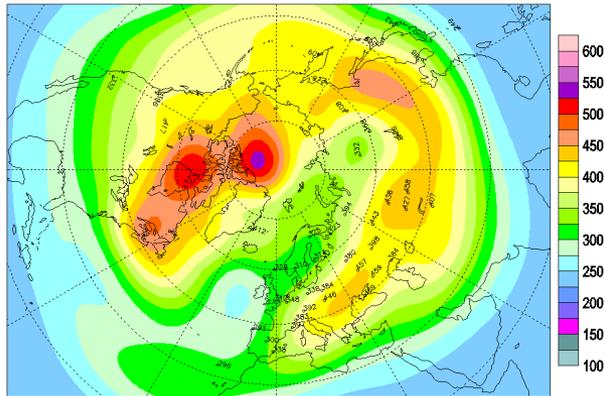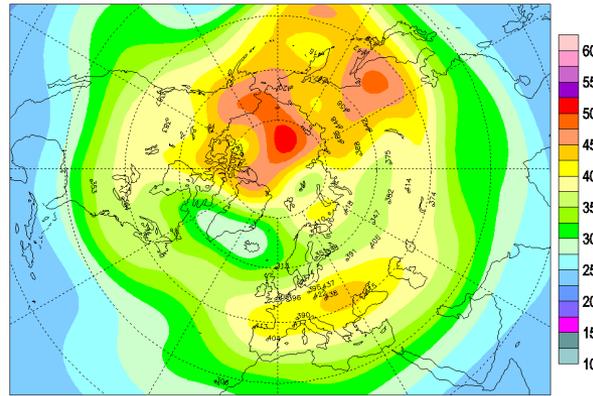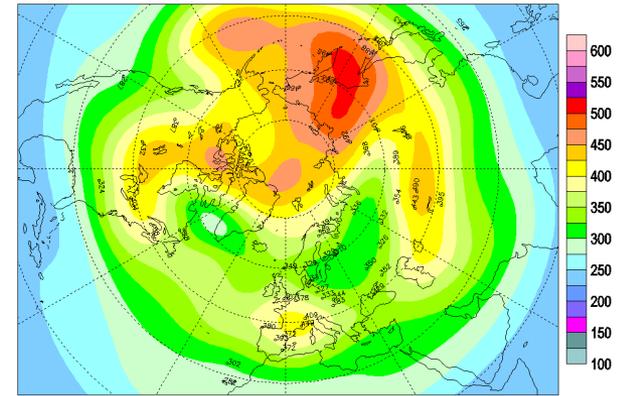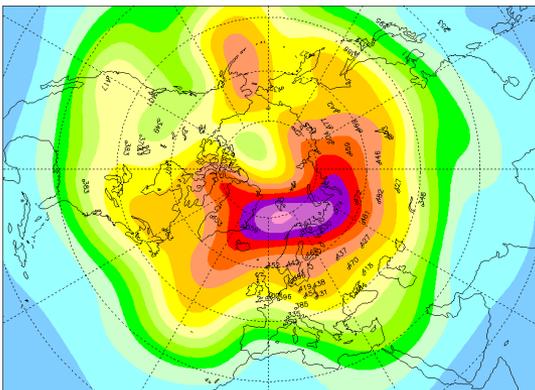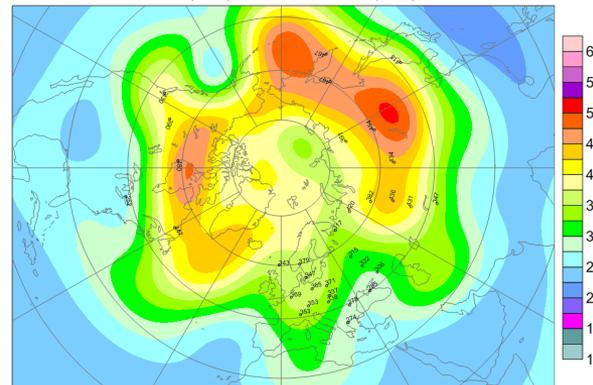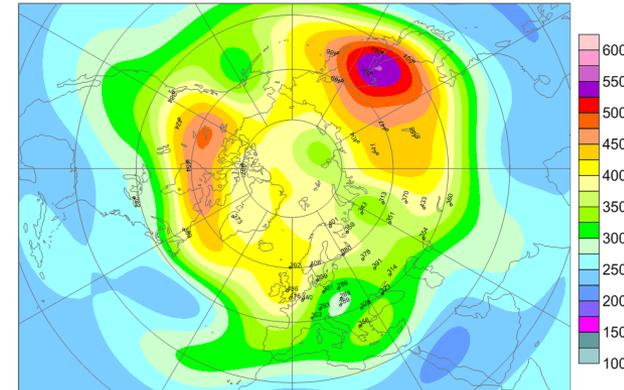
The primary way ozone depletion heats air is when increased ultraviolet-B radiation causes dissociation of ground-level ozone pollution

This is why warming has been twice as great in the northern hemisphere as in the southern hemisphere.

Tropospheric column ozone, DU
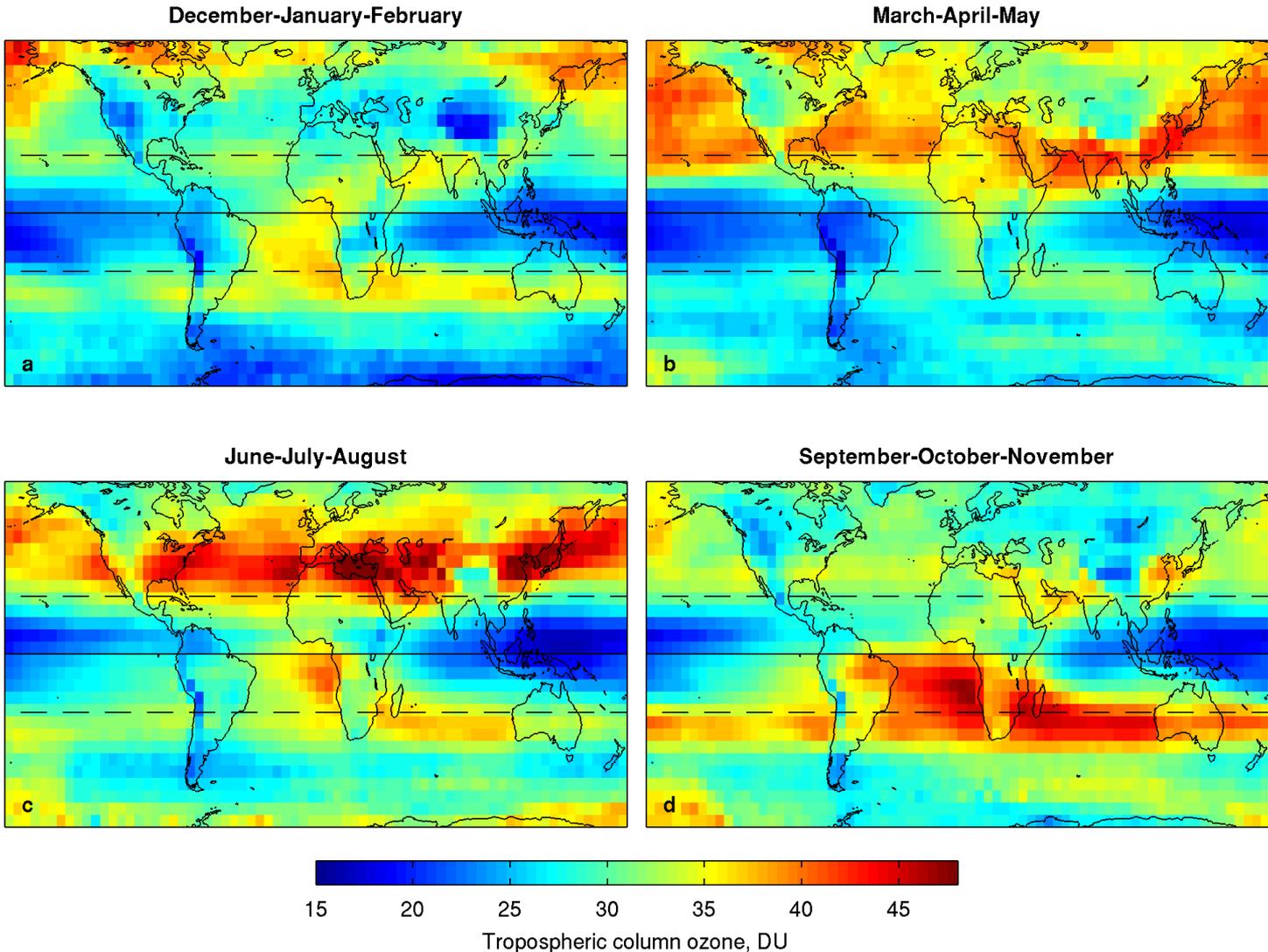
Planck's confusion about radiant energy

In the late 1800s, many radiation physicists used a prism to separate the colors of visible light. They then moved a sensor through each color and measured a very small electric current that they thought of as the amount of energy. They assumed light travelled as waves and thought of frequency as wave frequency.
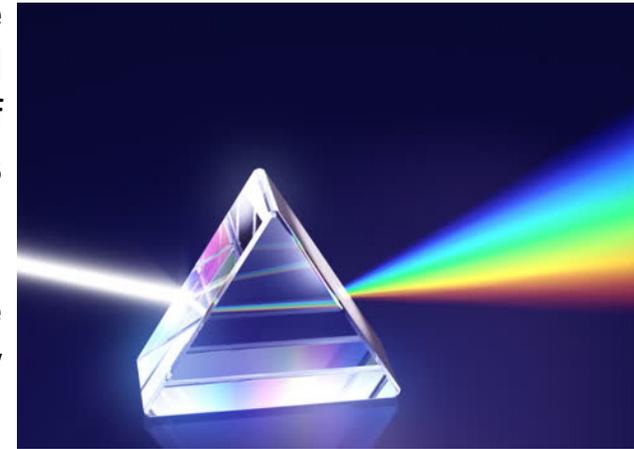
Planck, then, wrote his equation assuming that energy in watts per square meter was on the y-axis and that total energy could be calculated by integrating as a function of frequency.

But to justify his equation, Planck postulated that radiant energy (E) equals the Planck constant (h) times frequency (v). But he never stopped to think if E=hv, energy must be plotted on an alternative x-axis, parallel to frequency and the y-axis must be intensity or brightness.

Planck also never stopped to think that it makes no sense to integrate as a function of frequency because, for light, all frequencies coexist in air and space. It makes no physical sense to add them together.

Planck's empirical law

$$B_v(T) = h\nu \left(\frac{2\nu^2}{c^2}\right)\left(\frac{1}{e^{h\nu/k_BT} - 1}\right)$$
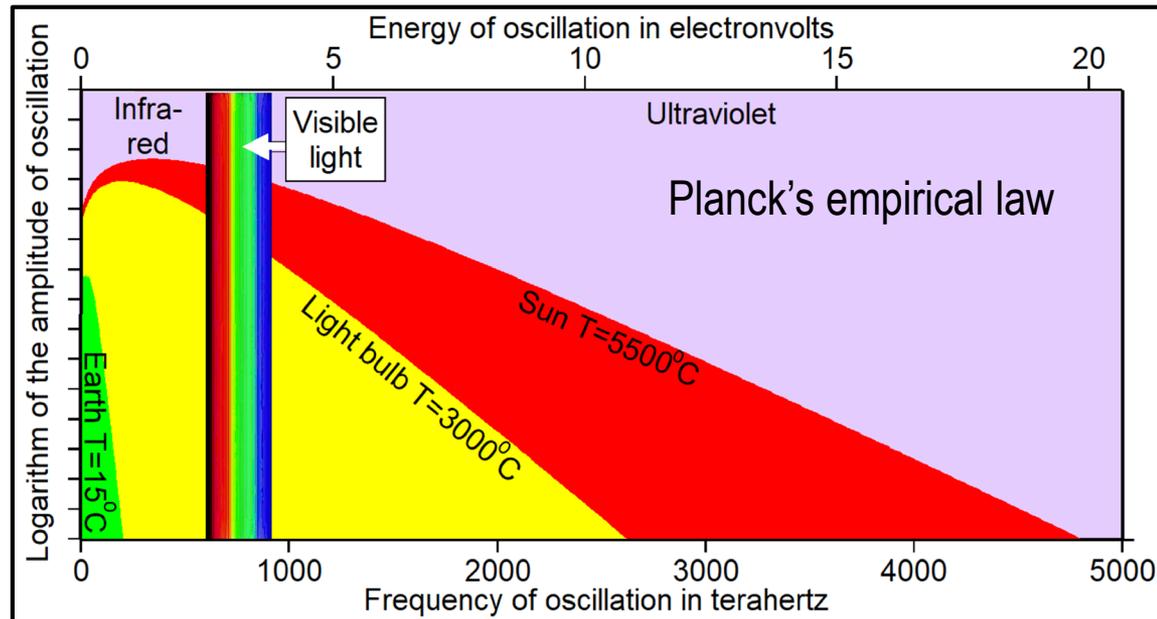
Primary role of the middle atmosphere in determining global temperatures

Atmospheric temperature
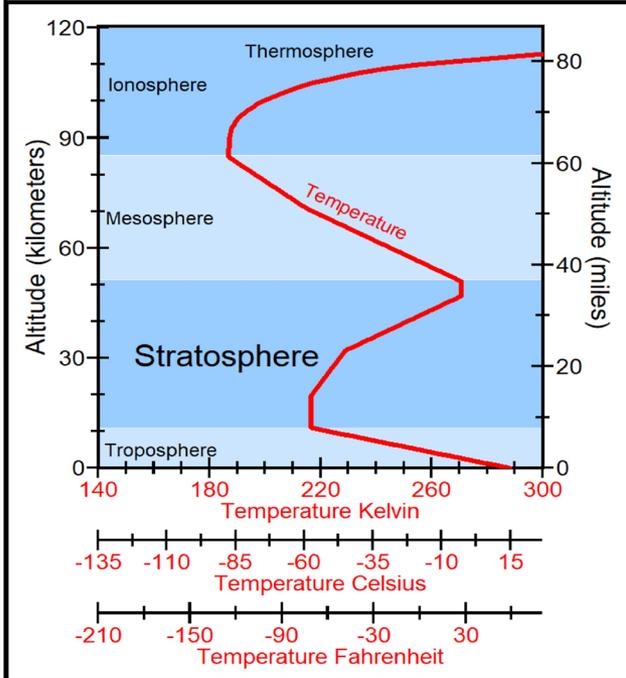
The stratosphere, absorbing solar ultraviolet C and B, forms an "electric blanket" around Earth, raising the temperature of the stratopause 30 to 35 degrees Celsius above the temperature of the tropopause. "Electric blanket in the sense that the thermal energy comes from a distant source, Sun, not from the body under the blanket, Earth.

Ward 2016

A decrease in yearly total column ozone at mid-latitudes of the northern hemisphere by 30 Dobson Units (DU) corresponds to a 0.9 °C increase in temperature anomaly in the northern hemisphere based on HadCRUT4. Numbers are the years observations were made at Arosa Switzerland.
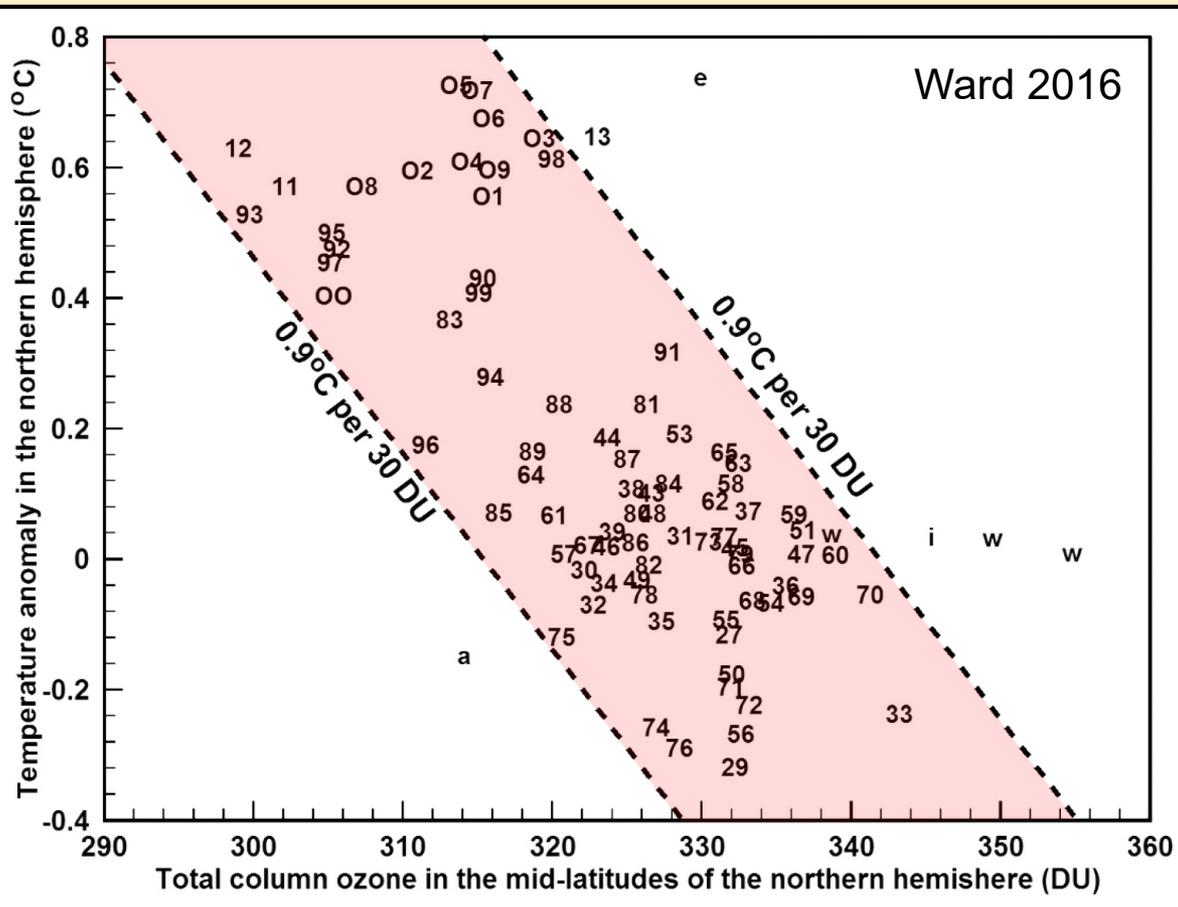
Resonance is a fundamental physical property of oscillating systems

When one discrete molecular-bond-sized oscillator on the surface of the emitting body is in resonance with one discrete oscillator on the surface of the absorbing body oscillating at the same frequency and within line-of-sight, amplitude of oscillation is observed to decrease on the emitting body and increase on the absorbing body.

Resonance, in an ideal case, averages amplitudes of oscillation, just as temperatures are averaged when two identical bodies of matter with different temperatures are placed in thermal contact.

A simple example of resonance via mechanical contact is when you push a child on a swing. If you push at exactly the same frequency of oscillation as the swing is swinging, the amplitude of the swing will increase.

Radios work by resonance. A radio transmitter causes a frequency of oscillation on its antenna. You tune your radio receiver to resonate at the same frequency of oscillation as the transmitter.

Electromagnetic radiation travels through air and space via resonance

Electromagnetic radiation, heat, travels through air and space by simultaneous resonance of all modes of oscillation of all molecular bonds on the surfaces of the bodies that are visible to each other.

Resonance operates very quickly over any distance between bodies that are within line-of-sight

Conduction of heat in matter is by resonance made possible by physical touching.

Resonance is all around us. You see by resonance. You hear by resonance. Radios, televisions, and cell phones all receive signals via resonance.

Resonance is the physical process that the concept of **quantum entanglement** tries to explain, what Einstein called **spooky action at a distance**.

Conclusions

Heat is what a body of matter must absorb to increase its temperature and lose to decrease its temperature.

Planck's empirical law shows unequivocally that both temperature and heat are the result of a broad continuum of frequencies of oscillation and a broad continuum of amplitudes of oscillation of all the bonds holding matter together.

This continuum of energies cannot be described by some single number of watts per square meter as is currently done.
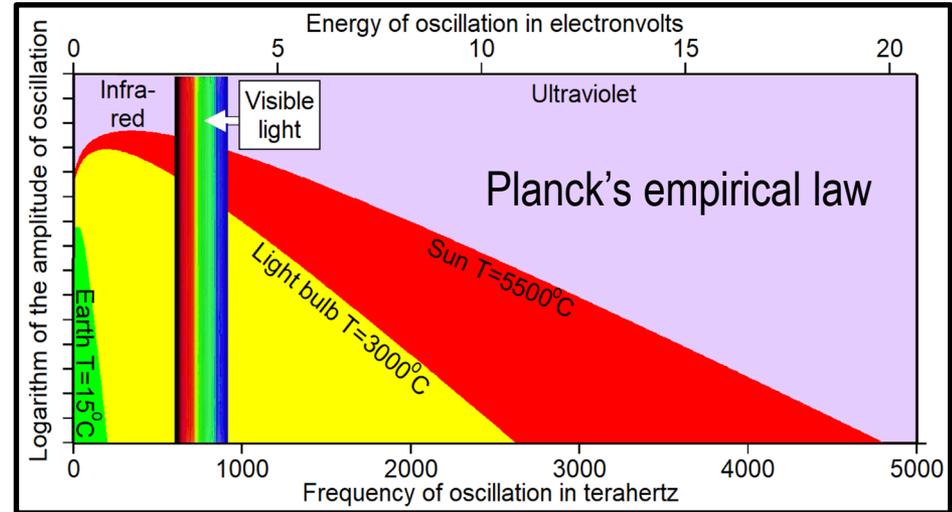
Since thermal energy is well known to be equal to the Planck constant times frequency of oscillation, there is a different value in watts per square meter for every frequency.

Heat flux is proportional to the difference in temperature between the emitter and the absorber causing asymptotic curves of warming and cooling.

Earth's temperature is determined primarily by how much ultraviolet-B radiation reaches Earth, which is determined by the optical thickness of the ozone layer.