Greenhouse-Warming Theory Is Mistaken
As Shown Clearly and Unambiguously By a New Revolutionary Understanding Of the Physics of Heat

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Overview

Annual average global temperatures have risen 1.6°F (0.9°C) since 1950. Most climate scientists are convinced this warming is caused primarily by increasing emissions of greenhouse gases from burning fossil fuels. Based on the most widespread consensus ever forged in science, world leaders agreed in Paris in 2015 to work together to reduce greenhouse-gas emissions to limit global warming to well below 3.6°F (2°C)—preferably to 2.7°F (1.5°C).

Meanwhile, a revolution in our understanding of the physics of heat, discovered in 2015, shows clearly and unambiguously that greenhouse-warming theory is mistaken. Greenhouse-warming theory is based on mathematical assumptions made two-hundred years ago about what heat is physically and how heat flows that have no basis in physical reality. There is no way known in physics that greenhouse gases absorbing low-energy infrared radiation from Earth can warm Earth's surface or slow the cooling of Earth.

Global warming of 1.1°F (0.6°C) from 1970 to 1998 was initiated by humans manufacturing chlorofluorocarbon gases (CFCs) that turned out to release atoms of chlorine in the stratosphere, depleting the ozone layer. The UN Montreal Protocol mandated major cutbacks in CFC production starting in 1989. Concentrations of CFCs stopped increasing in 1993. Ozone depletion stopped increasing in 1995. Temperatures stopped increasing in 1998, completing the only successful experiment linking global warming to the concentrations of trace gases in Earth's atmosphere.

Rapid global warming of 0.5°F (0.3°C) from 2014 to 2016 was contemporaneous with the largest basaltic lava eruption since 1785, releasing chlorine and bromine gases that depleted the ozone layer. Global warming throughout Earth history is explained in remarkable detail by eruptions of basaltic lava—the larger the eruption, the greater the warming.

But my fellow scientists, by refusing to evaluate this new, unequivocal evidence, are causing substantial economic, political, and environmental harm as world leaders, at the behest of these scientists, begin to waste tens of trillions of dollars trying to reduce greenhouse-gas emissions. Greenhouse-warming theory is rapidly becoming the most expensive mistake ever made in the history of science.

Science is a process done by fallible humans. Mistakes do happen. Revolutions in scientific understanding are not uncommon, but it normally takes years to decades for most scientists to agree with new, revolutionary ideas. Time is now of the essence, however. Climate scientists, to keep the public trust, must evaluate this revolutionary change in our understanding of the physics of heat promptly and lead us out of this climate crisis that they unintentionally created.

About the Author

Dr. Peter Langdon Ward earned a BA at Dartmouth College and a PhD at Columbia University in geophysics. He worked 27 years at the United States Geological Survey in Menlo Park California, leading a group of more than 140 scientists and staff. He played a lead role in developing the National Earthquake Hazard Reduction Program passed by Congress in 1977 by organizing development of the strategic plans among the research community and briefing the President's Advisory Panel on Anticipated Advances in Science and Technology, the Secretary of Interior, and many others. He testified before Congress in 1978. In the late 1990s, Ward chaired a committee under the Office of Science and Technology Policy and worked on a committee for Vice President Gore. He testified before Congress again in 2004. Ward is a well-published scientist who earned two national awards for explaining science to the public. He and his work were featured on Good Morning America. Much of his work, throughout his life, has been along the boundary between science and public policy.

More details at WhyClimateChanges.com/About/biography.

Since 2006, Ward has worked full time in retirement, at his own expense, with minimal distraction, carefully reexamining all the evidence and theories for why climate has changed throughout Earth history. He discovered a fundamental error in the physics of heat that shows greenhouse-warming theory is not only mistaken, it is not even physically possible. He also discovered that while sequences of explosive volcanic eruptions cause slow, incremental global cooling, effusive basaltic eruptions cause rapid global warming in highly erratic sequences that average every few thousands of years.

Key References

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All papers and abstracts including those rejected without review with the Editor's comments are available at OzoneDepletion-Theory.info/publications-ozone-depletion/.

Primary Websites: WhyClimateChanges.com

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Executive Summary

1. Greenhouse-warming theory is based on mathematical assumptions about what heat physically is and how heat flows that have no basis in physical reality. Heat does not exist as amounts of watts per square meter that are additive, as has been assumed for more than 200 years.
2. Temperature of solid matter is the result of a very broad spectrum of frequencies of oscillation of all the bonds holding matter together. Planck's empirical law, when corrected, calculates the amplitude of oscillation at each frequency of oscillation as a function of temperature. Amplitudes of oscillation flow from a warmer body to a cooler body by resonance simultaneously at each and every frequency of oscillation.
3. There is no physical process known in physics or in photo-chemistry by which greenhouse gases absorbing low-energy infrared radiation could have caused observed global warming.
4. The science behind these most unexpected conclusions is so remarkably clear and unambiguous that we can posit with some confidence that anyone disagreeing is not well informed.
5. None of the tens of thousands of peer-reviewed, scientific papers supporting the current climate consensus regarding greenhouse gases question the physics of global warming even though it is the physical processes that determine temperatures and changes in temperatures.
6. Major warming in future decades predicted by computer models based on greenhouse-warming theory cannot and will not happen. We can burn fossil fuels safely provided we minimize pollution.
7. The physics of global warming is undergoing a revolution in thinking, but climate scientists are locked in by their consensus over the outdated, mistaken, greenhouse-warming theory.
8. The well-intentioned political decision by scientists to demonstrate consensus for the purpose of convincing world leaders to take action to reduce greenhouse-gas emissions has derailed scientific debate.
9. My fellow scientists, by refusing to evaluate this new unequivocal evidence, are causing substantial economic, political, and environmental harm as world leaders, at the behest of these scientists, begin to waste tens of trillions of dollars trying to reduce greenhouse-gas emissions.
10. Greenhouse-warming theory is rapidly becoming the most expensive mistake ever made in the history science. Science is a process done by fallible humans. Mistakes do happen. Revolutions in scientific understanding are not uncommon. Climate scientists, to keep the public trust, need to address promptly the revolutionary change in our understanding of the physics of heat.
11. It is time for world leaders to ask the United Nations Intergovernmental Panel on Climate Change (IPCC) to either prove me wrong or stop insisting that we must reduce greenhouse-gas emissions right now. It is time for national political leaders to ask the President's Science Advisor, the President's Science Advisory Committee (PSAC), the U.S. Global Change Program, or the National Academy of Sciences to prove me wrong. It is time for all of us to

ask climate scientists to prove me wrong or recognize that greenhouse-warming theory is mistaken. It is time for scientists and the science establishment to lead the world out of the climate crisis that they unintentionally created.

12. Ultraviolet-B is the hottest, highest-energy solar radiation reaching Earth's surface where it causes sunburn, skin cancer, cataracts, mutations, slow fading of colors, slow degradation of materials, bleaching of corals, efficient warming of oceans, and, most important, warming of air containing ozone pollution.
13. Depletion of the ozone layer, which then allows more high-energy solar ultraviolet-B radiation to reach Earth, explains observed global warming in considerable detail throughout Earth history. Ultraviolet-B radiation warms air in the troposphere primarily by photo-dissociating ground-level ozone pollution. A decrease in total column ozone by 5% (16 Dobson units) is observed to cause warming on the order of 1.1°F (0.6°C) at mid latitudes in the northern hemisphere.
14. Global warming of 1.1°F (0.6°C) from 1970 to 1998 was caused by humans manufacturing CFC gases that depleted the ozone layer. Because CFCs are extremely inert gases, this depletion and related high temperatures are highly likely to continue for at least the next 40 years.
15. Rapid warming of 0.5°F (0.3°C) from 2014 to 2016 was caused by the largest basaltic lava eruption since 1785, releasing chlorine and bromine gases that depleted the ozone layer.
16. Global temperatures are expected to decrease slowly, over the rest of this century, back down to levels common before 1970, as CFCs are consumed, allowing the ozone layer to recover. Periods of two years of sudden warming and subsequent cooling associated with basaltic lava flows are also likely.
17. If record warming and drought throughout western North America are caused by ozone depletion, which they appear to be, they will continue for at least 40 more years. Finding ways to speed recovery of the ozone layer, therefore, is of critical national interest.

The conclusions in this document are based on direct observation of what is physically happening in the natural world around us. You should not need any specialized training in science to understand these observations as presented in the 34 figures. I emphasize the critical observational evidence and use hyperlinks to speed access to the data, to references easily understood by non-specialists, and to some key scientific references.

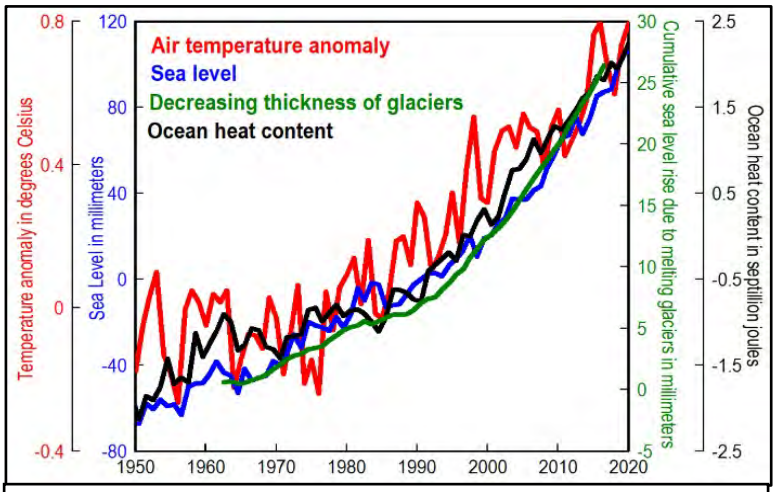
Sections 1 to 11 summarize observations of global warming. Sections 12 to 16 summarize the physics of global warming. Sections 17 to 24 summarize why greenhouse-warming theory is mistaken, how a revolution in our understanding of heat allowed us to recognize the problems, and what we should do now.

I hope that all sides of the climate wars can now come together
to deal constructively with the global warming
that we accidently caused from 1970 to 1998.

Table of Contents

(1) The World Is Warming

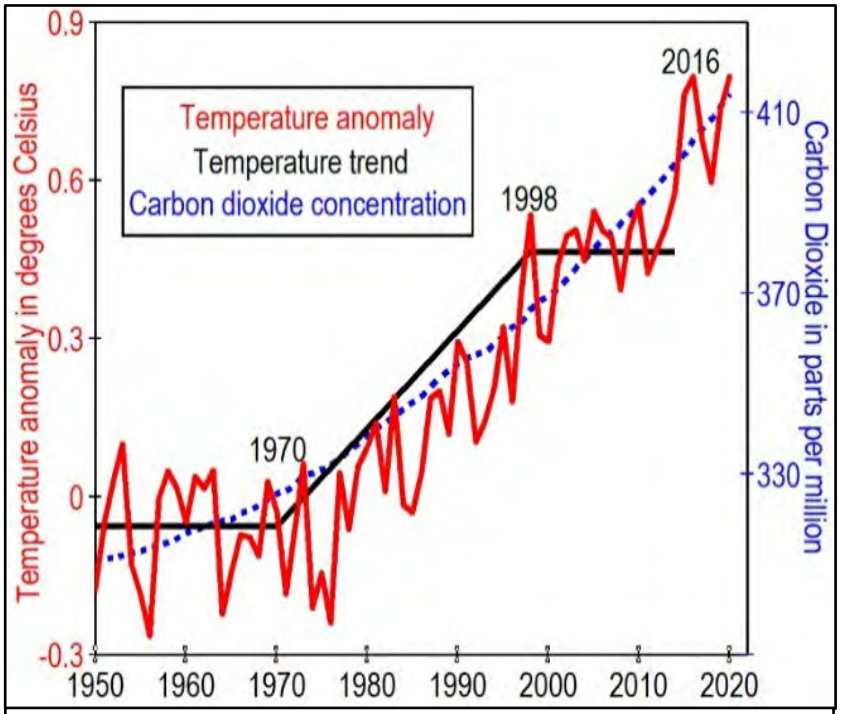
Annual average global temperatures have increased 1.6°F (0.9°C) since 1950 (red line). Sea level has risen 6.7 inches (17 cm) since 1950 (blue line). Glaciers are losing 20 inches (50 cm) of ice each year (green line). Ocean heat content is rising rapidly (black line). Wet regions are getting wetter. Dry regions are getting drier and expanding over larger areas. Since 2000, the south-western United States has suffered from one of the worst droughts in 1200 years. Wildfires in the United States are burning twice as many acres per year as they were in 1980.



(1) The world has been warming since 1950. Temperature anomaly (red line) in Figures 1, 2, and 6a is a normalized average of four datasets HadCRUT4, GISS, NOAA, and Berkeley Earth.

(2) Greenhouse-Gas Emissions Have Increased Steadily While Temperatures Increased Only From 1970 to 1998 and From 2014 to 2016

Greenhouse gas concentrations in the atmosphere have been rising steadily at ever increasing rates as shown by the dashed blue line. Annual average global temperatures (red line), however, remained relatively constant from 1950 until around 1970, rose 1.1°F (0.6°C) from 1970 to 1998 at a rate of approximately 0.3°F (0.2°C) per decade, remained relatively constant from 1998 through 2013, and rose 0.5°F (0.3°C) at a rate of approximately 2.3°F (1.3°C) per decade from 2014 to 2016, the hottest year on record.



(2) Steady increases in emissions of carbon dioxide cannot explain why temperatures changes suddenly around 1970, 1998, and 2014.

Greenhouse-warming theory cannot explain the clear changes in temperature trends around 1970, 1998, and 2014. The period from 1998 through 2013 is known in the scientific literature as the global warming hiatus. Hundreds of peer-reviewed scientific papers try to explain why global warming pauses for fifteen years even though greenhouse-gas concentrations continue to increase. Many ideas are proposed but there is little agreement.

(3) There Are Only Three Physical Processes by Which Air in Earth's Atmosphere is Heated Every Day

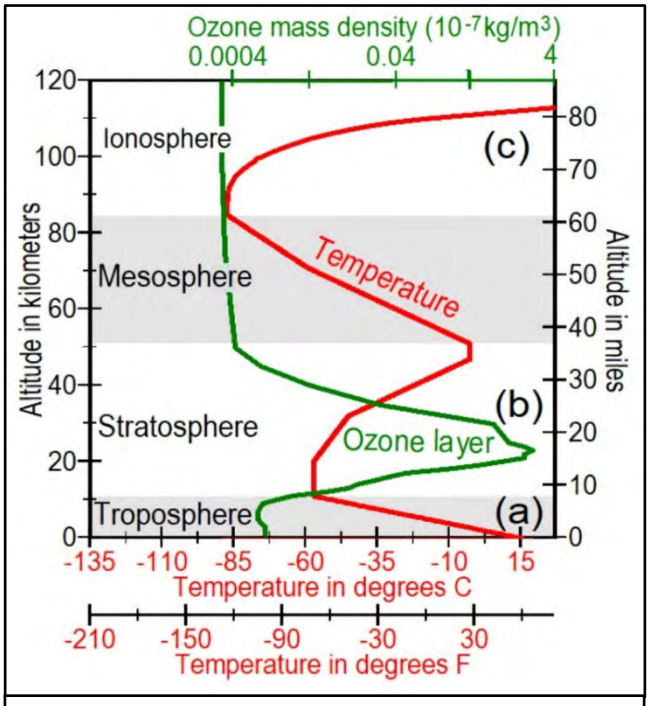
Process (a) in the troposphere when air touches Earth's sun-warmed surface and convects upward.

Process (b) in the stratosphere where primarily molecules of oxygen and ozone are photo-dissociated over and over again by solar ultraviolet-C and solar ultraviolet-B radiation.

Process (c) in the ionosphere where primarily molecules of nitric oxide, nitrogen, and oxygen are photo-ionized by solar extreme ultraviolet radiation.

We live at the base of the troposphere, the lowermost layer in Earth's atmosphere, and we fly large airplanes near the top of the troposphere, which averages 11 miles (17 km) above Earth at mid-latitudes. The troposphere is heated from below by Earth's sun-warmed surface much like air above a hot frying pan. Average annual temperature just above Earth's surface is around 57°F (14°C), decreasing to -60°F (-51°C) at the top of the troposphere.

Everything above the troposphere, on the other hand, is heated every day from above by solar ultraviolet radiation.

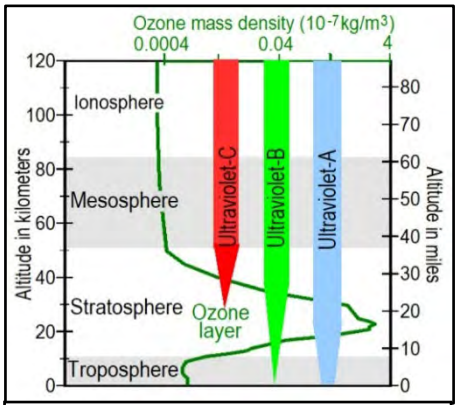


(3) There are only three ways known that air is warmed every day in the atmosphere: (a) *by conduction when air touches Earth's sun-warmed surface at the base of the troposphere,* (b) *by dissociation in the stratosphere and mesosphere, and* (c) *by ionization in the ionosphere. (U.S. Standard Atmosphere, 1976, Ozone data)*

(4) Solar Ultraviolet-C Warms the Upper Stratosphere by Dissociation

When a molecule of oxygen absorbs certain frequencies of solar ultraviolet-C radiation, the chemical bond between the two atoms of oxygen is broken. These two atoms fly apart at high velocity much like the ends of a snapped rubber band. Temperature of a gas is well-known to be proportional to the average velocity squared of all molecules and atoms making up the gas.

When two atoms of oxygen collide, they typically form a new molecule of oxygen without any effect on air temperature. This molecule can then be photo-dissociated as long as appropriate frequencies of solar ultraviolet-C radiation are available. All solar ultraviolet-C radiation has usually been absorbed in this way before it reaches the lower stratosphere as shown by the red arrow in Figure 4.



(4) Most solar ultraviolet-B is absorbed in the ozone layer, warming the lower stratosphere.

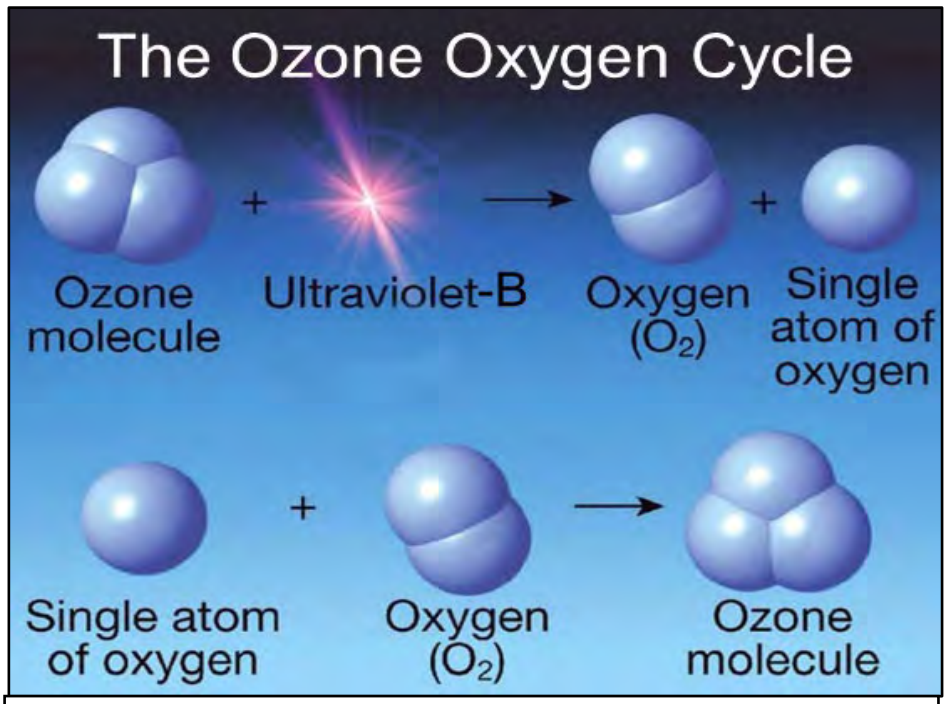
Thus, photo-dissociation converts kinetic energy of bond oscillation directly and completely into increased air temperature over and over again, maintaining the temperature at the top of the stratosphere approximately 97°F (54°C) warmer than the temperature at the bottom of the stratosphere. In this way, the stratosphere forms an "electric blanket" around Earth, keeping Earth 59°F (33°C) warmer than expected for a planet at Earth's distance from Sun. "Electric" in the sense that the thermal energy comes from a distant source, Sun, not from the body under the blanket, Earth.

(5) Solar Ultraviolet-B Warms the Ozone Layer in the Lower Stratosphere by Dissociation

Ozone is a molecule consisting of one atom of oxygen and one molecule of oxygen. When a molecule of ozone absorbs certain frequencies of solar ultraviolet-B radiation, the molecule of oxygen and the atom of oxygen fly apart at high velocity warming air in the ozone layer. A molecule of oxygen and an atom of oxygen can collide forming a new molecule of ozone, as observed, that can then be photo-dissociated as long as appropriate frequencies of solar ultraviolet-B radiation are available.

Normally all solar ultraviolet-B radiation has been absorbed before penetrating to the base of the ozone layer. If the concentration of ozone in the ozone layer is depleted for any reason, however, less ultraviolet-B solar radiation is absorbed within the ozone layer, cooling the ozone layer as observed (red line in Figure 7), and more ultraviolet-B solar radiation is observed to reach Earth's surface where it photo-dissociates ground-level ozone pollution, warming air just above Earth's surface, especially in populated areas containing substantial ozone pollution.

The ozone layer normally protects life on Earth from this high-energy ultraviolet-B solar radiation that causes sunburn, skin cancer, cataracts, mutations, slow fading of colors, slow degradation of materials, bleaching of corals, and global warming. Most periods of major warming throughout Earth history are contemporaneous with wide-spread mutations of plant life most likely caused by ozone depletion.

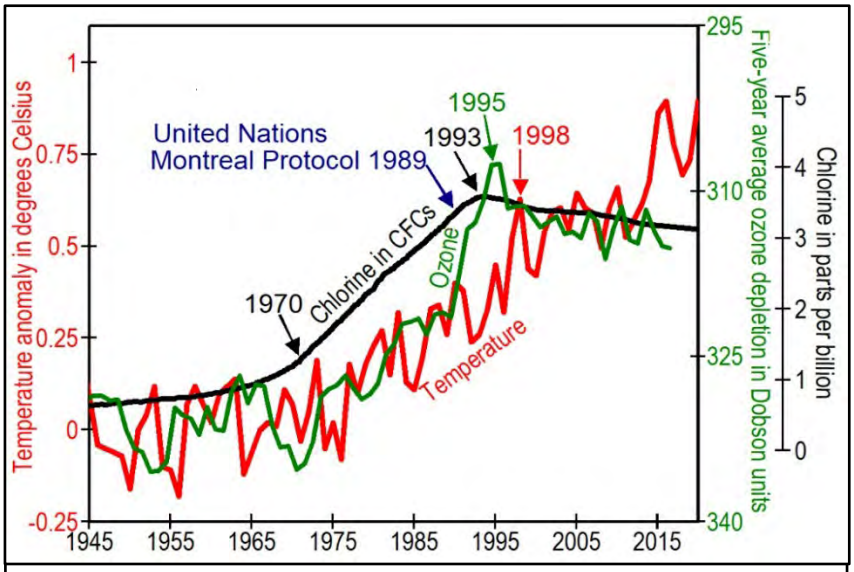


(5) Ozone is dissociated, reforms, and is dissociated again in an endless cycle that continues as long as sufficient solar ultraviolet-B radiation exists, warming the ozone layer. (Graphic source)

(6) Global Warming From 1970 to 1998 Was Caused by Humans Depleting the Ozone Layer

The most definitive scientific experiment ever done demonstrating how global warming is caused by a change in the concentration of a trace gas in the atmosphere was carried out unintentionally from 1970 to 1998.

In the 1960s, increasing amounts of chlorofluorocarbon gases (CFCs) were manufactured for use as refrigerants, spray-can propellants, foam-blowing agents, and solvents (black line). It takes approximately five years for the CFCs to rise into the stratosphere. Beginning around 1970, the ozone layer began to be depleted (green line) and tempera-tures began to rise (red line).

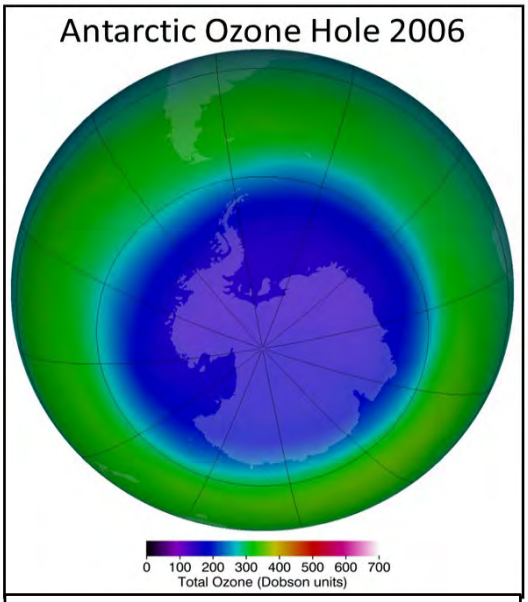


(6a) Increases in manufacturing of CFCs (black line) appears to have caused increases in ozone depletion (green line), leading to increases in temperature (red line). Temperatures were lowered around 0.9°F (0.5°C) for 2 to 3 years following the eruptions of Agung in 1963, El Chichón in 1982, and

In 1974, scientists discovered that when CFCs reach the stratosphere, they can be broken down by solar ultraviolet radiation, releasing atoms of chlorine. They showed that one atom of chlorine, under very cold conditions in late winter, can destroy up to 100,000 molecules of ozone.

When scientists discovered the Antarctic Ozone Hole in 1985, they realized that ozone depletion was a much bigger problem than had been assumed. They worked very effectively with political leaders to frame and pass the United Nations Montreal Protocol on Substances that Deplete the Ozone Layer, severely restricting production of CFCs beginning in 1989. Sure enough, by 1993, chlorine concentrations stopped increasing. By 1995, ozone depletion stopped increasing. By 1998, temperatures stop-ped increasing.

Note that air temperatures increase only when ozone depletion is increasing. Thus, average global temperatures appear to be inversely proportional to average total column ozone. The more depleted the ozone layer is, compared to levels before 1970, the warmer Earth's surface will become. The greatest observed warming was of minimum temperatures in polar regions in late winter, when and where ozone depletion was greatest.



(6b) The ozone hole over Antarctica during the late winter of 2006.

The Montreal Protocol may have prevented 443 million cases of skin cancer, 63 million cataract cases, and 2.3 million skin cancer deaths for people born in the United States between 1890 and 2100. Without the Montreal Protocol, global temperatures today would likely be 0.9°F (0.5°C) warmer. In 2003, Kofi Annan, Secretary General of the United Nations called the Montreal Protocol "perhaps the single most successful international environmental agreement to date." Three scientists earned the Nobel Prize in Chemistry in 1995 for their discovery of the effect of CFCs on ozone and for their work leading to the Montreal Protocol.

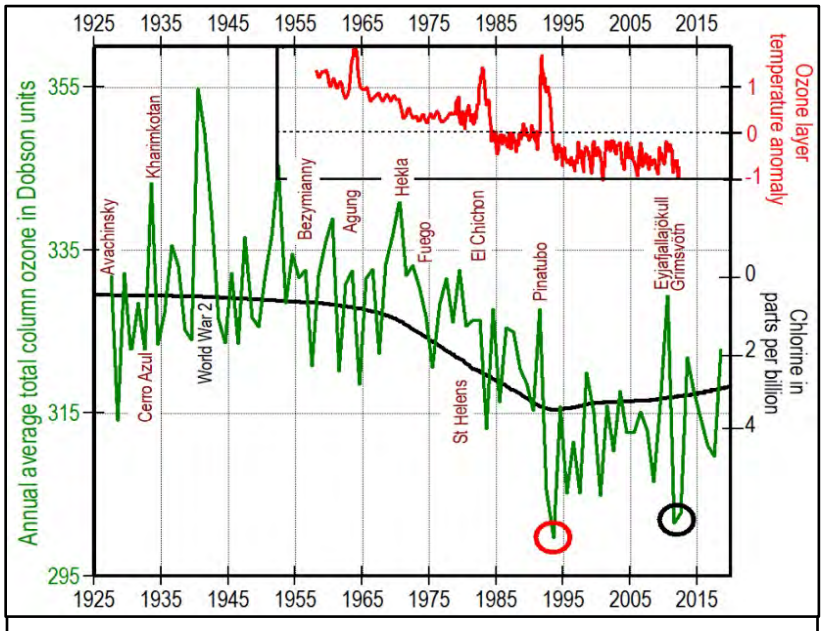
(7) When the Ozone Layer is Depleted, More Solar Ultraviolet-B Radiation is Observed to Reach Earth Where It Heats Air by Dissociating Ground-Level Ozone Pollution

When a molecule of ozone absorbs ultraviolet-B solar radiation, it is dissociated. A new molecule of ozone can be formed by collision of an oxygen molecule with an oxygen atom and then dissociated over and over again. Most molecules of ozone reside in the ozone layer, 9 to 22 miles (15 to 35 kilometers) above Earth's surface, as shown by the green lines in Figures 3 and 4. The average lifetime of a molecule of ozone in the ozone layer is only about 8.3 days.

In 1924, Gordon Dobson invented an instrument that measures the amount of ultraviolet-B radiation reaching Earth's surface and converts this number into the amount of ozone contained in a vertical column up through the atmosphere. The less ozone in the atmosphere, the more ultraviolet-B is observed to reach Earth.

The oldest routine measurements of total column ozone began in 1926 at Arosa Switzerland (latitude 47°N) shown by the green line. While ozone concentrations are constantly changing, annual average total column ozone shows several distinct trends.

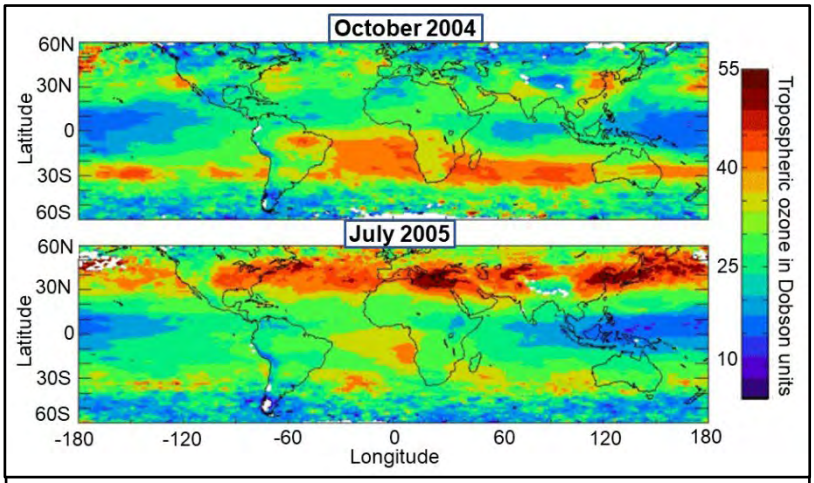
From 1926 until 1970, ozone above Arosa averaged 331 Dobson units as shown by the green line in Figure 7a. From 1970 to 1991, total column ozone, decreased as chlorine from CFCs in the atmosphere increased (black line increasing downward). In 1991, Mount Pinatubo in the Philippines erupted, the largest explosive volcanic eruption since 1912. Ozone concentrations were unusually high in 1991 and unusually low is 1992 and 1993 (red circle). Ozone levels related to the eruption appear to recover within a decade. But they spiked again in 2010 associated with the much smaller basaltic eruptions



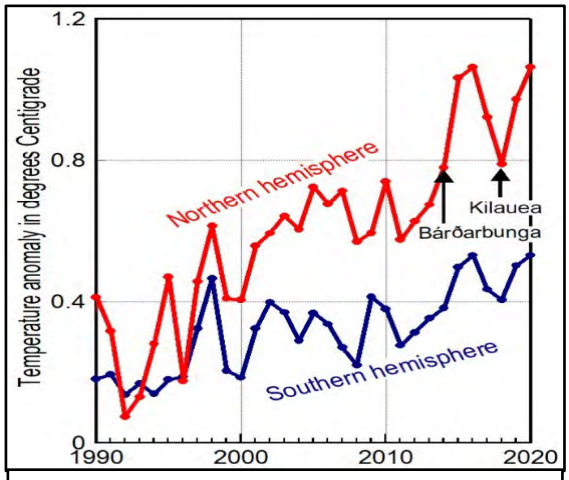
(7a) The greatest ozone depletion observed at Arosa since 1926 followed the eruption of Mt. Pinatubo in the Philippines in 1991 and two smaller basaltic eruptions in Iceland in 2010 and 2011.

of Eyjafjallajökull and Grímsvötn in Iceland and plummeted again in 2011 and 2012 (black circle). Most volcanic eruptions (labeled in maroon) are contemporaneous with unusually high levels of ozone during the year of an eruption and unusually low levels of ozone during the first and second years following an eruption.

Note in the upper right of Figure 7a how temperature in the ozone layer (red line) spikes during the largest eruptions (Pinatubo, El Chichón, and Agung) when ozone levels spike, but decreases as ozone levels decrease, showing that less ultraviolet-B rad-iation is being absorbed in the ozone layer and more is reaching Earth. Ultraviolet-B radiation reaching Earth is observed to dissociate ozone pol-lution in the troposphere (Figure 7b), warming air near the surface. This is most likely why warming since 1970 has been greater in urban areas where ozone pollution is greatest. This is most likely why warming has been twice as great in the northern hemisphere where 87% of people live than in the southern hemisphere (Figure 7c). This is most likely why warming has been greatest in polar regions during the winter, where and when ozone depletion has been greatest.



(7b) Ozone pollution in the troposphere is greatest during the summer in populated regions.



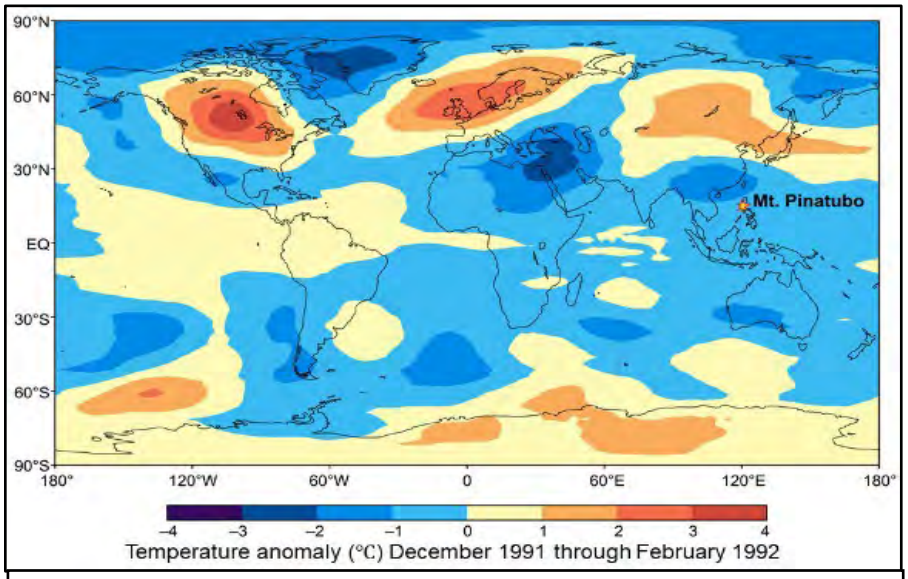
(7c) Annual average temperatures rose twice as much in the northern hemisphere as in the southern hemi-sphere with sharp increases following the 2014 eruption of Bárðarbunga and the 2018 eruption of Kilauea.

Ultraviolet-B radiation penetrates oceans at least ten meters and is, therefore, absorbed very efficiently. This is most likely why ocean heat content has been in-creasing rapidly since 1970 and continues to increase as long as ozone depletion remains high (green line in Figure 6a). Since 1970, approximately 40% of the increase in ocean heat content has been in the Southern Ocean, most of which is within the Antarctic ozone hole (Figure 6b) where ozone depletion is the highest on Earth. Ultraviolet-B radiation sunburns human skin, increases risks of skin cancer and cataracts, causes mutations, and bleaches coral reefs.

Observed global warming is explained in detail by depletion of the ozone layer, allowing more high-energy solar ultraviolet-B radiation to reach Earth. Ultraviolet-B radiation warms air near Earth's surface by photo-dissociating ground-level ozone pollution. A decrease in total column ozone of 5% (16 Dobson units) is observed to cause warming on the order of 1.1°F (0.6°C) at mid latitudes in the northern hemisphere (Ward, 2016).

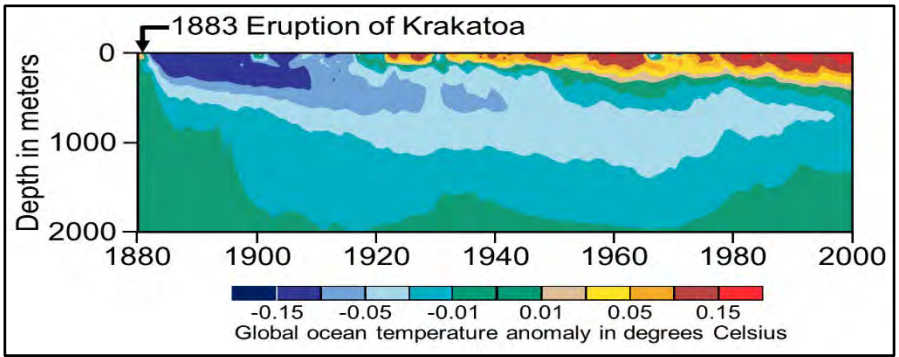
(8) Sequences of Major Explosive Volcanic Eruptions Form Aerosols in the Lower Stratosphere that Cool Earth Slowly and Incrementally Over Millennia

The greatest ozone depletion observed at Arosa since routine measurements began in 1927 was in 1992 and 1993 following the June 1991 eruption of Mt. Pinatubo in the Philippines, the largest explosive volcanic eruption since 1912 (red circle Figure 7a). Lower tropospheric temperatures rose more than 5.4°F (3°C) in some northern areas (Figure 8a) during the first winter when ozone depletion was greatest. But the Pinatubo eruption exploded megatons of water vapor and sulfur dioxide into the lower stratosphere where they merged to form a sulfuric-acid aerosol or mist. This aerosol was observed by satellite to spread around the world within 21 days and into polar regions within a year. Over months, the aerosol droplets grew large enough to reflect and scatter sunlight, causing net global cooling of 0.9°F (0.5°C) for three years. Such cooling has been observed after all major explosive volcanic eruptions throughout recorded history.

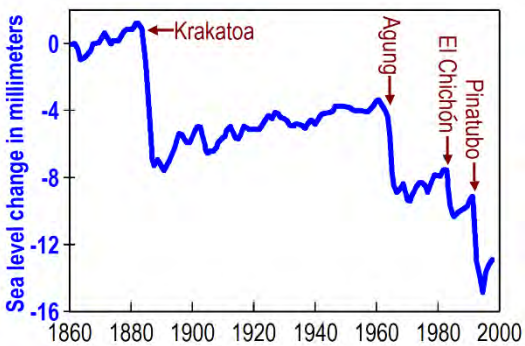


(8a) Lower tropospheric temperatures rose more than 3°C during the first winter after the June 1991 eruption of Mt. Pinatubo in the Philippines.

Modelling of ocean temperatures shows that this short-term, worldwide cooling decreases ocean temperatures at some depths for as long as a century. Thus, several large, explosive eruptions per century continuing for millennia can cool oceans incrementally down into ice-age conditions (blue line). The greater the number of large, explosive volcanic eruptions per century, the faster the cooling.



(8b) Calculated global ocean temperatures show the effects of several years of cooling following the 1883 eruption of Krakatoa can still be observed more than a century later.



(8c) Sea level change in millimeters calculated based on ocean temperatures.

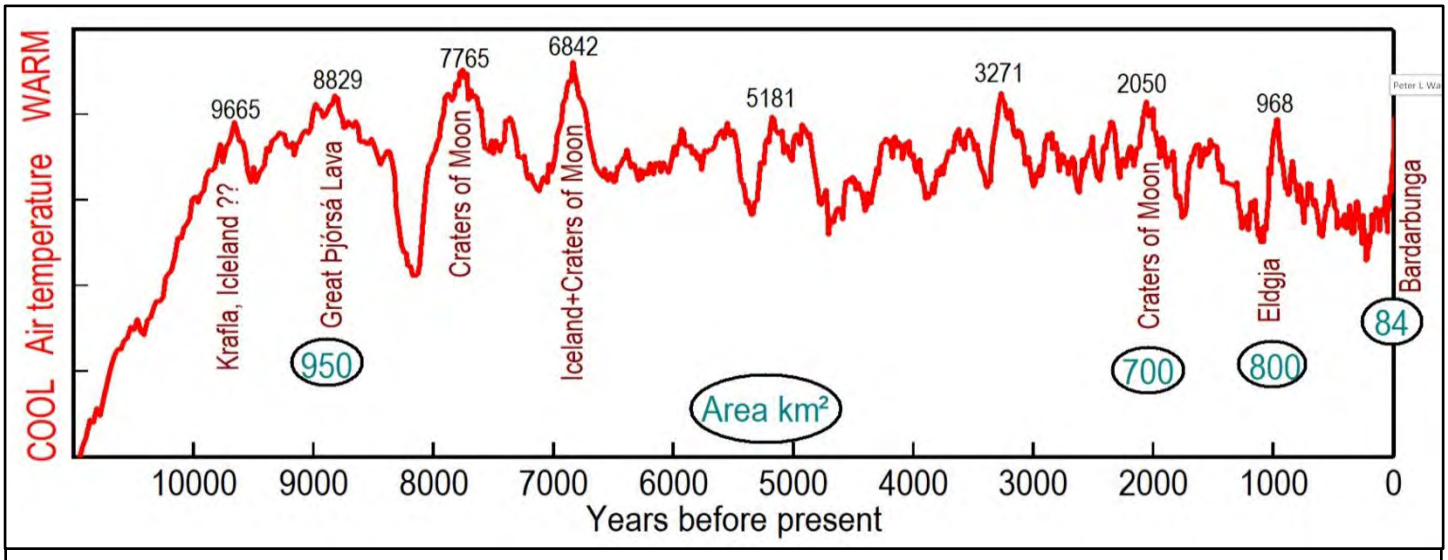
(9) Major Effusive Basaltic Volcanic Eruptions Warm Global Surface Temperatures Suddenly Within Two Years by Depleting the Ozone Layer

From late August 2014 thru February 2015, in central Iceland, Bárðarbunga volcano erupted basaltic lava covering an area the size of Manhattan (33 mi^2, 85 km^2). This was the most voluminous eruption of basaltic lava in 230 years. There was little explosive activity. No significant aerosols were formed. Average global temperatures rose rapidly in 2014 thru 2016, making 2016 the hottest year on record (Figure 7c).

(9a) Bárðarbunga volcano in central Iceland extruding basaltic lavas for six months over an area the size of Manhattan (Arctic-Images/Corbis).

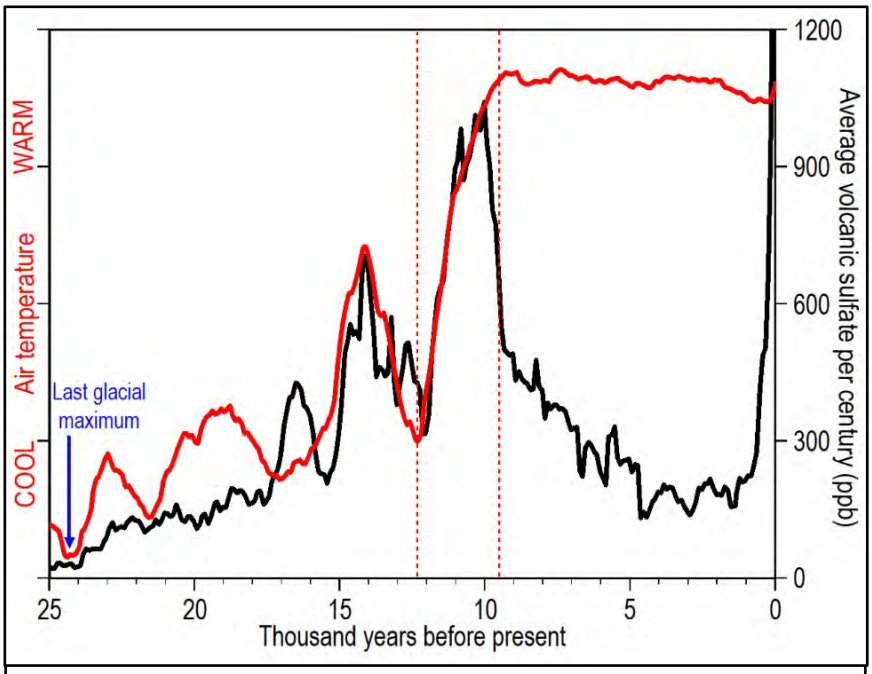
Global temperatures decreased in 2017 and 2018, but in May 2018 basalts began erupting from the East Rift Zone of Kilauea volcano in Hawaii at a rate 25% less than Bárðarbunga and lasting only three months. This was the largest lava flow from Kilauea volcano in 58 years. Global temperatures rose again, making 2020 as hot as 2016 (Figure 7c).

On March 19, 2021, Fagradalsfjall volcano in southwestern Iceland began extruding basaltic lava. As of September 13, 2021, the eruption had lasted longer than Bárðarbunga, but the lavas only covered an area of 1.8 mi^2 (4.6 km^2), a mere 5% of the area covered by lava from Bárðarbunga. On September 19, 2021, the Cumbre Vieja volcano on the island of La Palma in the Canary Islands began erupting basaltic lavas. On September 29, Kilauea volcano in Hawaii began erupting in the summit caldera. The effects of these small eruptions in 2021 on global temperatures have yet to be analyzed, but they are likely to be small.



(9b) Since the end of the last ice age, air temperatures in Greenland peaked at least nine times, seven of which were contemporaneous with known basaltic lava flows covering areas as large at 370 square miles (950 square kilometers).

Since the end of the last ice age, 10,000 years ago, air temperatures near Summit Greenland measured using oxygen isotopes in air bubbles trapped in glacial ice, peaked every thousand years or so (Figure 9b). Seven of these nine peaks were contemporaneous with known basaltic lava flows covering areas of up to 370 mi^2 (950 km^2). The Medieval Warm Period began about 934 to 940 AD with the large eruption of basalts from the volcano Eldgjá in Iceland. The Roman Warm Period, beginning around 2050 years before present, was contemporaneous with the most recent basaltic lava flows at Craters of the Moon National Monument in south-central Idaho.



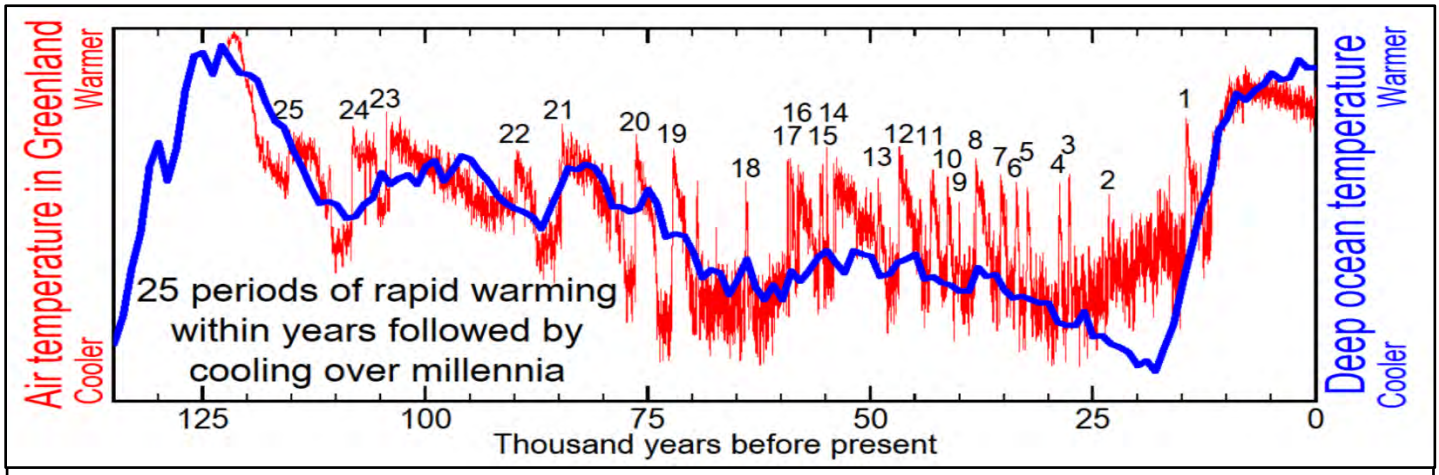
(9c) Average air temperatures in Greenland (red line) increased at the same time as volcanic activity (black line). The increases in air temperature lasted long enough to warm the ocean out of ice-age temperatures by 9,500 years before present.

The period of most intense volcanism recorded in Greenland ice over the past 100,000 years was precisely contemporaneous with the period of greatest warming at the end of the last ice age from 12,200 to 9,500 years before present. The black line in Figure 9c shows the average amount of volcanic sulfate per century measured in ice cores under Summit Greenland. Most of these eruptions were of basaltic volcanoes in Iceland. The red line shows air temperatures at the time the ice formed estimated by studying isotopes of oxygen in air bubbles trapped in ice.

(10) Climate Has Warmed Suddenly and Cooled Slowly in Highly Erratic Sequences Averaging Every Few Thousand Years

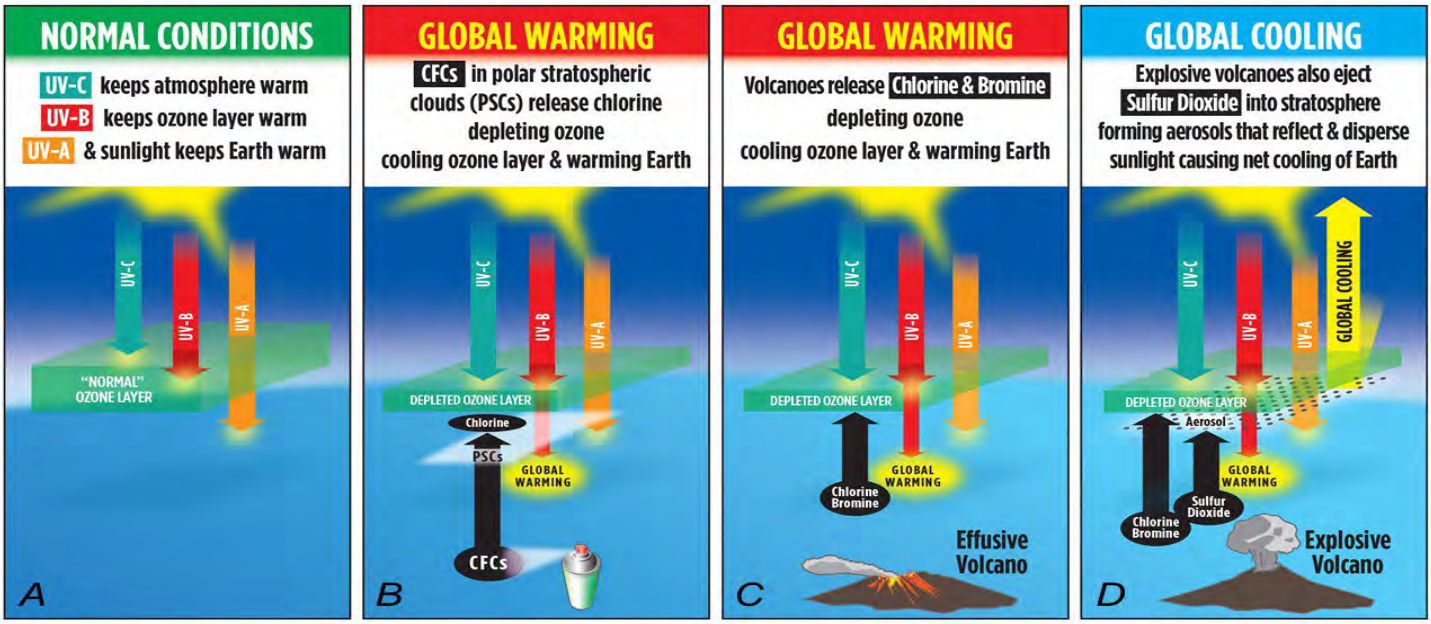
The red line in Figure 10a shows air temperatures at Summit Greenland estimated by studying isotopes of oxygen in air bubbles trapped in ice. The blue line shows deep ocean temperatures estimated by studying oxygen isotopes in tiny seashells. Note how ocean temperatures change much more slowly than air temperatures because of the massive heat content stored in oceans.

The numbers label twenty-five periods between 115,000 and 14,000 years before present when air temperatures in Greenland rose 9 to 29°F (5 to 16°C) within years to decades, followed by slow, incremental cooling over thousands of years. These sequences average every 4000 years, but the onsets and amounts of warming are highly erratic. The youngest, best resolved periods of sudden warming are contemporaneous with increased amounts of volcanic sulfate measured in the same ice cores. These observations are explained most directly by sudden warming associated with basaltic volcanism (Figure 9a) and slow, incremental cooling associated with sequences of major explosive volcanic eruptions (Figure 8c).



(10a) The footprints of climate change are rapid warming within years followed by slow, incremental cooling over millennia in highly erratic sequences that averaged every 4000 years.

Such sudden changes in climate had major effects on the evolution of humans. For example, sudden warming around 38,220 years before present (event 8 in Figure 10a) was followed by high levels of basaltic volcanism for 2000 years. This period is known as the Upper Paleolithic



(10b) A) Under normal conditions prior to 1970, most ultraviolet-B (UV-B) solar radiation was absorbed in the ozone layer 9 to 22 mi (15 to 35 km) above Earth. B) Beginning around 1970, CFCs manufactured for use as refrigerants and spray-can propellants, reached the stratosphere where they were broken down by UV radiation, releasing atoms of chlorine. One atom of chlorine can destroy 100,000 molecules of ozone especially in the vicinity of polar stratospheric clouds (PSCs). This depletion of the ozone layer allowed more UV-B to reach Earth's surface where it dissociated ground-level ozone depletion causing global warming. C) Chlorine and bromine released during volcanic eruptions are also observed to deplete the ozone layer causing warming. D) Explosive volcanoes, on the other hand cause global cooling when they eject megatons of water vapor and sulfur dioxide into the stratosphere, forming aerosols, a mist, that reflects and scatters solar radiation, lowering global temperatures approximately 0.9°F (0.5°C) for 2 to 4 years.

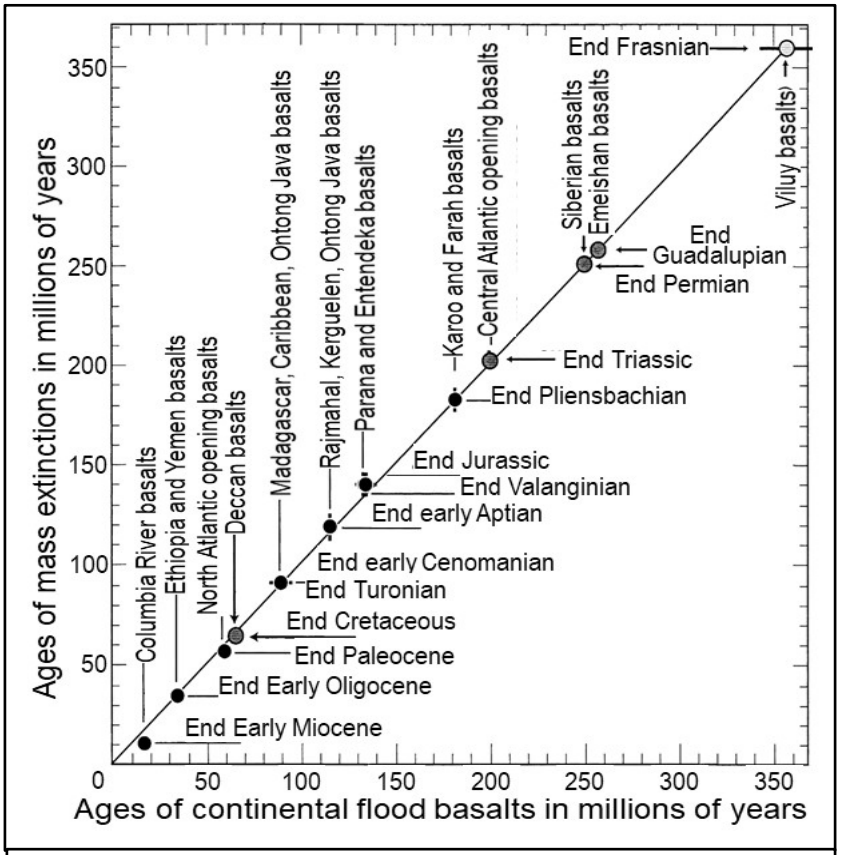
Revolution when modern humans spread rapidly into Eurasia and there was a sudden increase in sophistication of stone-working technologies, art, music, and elaborate burials.

Similar major rapid changes in temperature every four to five thousand years are difficult to resolve in the older geologic record with current age-dating techniques. But exceptionally fine layering of oil shales and trona in the Green River Formation of southwestern Wyoming document numerous cycles in temperature averaging approximately 5000 years between 53 and 48 million years ago. Detailed studies of ocean temperatures based on oxygen isotopes contained in tiny seashells document rapid changes of ocean temperatures from 485 to 200 million years ago. There is no reason to assume that such rapid changes observed in Figure 10a did not occur throughout Earth history.

(11) Major Basaltic Eruptions Have Been Contemporaneous with Major Mass Extinctions

Throughout Earth history, large basaltic lava flows have been contemporaneous with periods of rapid global warming—the larger the flow, the greater the warming.

In Siberia, 252 million years ago, basaltic lavas began erupting from fissures over a large area. Within two million years, these basalts covered an area almost as large as the contiguous United States. Oceans became highly acidic and as hot as hot tubs. More than 95% of marine species and 70% of land species went extinct—the greatest known mass extinction in Earth history. There is wide-spread evidence of mutations in plants during this time, suggesting massive ozone depletion.



(11a) Major mass extinctions occurred at the same time as continental flood basalts at the ends of geologic time periods when there were sudden changes in climate, sediment types, and fossils. (Courtillot and Renne, 2003)

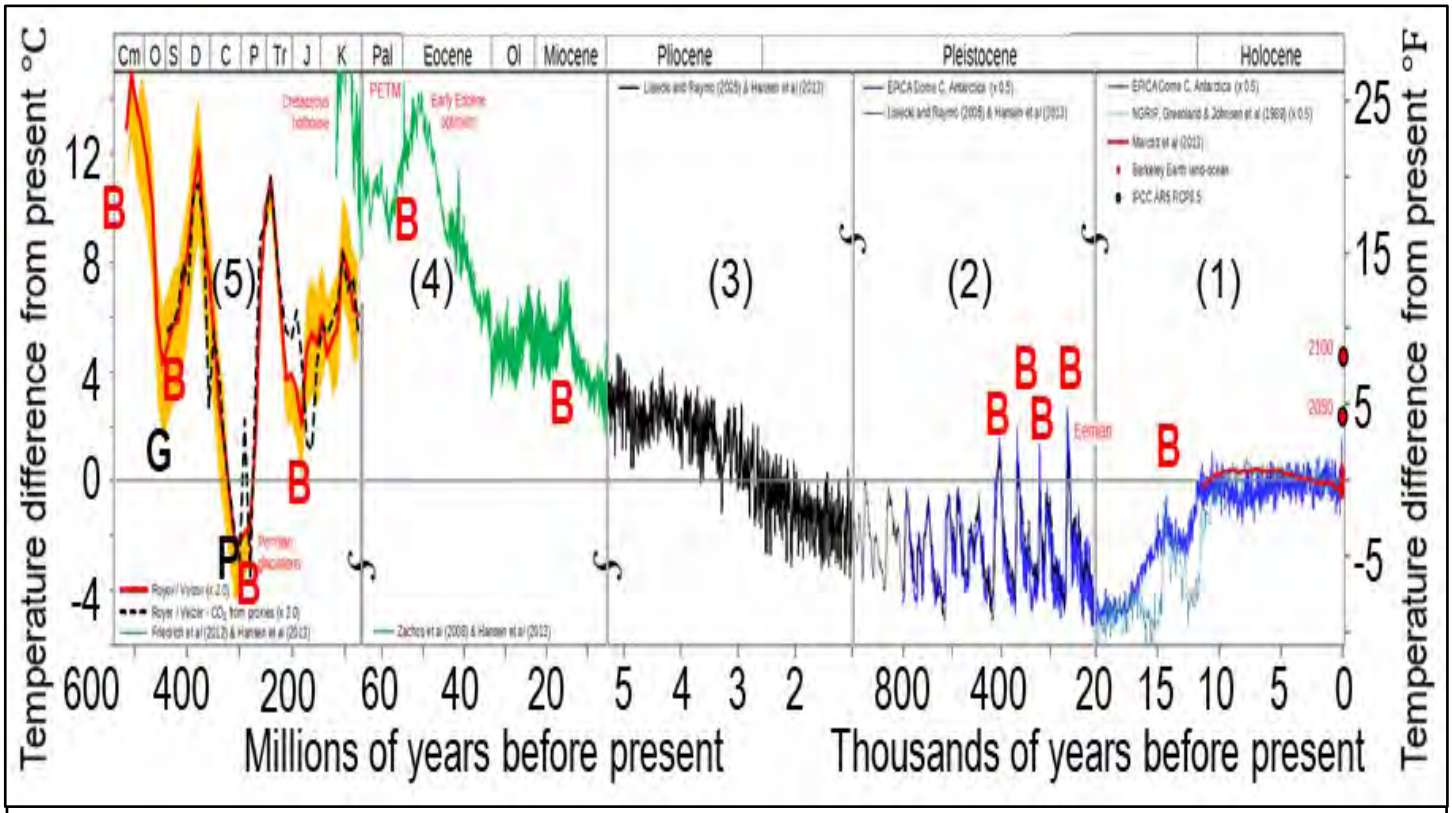
The last major basaltic lava flow was 16 million years ago along the Columbia River in eastern Washington and Oregon, covering an area the size of Kansas, the 15th largest state (81,000 mi^2, 210,000 km^2). Much smaller basaltic lava flows have progressed eastward across the Snake River Plain in southern Idaho.

Throughout Earth history, major basaltic lava flows have been contemporaneous with major mass extinctions and have occurred at the ends of geologic time

periods when there is typically a sudden change in sedimentation types and fossils (Figure 11a). It is highly unlikely that humans would survive the effects of any of these very large basaltic lava flows.

Figure 11b shows an ingenious summary of the most detailed studies of global temperatures during the last 540 million years devised by Glen Fergus. The right half of section (1) on the right shows data similar to data shown in Figure 9b over the past 10,000 years. All of section (1) shows data similar to data shown by Figure 9c over the past 25,000 years. Figure 10a shows data from the Eemian temperature peak in section (2) of this figure to present over the past 135,000 years. The red Bs show times of the largest known basaltic lava eruptions.

The red and dashed black lines on the left in section (5) show large changes in temperature from 600 million to 60 million years before present that are contemporaneous with the formation of two major supercontinents, Gondwana (G) and Pangea (P). Such supercontinents have formed ten times in the last 3.636 billion years—on average once every 360 million years. Explosive volcanic eruptions and associated global cooling are most common in areas where ocean plates are being subducted down under continents, bringing continents together. Effusive basaltic eruptions and associated rapid global warming are most common in areas where supercontinents

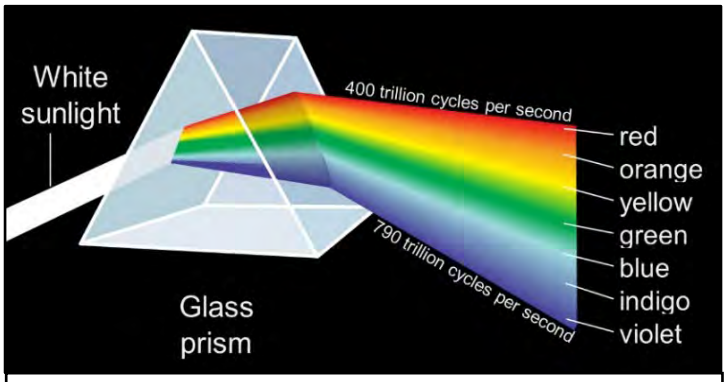


(11b) Temperature of Earth over the last 540 million years. The time scale on the x-axis changes 4 times from thousands of years on the right (1) to hundreds of millions of years on the left (5). Times of well-known, major basaltic eruptions (B) are contemporaneous with periods of major warming. The large changes in temperature from 60 million to 600 million years before present (red and dashed black lines on the left) are contemporaneous with the formation of major supercontinents (G is Gondwana and P is Pangea) when subduction and associated explosive volcanism was widespread causing cooling and when rifting of these supercontinents and associated basaltic volcanism was widespread causing rapid warming.

are being rifted apart. There is an immense amount of research needed to fill in the details in this figure.

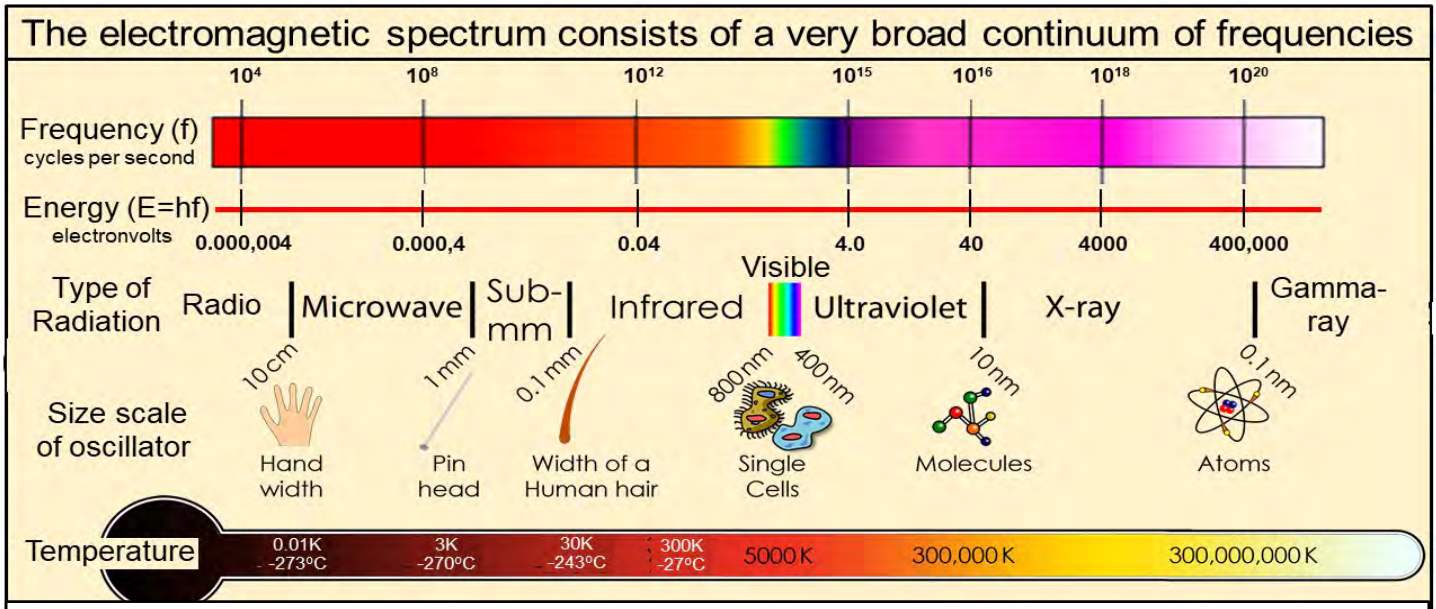
(12) Temperature of Solid Matter Is the Result of a Broad Spectrum of Frequencies of Oscillation, All of Which Must Co-Exist

For more than 200 years, physicists have thought of heat as thermal energy in transfer via radiation in air and space and via conduction in solid matter. Physicists have traditionally quantified heat as a flux, an amount of thermal energy flowing through some surface in units of watts per square meter. But flux is merely a concept in applied mathematics. Flux is not a physical thing. This mathematical definition of heat does not depend on assuming or knowing what heat is physically or how heat flows physically. Yet physics is supposed to be about what is physically happening in the world around us. What is physically flowing when temperatures change?



(12a) A prism spatially separates the rainbow of colors that make up white sunlight. (Encyclopedia Britannica)

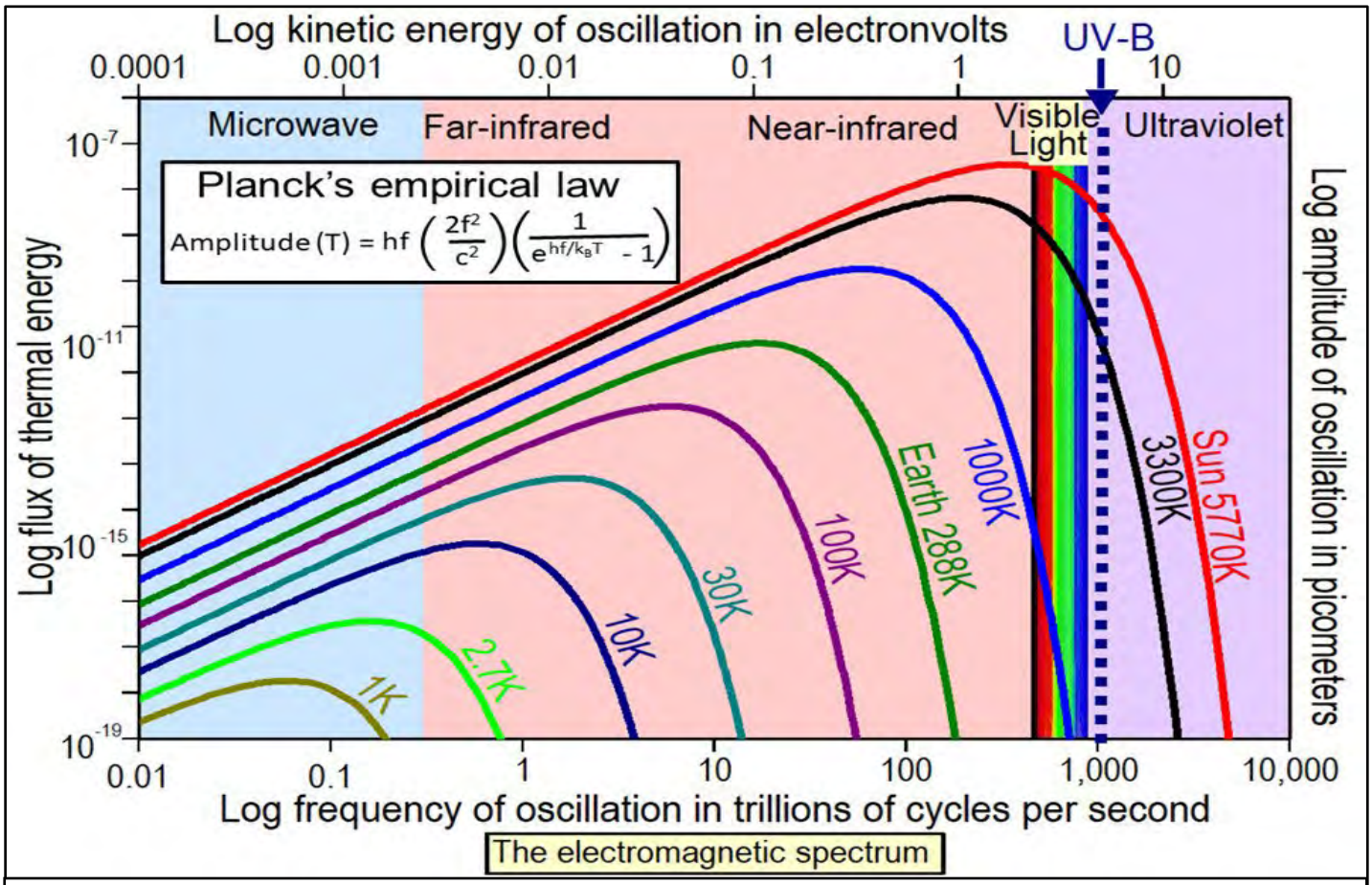
The physical result of the flow of heat is to decrease the temperature of the hotter body and to increase the temperature of the cooler body. Thus, what is physically flowing is that which causes a change in temperature within solid matter.



(12b) The electromagnetic spectrum of frequencies of oscillation extends over more than sixteen orders of magnitude. The higher the frequency, the smaller the oscillator resonating at that frequency. We see visible light because those are the frequencies that the cells in the cones of our eyes can resonate with from red at 400 terahertz to violet at 790 terahertz.

Visible radiation consists of a spectrum of frequencies of oscillation typically ranging from 400 to 790 trillion cycles per second. The human eye can typically detect more than one million shades of color within this range. Ever since 1665, Isaac Newton and many other physicists have sought to measure the physical properties of thermal radiation by passing sunlight through a prism, spatially separating the colors of the rainbow as shown in Figure 12a. They then placed a thermometer or other type of sensor within each band of color and measured the intensity of that color relative to other colors. They mistakenly thought that a more intense, brighter color must have more energy. So, they plotted flux of thermal energy on the y-axis as a function of frequency on the x-axis (Figure 12c).

In this way, physicists discovered the existence of infrared radiation in 1800, ultraviolet radiation in 1801, radio frequencies in the 1880s, X-rays in 1895, and gamma rays in 1900. We now understand that thermal radiation consists of an extremely broad spectrum or continuum of frequencies of oscillation that in the 1860s James Clerk Maxwell called the electromagnetic spectrum (Figure 12b).



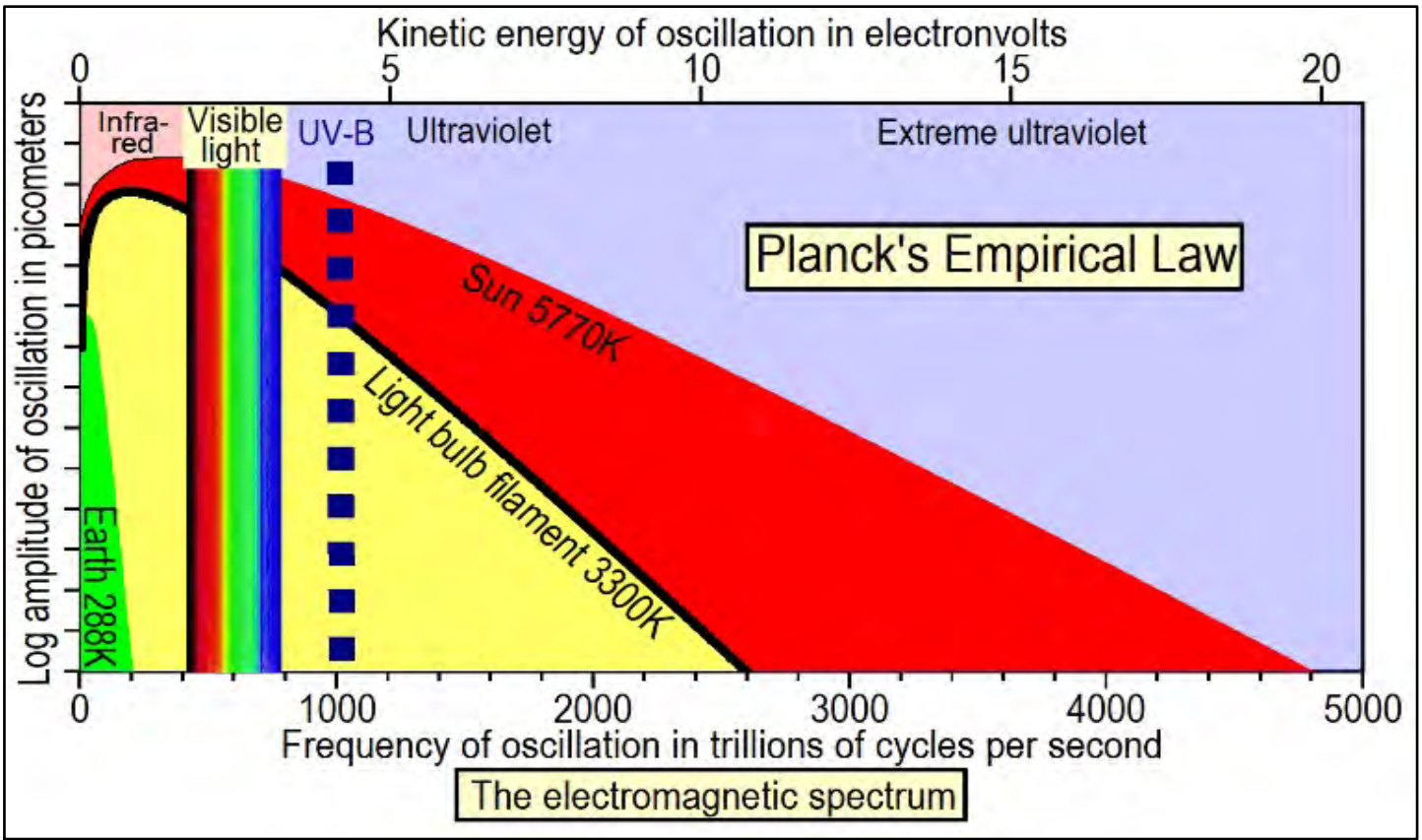
(12c) Temperature in solid matter is observed to be the result of an extremely broad spectrum of frequencies of oscillation whose amplitudes of oscillation vary as a function of temperature of the body. Planck's empirical law, plotted here, calculates the amplitude of oscillation as a function of absolute temperature (T) in units Kelvin. h is the Planck constant, f is frequency of oscillation, c is the velocity of light, and the k_B is the Boltzmann constant. In this plot, the x-axis is logarithmic. Planck's empirical law is plotted with a linear x-axis in Figure 13.

In 1900, Max Planck, one of the fathers of modern physics, was able to devise an equation by trial and error that calculates what they thought at the time was the flux of thermal energy at each frequency as a function of the absolute temperature of a radiating body of solid matter in degrees Kelvin. Calculations using Planck's empirical law are shown in Figure 12c for nine different temperatures.

Planck's empirical law is based on extensive observations. It is not based on theory. It not only calculates the spectrum of oscillations contained in thermal radiation, but it also must calculate the spectrum of oscillations on the surface of solid matter that gives rise to radiation and the spectrum of oscillations within solid matter for that matter to "possess" a temperature. Planck's empirical law shows that for a body of solid matter to be warmed, it must absorb an increase in what they thought at the time was flux of thermal energy at each and every frequency. Such increases are only available in Nature by absorbing heat from a hotter body.

(13) Thermal Energy Consists of a Broad Spectrum of Energies of Oscillation All of Which Must Co-Exist

Physicists now understand that temperature of solid matter is the result of oscillation of all the bonds holding atoms and molecules together. Each bond is assumed to oscillate between the attractive forces of opposite electric charge and repulsive forces of similar electric charge. These



(13) The electromagnetic spectrum of frequencies of oscillation radiated by a body of solid matter as a function of the body's absolute temperature. The x-axis is linear. Planck's empirical law is plotted with a logarithmic x-axis in Figure 12c.

frictionless oscillators are tiny. Their lengths are measured in picometers (10^{-12} meters). They oscillate at frequencies measured in trillions (10^{12}) of cycles per second. Such frequencies are much too high to be perceived as oscillations. We perceive them as temperature.

Planck, to devise his empirical law, postulated that the energy of oscillation (E) of a single frictionless oscillator must equal frequency (f) times a scaling-factor (h) that is equal to the energy contained in a frequency of one-cycle per second. This simple equation, E=hf, known as the Planck-Einstein relation, says that oscillatory energy is the same physical thing as frequency of oscillation. Energy is defined as that which causes change. When the frequency of oscillation is high enough, its energy of oscillation is observed to cause chemical change. This simple equation is used in photo-chemistry to specify the minimum frequency, the minimum level of oscillatory energy, that must be present in radiation for that radiation to cause a photo-chemical reaction such as the photo-electric effect, photo-dissociation, or photo-ionization. Nearly all frequencies causing photo-chemical change are in the violet, ultraviolet, X-ray, and gamma ray frequency bands. None are in the infrared frequency band radiated by Earth and absorbed by greenhouse gases (Figure 13).

In 1900, Planck called E an "energy element." In 1905, Einstein called E a "light quantum," leading to the development of quantum mechanics. In 1926, Lewis called E a "photon." E is currently thought of in physics as the energy of a photon where a photon is thought of as an elementary particle, the quantum of electromagnetic radiation.

In physics, a quantum is defined as the minimum amount of any physical entity involved in an interaction. We will see below that what we think of as electromagnetic radiation is an interaction between a molecular-bond-scale oscillator on the surface of the radiating body and a molecular-bond-scale oscillator on the surface of the absorbing body when both are oscillating at the same frequency. Thus, the physical quantum of electromagnetic radiation is not the frequency, it is the source of the frequency, which is a physical molecular-bond-scale oscillator.

For thermal radiation, however, frequency is observed to be the electromagnetic spectrum, a continuum of frequencies, all of which coexist in air and space without interacting in any way except when in the immediate presence of matter. If E=hf, then a spectrum (f) times the Planck constant (h) must be a spectrum or continuum of energies. Therefore, thermal energy (E) is an extremely broad spectrum of energies, all of which coexist within matter and within radiation travelling through air and space. Radiant energy cannot be described accurately by a single number of joules as assumed by greenhouse-warming theory.

What Planck failed to recognize in 1900 was that if energy (E) is simply a function of frequency (f) as he postulated, then energy must be plotted on the x-axis parallel to frequency as shown at the top of Figures 12c and 13. Physicists at the time thought they were measuring energy at each frequency. So, they plotted thermal energy on the y-axis. But radiation is the result of tiny oscillators that have two primary physical properties: frequency of oscillation and amplitude of oscillation. We perceive frequency of oscillation of visible light as color and we perceive amplitude of oscillation of visible light as intensity or brightness of that color. Thus, in measuring the intensity of light at each frequency, physicists were not measuring radiant flux, they were

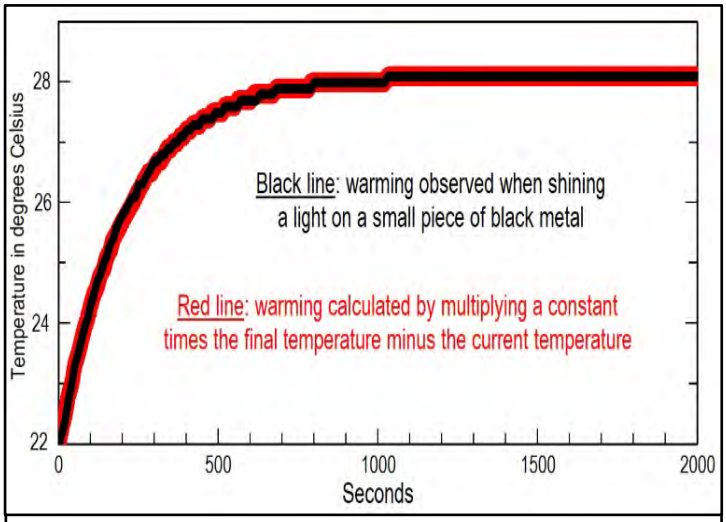
measuring amplitude of oscillation as shown on the y-axis on the right in Figure 12c and on the left in Figure 13. I do not show numbers on this axis because the precise numeric values of amplitude still need to be calibrated in the laboratory.

It is extremely important to realize that the electromagnetic spectrum exists at all times and at all locations on Earth and throughout the cosmos. What varies in time and space is amplitude of oscillation at each and every frequency as a function of temperature of the radiating body as calculated by Planck's empirical law. Therefore, what is flowing as heat is a spectrum or continuum of amplitudes of oscillation described by the area between the Planck curves for the temperatures of the emitting and absorbing bodies of solid matter (Figures 12c and 13).

(14) Temperature Flows at a Rate Proportional to the Difference in Temperature

Temperature of solid matter is observed to flow spontaneously by conduction or by radiation only from higher temperature to lower temperature. All measurements of warming or cooling of solid matter show that the instantaneous rate of temperature change is proportional to the instantaneous difference in temperature.

For example, the black curve shown in Figure 14 plots the warming measured when shining a light on a small piece of thin black metal. The red line plots the warming calculated by multiplying a constant times the final temperature minus the current temperature. Clearly, the greatest rate of warming is in the first second when the temperature difference is greatest. The rate of warming approaches zero as the temperature difference approaches zero. When there is no difference in temperature, there is no flow of thermal energy. All plots of warming or cooling have the same shape where temperature approaches its final value slowly in what is called an asymptotic manner.



(14) Temperature changes at a rate proportional to the instantaneous difference in temperature.

You get this same asymptotic shape if you plot your approach to a wall by travelling one half the distance between you and the wall during each unit of time. You will approach the wall rapidly at first, but you will never, in theory, reach the wall even though you will be extremely close.

Temperature of the warming body will always be somewhere between its initial temperature and the temperature of the source of heat. Temperature of the cooling body will always be somewhere between its initial temperature and the temperature of the warming body. The body absorbing the radiation can never become warmer than the body emitting the radiation.

Planck's empirical law (Figures 12c and 13) calculates the amplitude of oscillation for each frequency of oscillation that must exist within a body of matter and within its radiation for that body to "possess" a specific temperature. A difference in temperature at the macroscopic level is causally related to a difference in amplitude of oscillation at the molecular-bond level as calculated by Planck's law. The higher the temperature, the higher the amplitude of oscillation at each and every frequency of oscillation and the higher the frequency of oscillation with the greatest amplitude of oscillation.

Note in Figure 13 that as a body of solid matter warms, the greatest differences in amplitude of oscillation are at the highest frequencies of oscillation. This means that the highest rate of change of amplitude of oscillation, the highest rate of change of temperature, is at the highest frequencies of oscillation that are absorbed. This is why ultraviolet-B (blue dashed line), which is the highest frequency, highest energy, solar radiation penetrating all the way through Earth's atmosphere, plays the primary role increasing global temperatures. The less ozone in the ozone layer, the less ultraviolet-B radiation is absorbed in the ozone layer and the more ultraviolet-B radiation is observed to reach Earth. In this way, annual average global temperatures are inversely proportional to average total column concentrations of ozone. As stated above, a decrease in total column ozone of 5% (16 Dobson units) is observed to cause warming on the order of 0.8°F (0.5°C) at mid latitudes in the northern hemisphere (Ward, 2016).

(15) Temperature Flows by Resonance Simultaneously at Each and Every Frequency of Oscillation

Planck's empirical law (Figures 12c and 13) shows clearly that what increases with increasing temperature of solid matter is amplitude of oscillation at each and every frequency of oscillation simultaneously. The greatest rate of change in amplitude of oscillation occurs at the highest frequencies where the differences in amplitude are greatest.

In most oscillatory systems, amplitude of oscillation at each frequency of oscillation is observed to change via resonance. Resonance is a fundamental physical property of oscillating systems. Resonance, involving the electromagnetic spectrum, is the observed reality that when two electromagnetic oscillators are oscillating at identical frequencies and they are either physically touching each other or are within line-of-sight of each other, they share amplitudes of oscillation. The hotter body, with the larger amplitude of oscillation at a specific frequency, loses amplitude of oscillation while the cooler body, with the shorter amplitude of oscillation at the identical frequency, gains amplitude of oscillation. This sharing at each frequency occurs simultaneously at all frequencies. In the simplest case, the resulting amplitudes of oscillation will be the average of the initial amplitudes. This simultaneous sharing is how the Planck curves maintain their general shape and why Planck curves never cross each other (Figures 12c and 13). The amplitude of oscillation will always be somewhere between the initial amplitudes.

Resonance is often thought of as constructive interference. Because the frequencies are identical, if they are in phase, the higher amplitude of oscillation "pushes" the lower amplitude of oscillation causing it to increase. When you push a child on a swing at the same frequency as the swing is

swinging and just as the swing is falling in front of your hands, the child will swing higher. Any other timing or frequency causes destructive interference, and the swing will swing lower.

Resonance is how you listen to your favorite radio station. The station transmits at a specific frequency by acceleration of electric charge on the transmitting antenna. When you tune your radio receiver to that specific frequency, amplitude of oscillation is increased by resonance in your receiver allowing you to hear only that specific radio station.

(15a) A swing goes higher when you push at precisely the same frequency that the swing is swinging. Otherwise, your push interferes with the swing's motion. (ShaneKato iStock)

Each tiny oscillator on the surface of matter broadcasts its own frequency of oscillation and amplitude of oscillation just like a radio transmitter. Thus, the plethora of molecular-bond-scale oscillators making up the surface of matter are the source for the extremely broad spectrum of frequencies of oscillation known as the electromagnetic spectrum (Figure 12b). The physical properties of this electromagnetic spectrum are determined by the temperature of the emitting body as calculated using Planck's empirical law Figures 12c and 13).

Resonance is the primary way living things interact with the world around them. Visible light is visible because these frequencies are high enough, have sufficient energy, to interact with the cells in the cones of our eyes. Ultraviolet radiation, however, has energy high enough to damage the cells in our eyes causing cataracts. Resonance is how you see when a molecular oscillator on the surface of a green leaf, for example, resonates with three slightly different cells in the cones in your eyes. Your brain converts the slightly different amplitudes of oscillation, allowing you to detect more than one million different shades of color. You hear by resonance when hair-like cilia of different lengths resonate with frequencies of changes in fluid pressure within the cochlea in your ear.

Resonance is what Albert Einstein called "spooky action at a distance." Something over here interacts with something over there but there is no visible connection between them. Resonance, a fundamental physical property of oscillating systems, may be what physicists seek to explain by quantum entanglement theory.

For 2500 years, natural philosophers and then scientists have debated whether visible light travels as waves or as particles. In the past century physicists have argued for wave-particle duality. But waves, physically, are the deformation of matter and Michelson and Morley showed in 1887 that there is no luminiferous aether, there is no matter in space, that waves can deform. Furthermore, if E=hf as discussed above, then E is a spectrum of energies, not a photon as currently assumed.

We now recognize that light, physically, is a very broad spectrum of frequencies of oscillation, that the amplitude of oscillation at each frequency is a function of the temperature of the radiating

body as calculated using Planck's empirical law, and that amplitudes of oscillation are shared across air and space by resonance.

(16) Heat Is an Intensive Physical Property, Not an Extensive Physical Property as Currently Assumed

Helm (1898) and Tolman (1917) noted that physical properties of materials or systems are either extensive or intensive. An extensive physical property is typically quantified by a single numeric amount or value that is proportional to the extent or mass of the system. Examples are volume, mass, size, weight, or length. Extensive physical properties are typically measured at the macroscopic level as absolute amounts of standardized units such as meters, grams, or moles. Amounts specified with the same units of measure, can be added together—increasing the extent of the body of matter. Thus, extensive physical properties are physically additive.

An intensive physical property, on the other hand, is typically measured at the macroscopic level but it is the result of the arrangement or motion of atoms and molecules at the sub-microscopic level. An intensive physical property is spread evenly throughout a body of matter at the molecular level so that its value does not depend on the amount of the substance for which it is measured. An intensive physical property is typically measured as a level on a relative scale. Because levels are relative to each other, it does not make physical sense to add levels together. Intensive physical properties are not additive. They are typically averaged. They are averative.

Extensive Physical Properties	**Intensive Physical Properties**
Length, area, volume, size, mass, weight, quantity, amount	Temperature, heat, density, color, luster, hardness, pressure, bond energy, boiling point
Describes the size, extent, or mass of a body of matter	Describes the result of a bulk property distributed throughout
Describes an amount or quantity by a single number	Describes a level on an arbitrary scale such as Celsius or Kelvin
Kinetic energy of linear motion of the whole body	Distribution of kinetic energies of oscillation throughout a body
Different values of the same property are added together	**Cannot be added together in any physically meaningful way**

The classic example of an intensive physical property is temperature. If you divide a body of matter into many pieces with many different sizes, all pieces will initially have the same temperature. If you connect two bodies together that are identical in every way except for temperature, the resulting temperature will be the average of the initial

temperatures, not the sum. It makes no physical sense to add temperatures together.

Other examples of intensive phys-ical properties include density, color, hardness, pressure, bond energy, and frequency of oscil-lation. Intensive physical proper-ties are typically bulk properties that do not change when the size, extent, amount, or mass of a sample changes. Intensive physical properties are typically measured as values or levels on an arbitrary scale such as Celsius, Fahrenheit, or Kelvin. These levels can be averaged but cannot be added together in any physically meaningful way.

Currently in climate science and in physics, heat is assumed to be a flux, a numeric amount of thermal energy passing through some surface in units of watts per square meter. Thus, heat is thought to be an extensive physical property that is additive. But this mathematical definition does not address the issues of what heat is physically and how heat physically flows. Planck's empirical law shows clearly, as discussed above, that heat, just like temperature, is the result of a broad spectrum of frequencies of oscillation that cannot be described by a single number. The physical properties of heat are described by the area between a Planck curve for the higher temperature and a Planck curve for the lower temperature (Figures 12c and 13). Heat is an intensive physical property. Heats from different sources cannot be added together in any physically meaningful way. Yet greenhouse-warming theory is founded on the idea that heat from different sources, known as radiative forcings, can be added and subtracted to determine a net amount of heat in watts per square meter.

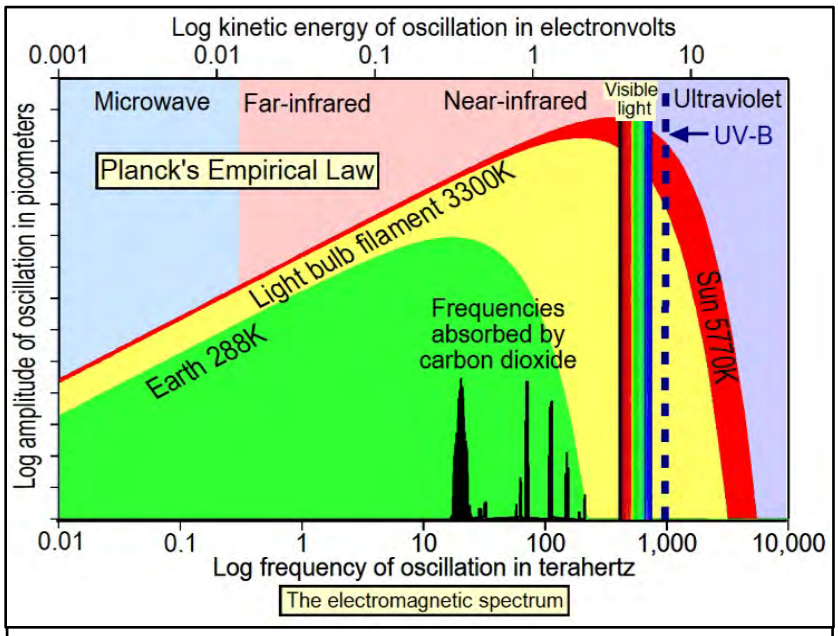
A common assumption in greenhouse-warming theory, first expressed clearly by Fourier in 1822, is that Earth becomes warmer when a lesser amount of heat is radiated back into space by Earth than is absorbed by Earth from Sun. But intensive physical properties are not additive. They do not exist in physical amounts. Heat simply does not flow in the manner assumed by greenhouse-warming theory.

The fundamental reason why greenhouse-warming theory is mistaken is that it is built on the mistaken assumption that heat is an extensive physical property that is additive.

(17) Greenhouse Gases Absorbing Terrestrial Infrared Radiation Cannot Explain Observed Warming

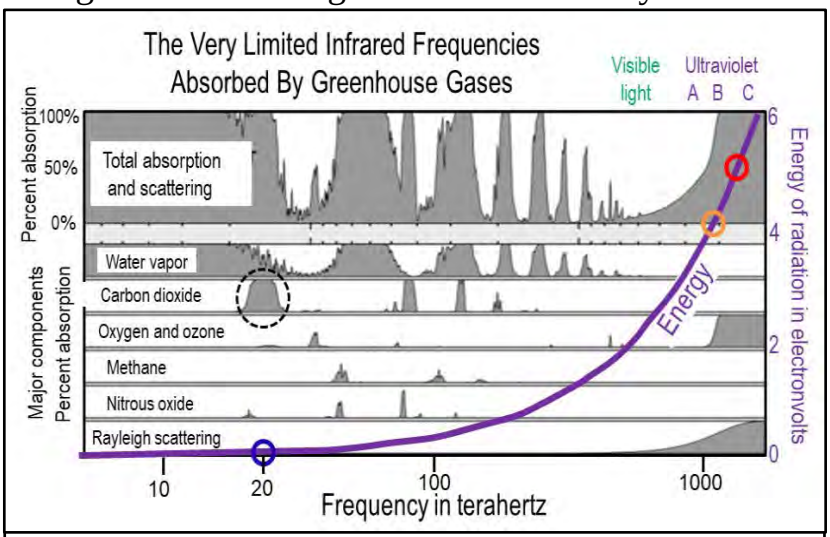
Greenhouse-warming theory is built on the assumption that because greenhouse gases are observed to absorb infrared radiation from Earth, they must get hotter. But there is no physical or chemical method known by which greenhouse gases absorbing infrared radiation could warm air (Figure 3). Infrared radiation from Earth simply does not have enough energy to dissociate greenhouse gases. The very limited number of frequencies absorbed are the resonant frequencies of the molecular bonds (Figures 17a, 17b, and 17c). These frequencies are absorbed into the bonds holding the molecule together. Some scientists argue that this energy is redistributed by collisions, increasing the velocity of some molecules, but such redistribution, if it occurs, has never been shown by experiment to have any significant effect on temperature of a gas.

Furthermore, no one has ever shown by experiment that greenhouse warming is physically possible. Ångström (1900) and Ward (2017) have done experiments that showed no detectable warming. Experiments reported on Internet, such as those done by Bill Nye the Science Guy, Maggie Aderin-Pocock, The Clean Climate Workshop (2011), or Mythbusters are flawed because they use heat lamps whose filaments have a temperature close to 5400°F (3000°C) rather than the average temperature of Earth's surface of 59°F (15°C) (Figures 12b, 13, and 17a). Many utilize glass jars, but infrared radiation does not have enough energy to penetrate through glass.



(17a) Less than 16% of the frequencies of oscillation emitted by Earth are absorbed by a molecule of carbon dioxide (black vertical lines).

Climate scientists assume that green-house-gas molecules re-emit absorbed radiant energy, causing warming or at least slowing the cooling of Earth. But a gas molecule can only re-emit the frequencies it absorbs. If these limited frequencies (Figures 17a, 17b, and 17c) were absorbed by solid matter, they would have no significant effect on temperature. Planck's empirical law (Figures 12c, 13 , and 17a) shows clearly that the only way to increase temperature of solid matter is by increasing the amplitudes of oscillation at each and every frequency of oscillation throughout the electromagnetic spectrum.



(17b) Greenhouse gases absorb only a small percentage of the frequencies of oscillation radiated by Earth. The thermal energies of these frequencies (purple line) are much lower than the energy of ultraviolet-B solar radiation shown by the orange circle. The infrared energy primarily absorbed (dashed black circle) is 50-times less energetic (blue circle) than the ultraviolet-B energy required to photo-dissociate ozone (orange circle) and 60-times less energetic than the ultraviolet-C energy required to photo-dissociate oxygen (red circle).

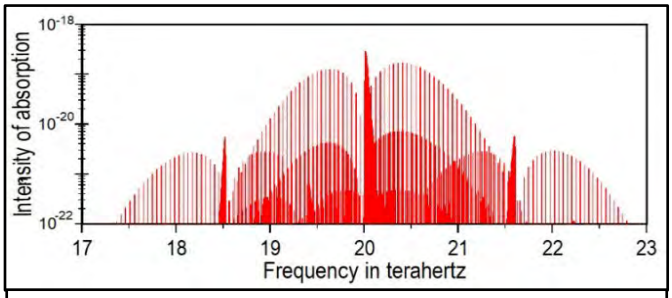
Greenhouse-warming theory is based on:

A) The assumption that heat is an extensive physical property measured and calculated as an amount of thermal energy flowing through some surface each second in units of watts per square meter (Thompson, 1798). But heat is a continuum of amplitudes of oscillation described by the area between the

Planck curve for the emitting body and the Planck curve for the absorbing body (Figures 12c, 13, and 17a). Heat and radiative forcings do not physically exist in units of watts per square meter.

B) The assumption that Earth will get warmer if it radiates a lesser amount of heat into space than it absorbs from Sun (Fourier, 1822). But heat and radiative forcings are intensive physical properties that are not additive as explained in Section 16.

C) The observation that molecules of water vapor and carbon dioxide absorb some infrared radiation (Tyndall, 1859). But Ångström (1900) and more detailed recent studies show that carbon dioxide, for example, absorbs less than 16% of the frequencies radiated by Earth (Figures 17a, 17b, and 17c) while Planck's empirical law shows that an increase in temperature of solid matter requires an increase in amplitude at 100% of the frequencies in the electromagnetic spectrum (Figures 12c, 13, and 17a).



(17c) Details of the spectral lines of absorption by a molecule of carbon dioxide for the dominant absorption band shown by the dashed black circle in Figure 15a.

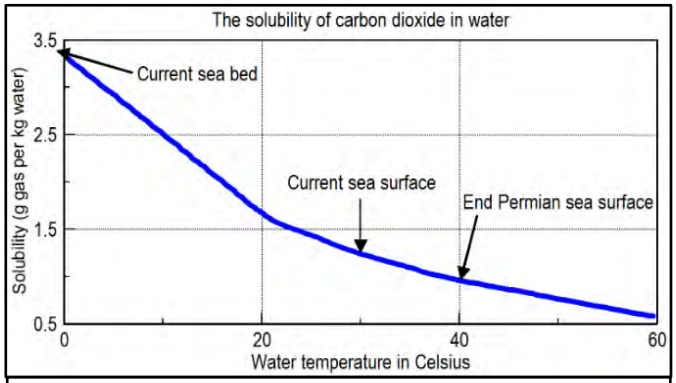
D) Measurements of how infrared radiation from the moon was absorbed by Earth's atmosphere (Langley, 1889). Yes, carbon dioxide absorbs some frequencies of infrared radiation.

E) Calculation that if the quantity of carbon dioxide increases in geometric progression, temperature will increase nearly in arithmetic progression (Arrhenius, 1896). But the physical process by which this could happen has never been clear.

F) The desire of Arrhenius (1896) to show that halving existing concentrations of carbon dioxide could explain 5°C cooling into an ice age (Crawford, 1997). Arrhenius spent 13 months, making numerous assumptions, just trying to come up with a numerical basis for this number. He knew the answer he wanted.

G) Observations that concentrations of carbon dioxide in the atmosphere have been increasing since the onset of the industrial revolution around 1750 and that atmospheric temperatures have also generally been increasing. But while concentrations of carbon dioxide have increased relatively steadily, changes in temperature trends vary considerably (Figure 2).

H) Observations that average air temperatures and atmospheric concentrations of carbon dioxide increase and decrease in phase during glacial cycles (IPCC, 1990). But this correlation can be explained by the well-known solubility of carbon dioxide in water (Figure 17d). The colder the ocean, the more carbon dioxide it absorbs from the atmosphere. Most detailed studies of these



(17d) The solubility of carbon dioxide in the oceans increases as the oceans get colder.

data show that air temperatures rise hundreds of years before concentrations of carbon dioxide rise as expected if the correlation is caused by solubility.

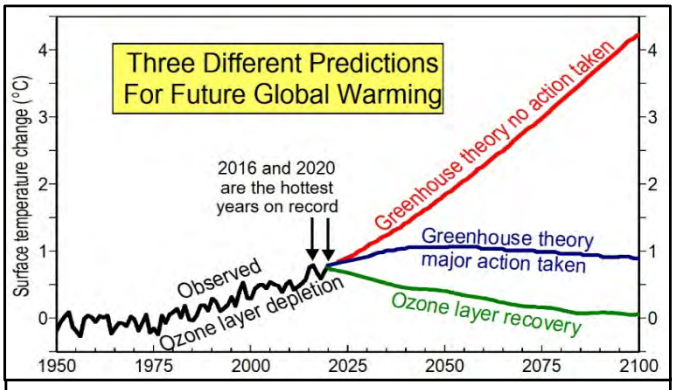
I) Calculations that without the greenhouse effect, Earth surface temperature would be approximately 59°F (33°C) cooler (IPCC, 1990). But as explained in Section 4, this warming is the result of solar ultraviolet-C radiation dissociating primarily oxygen molecules in the stratosphere. The top of the stratosphere is approximately 97°F (54°C) warmer than the temperature at the bottom of the stratosphere as shown in Figure 3.

J) Observation that carbon dioxide makes up 96.5% of the atmosphere of Venus and that temperature at the surface of Venus is 872°F (467°C) (IPCC, 1990). But this warming is explained much more clearly by solar ultraviolet-C radiation dissociating carbon dioxide.

K) One hundred distinct climate models produced by 49 different modelling groups based on past data, when properly tuned, appear to give reasonable answers for past climate and reasonable predictions for future climate. But all of these models are based on mistaken mathematical assumptions. Heat does not physically exist in amounts of watts per square meter, and heat is not calculated by integrating across spectral lines of absorption. Plus, even the modelmakers agree that current models are running implausibly hot.

L) The sensitivity of average global temperatures to a doubling in the concentration of carbon dioxide in the atmosphere is generally in the range of 3.2 to 10.1°F (1.8 to 5.6°C). But calculations of climate sensitivity are based on the assumption that greenhouse gases are the primary cause of observed warming. Ozone depletion appears to be the primary cause as discussed in Sections 6, 7, and 9 above.

It is physically impossible for observed increases in greenhouse-gas emissions to explain observed increases in average, global, surface temperatures. Therefore, reducing greenhouse-gas emissions will not reduce global temperatures. Major warming in future decades predicted by computer models based on greenhouse-warming theory (Figure 17e) can-not and will not happen. Greenhouse-warming theory is rapidly becoming the most expensive mistake ever made in the history of science economically, politically, and environmentally.



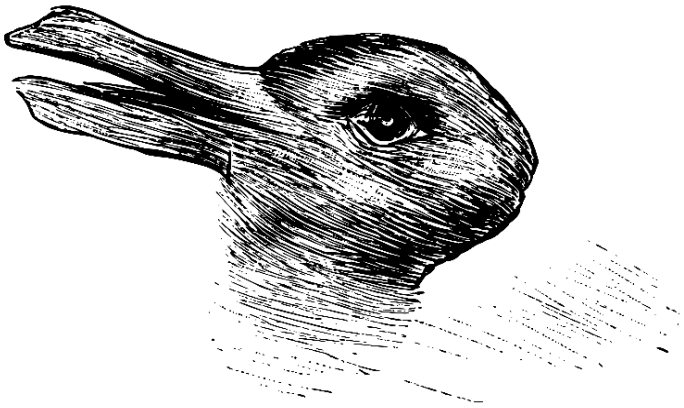
(17e) Warming predicted by computer models based on greenhouse-warming theory cannot and will not happen. Average global temperatures are expected to decrease slowly as the ozone layer recovers (green line). Warming associated with basaltic eruptions are possible but would rarely last more than a few years. (Red line is SSP5-8.5 in IPCC 2021. Navy line is SSP-1.9)

The very large scientific consensus developed to convince world leaders to spend the major resources required to reduce greenhouse-gas emissions, does not include any questioning of the physics of heat (IPCC, 2021). Not one of the tens of thousands of peer-reviewed papers supporting the climate consensus questions the physics of heat. Yet it is the physics of heat that determines how and by how much temperatures change.

The currently assumed physics of heat is mistaken, making greenhouse-warming theory mistaken. This conclusion is a tough pill to swallow for thousands of scientists who have dedicated their careers to studying greenhouse gases and have been deeply concerned about the major warming in future decades predicted by greenhouse-warming theory. Unfortunately, the longer these scientists refuse to recognize that greenhouse-warming theory is mistaken, the more trillions of dollars will be wasted trying to decrease greenhouse-gas emissions.

(18) We Are in the Midst of a Major Revolution in the Physics of Heat

Kuhn, in his widely-acclaimed book *The Structure of Scientific Revolutions (1962)*, now in its fourth edition (2012), describes how long periods of "normal science" involving problem solving guided by a specific conceptual paradigm are typically punctuated by sudden revolutions in conceptual thinking spawned by discovery of a new paradigm that explains observations much more clearly. According to Kuhn, "the transition between competing paradigms cannot be made a step at a time, forced by logic and neutral experience. Like the gestalt switch (Figure 18), it must occur all at once (though not necessarily in an instant) or not at all."



(18) Which do you see, a rabbit or a duck? This is a simple example of how a gestalt switch, a paradigm shift, could cause one to see precisely the same information in an entirely different way.

Scientists work within a culture and within a worldview dominated by paradigms. A paradigm, according to Kuhn, is a distinct set of ideas, concepts, theories, research methods, and standards for what constitutes a legitimate scientific contribution within a specific field of research. These paradigms are typically used to determine what is worth studying, what questions should be asked, what experiments should be carried out, how observations should be made, which methods should be utilized, and how interpretations should be formulated. As a paradigm becomes more widely accepted, it is typically used by individual scientists to decide which research works by others should be studied and which should be ignored. It is used by funding agencies to decide which research should be funded. It is used by journal editors to decide which papers should be rejected without review. There is little incentive within the culture of science to question a well-established paradigm.

As paradigms become more widely accepted, they tend to become more resistant to change. Increasing numbers of scientists do not see the need to question current paradigms. Unfortunately, humans tend to search for, interpret, favor, and recall information in a way that confirms or supports their prior beliefs or values, a behavior known as confirmation bias. Plus, humans have a reflex-like tendency to reject new evidence or new knowledge because it contradicts established norms, beliefs, or paradigms, a behavior known as the Semmelweis reflex. The broader the consensus among scientists, the more they tend to believe that a paradigm must be correct.

Greenhouse-warming theory has been the dominant paradigm for studies of global warming for more than two centuries. As we come to understand what heat is physically and how heat flows physically, however, it is remarkably clear, as explained above, that greenhouse-warming theory is based on mistaken assumptions about heat. There is no way known in physics or in photochemistry that greenhouse gases absorbing low-energy infrared radiation could have caused observed global warming.

According to Kuhn, "Probably, the single most prevalent claim advanced by the proponents of a new paradigm is that they can solve the problems that led the old one to a crisis." Ozone-depletion theory is a new paradigm that explains all observations of global warming much more clearly than greenhouse-warming theory. It is the only global-warming theory that has been shown by experiment to be physically possible (Figure 6a). As Kuhn explains, "The decision to reject one paradigm is always simultaneously the decision to accept another, and the judgment leading to that decision involves the comparison of both paradigms with nature and with each other."

Kuhn notes that "almost always the scientists who achieve these fundamental inventions of a new paradigm have been either very young or very new to the field whose paradigm they change." They typically stumble on an anomaly, an exception, that causes them to question prevailing wisdom. Without a life-long commitment to the prevailing paradigm, they can be much more objective and creative when thinking about possible ways to explain the anomaly. As Linus Pauling said, "The best way to have a good idea is to have lots of ideas."

(19) An Anomaly: How Can Volcanic Eruptions Cause Both Global Cooling and Global Warming?

In 2006, while thinking about something totally unrelated to climate, I stumbled on data on the Internet measured in the GISP2 ice cores drilled under Summit Greenland (Figure 9c). These data strongly imply that the warming at the end of the last ice age was caused by volcanism. I have studied volcanoes all my life, climbing my first active volcano at age 19. All volcanologists know that major explosive volcanic eruptions form aerosols in the lower stratosphere that reflect and scatter sunlight causing global cooling of about 0.9°F (0.5°C) for 2 to 4 years depending on the size of the eruption (Section 8). How can volcanic eruptions cause both cooling and warming?

The more I investigated this anomaly, the more I realized that solving this problem could be extremely important. Being retired and self-funded, I have been able to work fulltime since 2006, with minimal distraction, just following my insatiable curiosity wherever it led. My only responsibilities have been to myself, to do the very best science I can and to question regularly whether I was still in touch with physical reality. The fun empowering this quest has been making many new discoveries. The reality guiding this quest has been that most of these new discoveries have shown that my previous discoveries were not quite right. It has taken years of laser-focused work to check out all the possibilities and to put all the pieces together. I do not think I could have done what I have done while still employed. There were just too many distractions at the office, commuting to the office, and raising a family.

Being primarily an earth scientist with many years of practical experience in the field, I have been guided by one fervent belief: physics is about what is physically happening in the world around us. Any assumptions, theories, or equations in physics that are not physically intuitive are, therefore, suspect. We may need to improve our physical intuition, but in the end, if a process is not physically intuitive, it most likely is not physically happening in Nature. On the other hand, just because a proposed process is physically intuitive does not prove that it describes what is physically happening. I also believe that the closest things to truth in science are direct observations of what is physically happening in the world around us—fundamental observations that do not depend on some paradigm to be conceived, carried out, analyzed, and understood. All conclusions discussed in this document are based on clear observations of things happening in Nature.

(20) A Most Unconventional Truth: The Physics is Remarkably Clear

In summary, regarding the science, greenhouse-warming theory is based on mathematical assumptions about what heat is physically and how heat flows that have no basis in physical reality. Heat does not physically exist as amounts of watts per square meter that are additive, as has been assumed for more than 200 years. Temperature of solid matter is the result of a very broad spectrum of frequencies of oscillation of all the bonds holding matter together. Planck's empirical law, when corrected, calculates the amplitude of oscillation at each frequency of oscillation as a function of temperature. Amplitudes of oscillation flow from a warmer body to a cooler body by resonance simultaneously at each and every frequency of oscillation. There is no physical process known in physics or in photo-chemistry by which greenhouse gases absorbing low-energy infrared radiation could have caused observed global warming. The science behind these most unexpected conclusions is so remarkably clear and unambiguous that we can posit with some confidence that anyone disagreeing is not well informed.

Ozone-depletion theory, on the other hand, allowing more high-energy solar ultraviolet-B radiation to reach Earth, explains observed global warming in considerable detail, throughout Earth history. Ultraviolet-B radiation warms air in the troposphere primarily by photo-dissociating ground-level ozone pollution (Figure 7b). Dissociation is a well-known and well-understood photo-chemical process A decrease in total column ozone by approximately 5% (16 Dobson units) is observed to cause warming on the order of 1.1°F (0.6°C) at mid latitudes in the northern hemisphere (Ward, 2016).

Annual average global temperatures rose 1.1°F (0.6°C) from 1970 to 1998. This warming was initiated by humans manufacturing chlorofluorocarbon gases (CFCs) that were shown in 1974 to deplete the ozone layer by releasing atoms of chlorine when broken down in the stratosphere by solar ultraviolet radiation. This warming stopped increasing in 1998 after passage of the United Nations Montreal Protocol on Substances that Deplete the Ozone Layer mandated major reductions in the production of CFCs beginning in 1989. Observed ozone depletion and related temperatures are expected to continue for many decades as CFCs in the atmosphere are slowly consumed, allowing the ozone layer and world temperatures to return towards pre-1970 levels.

Annual average global temperatures rose an additional 0.5°F (0.3°C) during 2014 to 2016, making 2016 the hottest year on record. This sudden warming was caused by depletion of the ozone layer resulting from emissions of chlorine and bromine gases from the six-month eruption of Bárðarbunga volcano in central Iceland, the largest eruption of basaltic lavas since 1785. Normally such warming would return to pre-eruption levels within five years, but a smaller eruption along the East Rift Zone of Kilauea volcano in Hawaii caused 2020 to tie for the warmest year on record. Much smaller basaltic eruptions during 2021 in Iceland, the Canary Islands, and Hawaii will most likely slow the return to pre-2014 levels.

Ultraviolet-B also penetrates water to depths of at least 10 yards or meters increasing ocean heat content as observed (Figure 1) and sunburning coral reefs and plankton.

Major warming in future decades predicted to occur by computer models based on greenhouse-warming theory cannot and will not happen. Annual average global temperatures are expected to decrease slowly throughout the rest of this century as the ozone layer recovers (Figure 17e). We can burn fossil fuels safely provided we minimize pollution.

The science behind these most unexpected conclusions is so remarkably clear and unambiguous that we can assume with some confidence that anyone disagreeing is not well informed. None of the tens of thousands of peer-reviewed, scientific papers supporting the current climate consensus regarding greenhouse gases question the physics of global warming even though it is the physical processes that determine temperatures.

(21) The Well-Intentioned Political Decision to Demonstrate Global Consensus Behind Greenhouse-Warming Theory Has Shut Down Debate, the Stuff of Science

The Intergovernmental Panel on Climate Change (IPCC) was not formed to determine the cause of global warming. It was formed to expand the Advisory Group on Greenhouse Gases. It was formed to build international consensus behind greenhouse-warming theory in order to convince world leaders to take action to reduce greenhouse-gas emissions. This strategy paid off when nearly all world leaders agreed in Paris on 12 December 2015 to work together to reduce greenhouse-gas emissions.

(20) World leaders agreed in Paris on 12 December 2015 to work together to reduce greenhouse-gas emissions to reduce the risk of major warming in future decades. But greenhouse-warming theory is turning out to be mistaken.

The IPCC was not fertile ground for considering new ideas. As Planck noted 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." Science is done by debate. Revolutionary science is not done by committee. Revolutionary science is not done by consensus. As Michael Crichton said in 2003, "In science consensus is irrelevant. What is relevant is reproducible results. The greatest scientists in history are great precisely because they broke with the consensus. There is no such thing as consensus science. If it's consensus, it isn't science. If it's science, it isn't consensus. Period."

Plus, the climate-science community has not been fertile ground for considering new ideas. The problem is that scientists, defending their consensus, refuse to consider any evidence to the contrary. All major conclusions discussed in this report have been known since 2015. I have gone to unusual lengths to try to get my fellow scientists to understand.

In 2015, I wrote a book *What Really Causes Global Warming? Greenhouse Gases or Ozone Depletion* and sent free copies to hundreds of leading climate scientists and political leaders.

I reached out to more than 2000 top climate scientists by email and in a video with an urgent plea to consider the cracks appearing in the foundations of greenhouse-warming theory.

I challenged by email more than 8,000 leaders in science, politics, and the energy business, 5000 reporters, and nearly 18,000 others concerned with climate change to find any significant error on the single web page Physically-Impossible.com that could change my fundamental conclusions that greenhouse-warming theory is physically impossible.

I interacted with thousands of scientists at a booth in the exhibit halls of four major scientific meetings most years since 2015.

I "offered $10,000 of my children's inheritance to the first person or team of people who can demonstrate through direct measurements in the laboratory and/or in the field 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%."

I did many experiments that show no detectable warming.

I wrote numerous scientific papers, most of which have been rejected without review because they questioned greenhouse-warming theory.

I wrote a detailed, fully-referenced website OzoneDepletionTheory.info to help curious scientists access and understand the details. I wrote a major website and produced more than two dozen videos to help curious people understand WhyClimateChanges.com. These are attracting dozens of users per day.

I interacted regularly with several scientists who have been lead authors for the major National Climate Assessments or IPCC Reports.

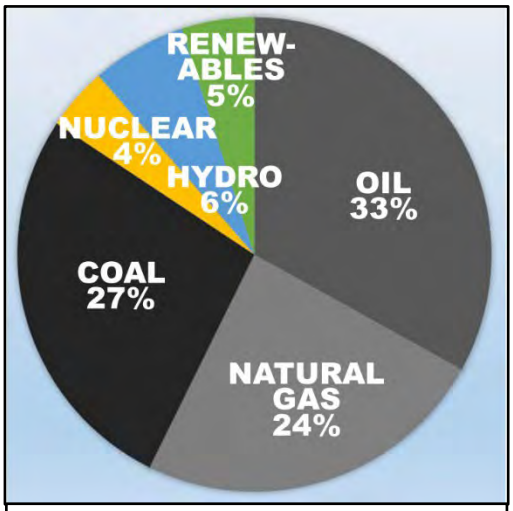
None of these thousands of scientists have provided any constructive criticism of what I have written or any evidence that I might be wrong. They simply refuse to engage in debate, the stuff

of science. The most common response is “Peter, there is no way that you can be right and all the rest of us are wrong!”

Most actively publishing climate scientists genuinely believe, based on the science as they understand it, that increasing emissions of greenhouse gases are causing observed warming and that the warming predicted during the rest of this century poses an existential threat to life on Earth. They are relieved that world leaders agreed in Paris in 2015 to work together to reduce greenhouse-gas emissions. They do not want anyone to slow or impede progress. Many climate zealots, armed with “The Climate Consensus” are promoting cancel culture to ostracize those who do not agree. Even Facebook will not allow any user to enter the URL of my scientific website WhyClimateChanges.com.

(22) Meanwhile, Greenhouse-Warming Theory Is Becoming the Most Expensive Mistake Ever Made in the History of Science

Greenhouse-warming theory is clearly mistaken as explained above. Any money spent reducing greenhouse-gas emissions in order to reduce global warming will be wasted.



(22) Primary global energy consumption in 2019.

Our economies, our standards of living, our qualities of life, and our health have all improved rapidly over the last century because of ample, relatively inexpensive, fossil-fuel energy that still in 2019, provides 84% of primary global energy consumption. Increasing the cost of energy by even a small amount will have major economic effects, many of which are regressive.

Raising the cost of energy in the United States and other developed countries while China plans to build hundreds of new coalfired power stations will handicap these countries significantly in world trade, in developing new technologies, and in improving global security. The rush to renewable energy has already raised energy costs substantially in Europe and elsewhere.

The demand and subsidies for renewable power generation have driven down costs so that new renewable power generation projects are increasingly undercutting existing coal-fired plants. But it is not clear that the raw materials required to substantially expand harvesting of wind and solar power and provide battery backup are available. Difficulties with supply increases costs and have geopolitical implications. All sources of energy are going to be important for quite a while, as the blend changes driven by market conditions and by scientific and engineering knowledge.

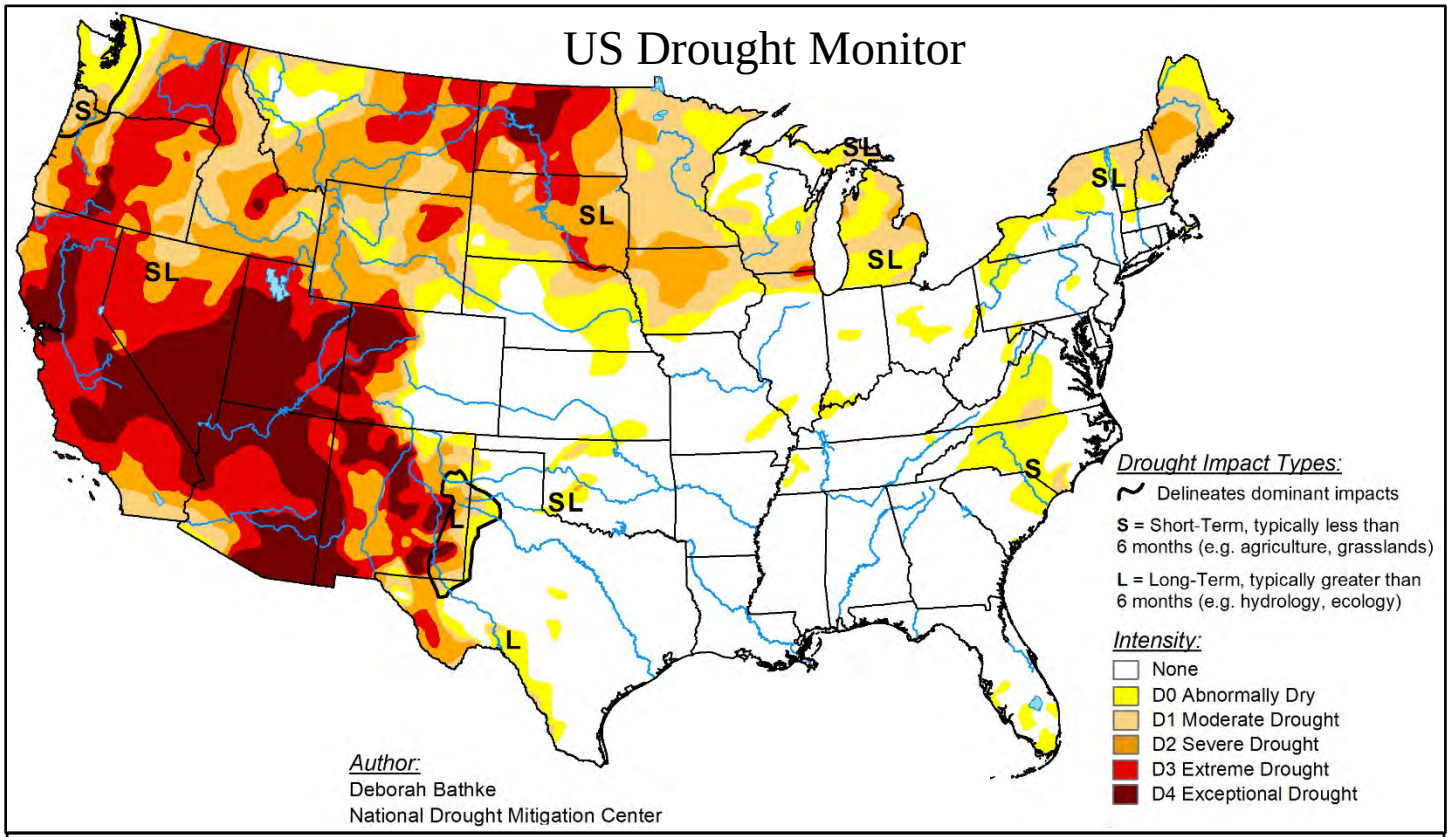
We are also wasting money in the courts. As of 1 July 2020, at least 1,550 cases of climate change litigation have been filed in 38 countries. There is now no scientific basis for any of these cases that are based on greenhouse-warming theory.

The political costs of greenhouse-warming theory have been substantial. Disagreement between liberals, who predominantly believe in the importance of science for informing sound public policy and libertarians and conservatives, who predominantly want to minimize government in their lives irrespective of what the science says, has led to little rational basis for discussion, deep polarization, personal attacks, political games, and very close elections often lost in many countries by those believing in the importance of science. The sooner we can agree that greenhouse-warming theory is mistaken and that two-thirds of the warming since 1950 was caused by humans manufacturing CFCs, the sooner we can come together to refocus our resources on adapting to climate reality and seeking ways to help the ozone layer recover. Now is a time for humility.

(23) Speeding Recovery of the Ozone Layer Needs to Become a National Scientific Priority

Since 2000, the southwestern United States has suffered one of the largest and longest droughts in 1200 years (Figure 23a), rivaled only by a major drought in the 1500s. Water levels in Lake Mead and Lake Powell, the two largest reservoirs in the country that supply water to 40 million people, 12% of U.S. population, are at the lowest levels seen since the Hoover dam was built in 1936 and the Glen Canyon dam was built in1966.

Preliminary studies show that the Dust Bowl droughts of the early 1930s were contemporaneous with ozone depletion caused by a highly unusual sequence of seven moderate volcanic eruptions



(23a) United States Drought Monitor map for June 29, 2021. This map focuses on broad-scale conditions.

around the Pacific Ocean (Page 136 in Ward 2016). If the 21-year long current drought is the result of contemporaneous ozone depletion, which it appears to be, then it is highly likely to last at least 40 more years while the ozone layer recovers (Figure 23b), creating the greatest environmental disaster in United States history.

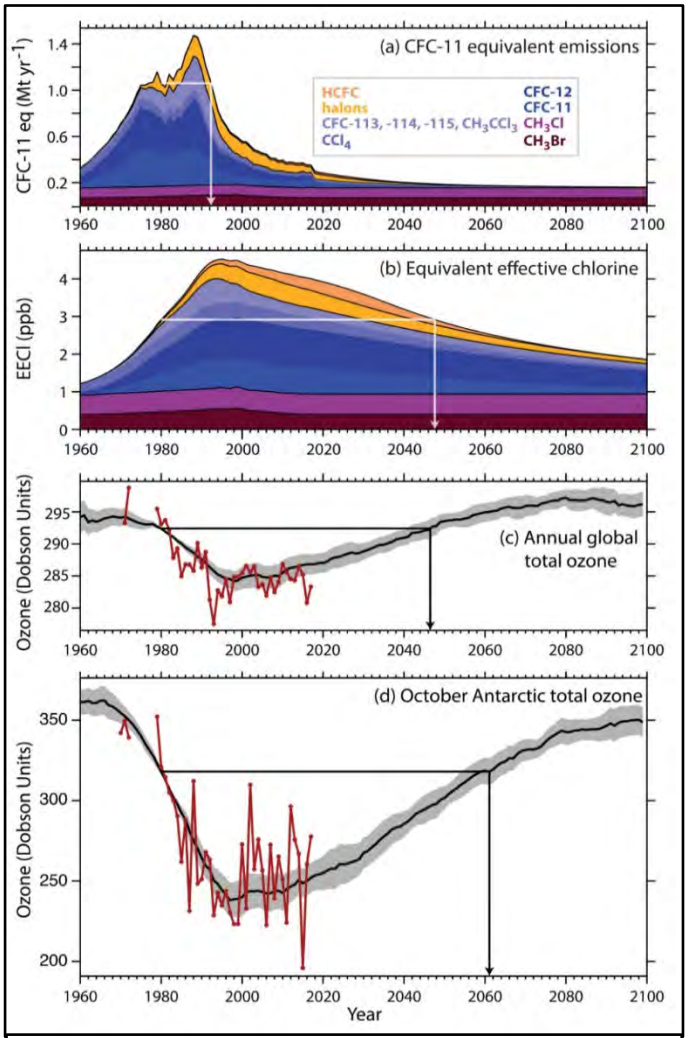
This reality suggests that finding ways to speed recovery of the ozone layer should become a national priority. We have many options:

A) Enforce the Montreal Protocol. In 2018, scientists measured atmospheric concentrations of CFC-11 in eastern China that suggested a major increase since 2012. The Environmental Investigation Agency traced the source to at least 18 factories producing polyol blend rigid foam used widely for insulation of buildings. The manufacturers admitted that they knew CFC use was illegal, but it was cost effective, and it was utilized by all their competitors. After this illegal manufacturing attracted international attention, the Chinese government has improved enforcement of the Montreal Protocol.

B) Shutdown the thriving black market for CFCs legally manufactured in developing countries but illegally diverted to developed countries for maintenance of existing equipment.

C) Ensure that CFCs in old refrigerators and air conditioners are disposed of properly. This is especially a problem in the developing world. It might be advantageous to donate new cooling equipment and decommission old cooling equipment throughout the developing world.

D) Research ways to remove CFCs from the atmosphere.



(23b) Timeline of ozone depleting substances and ozone observed from 1960 to 2017 and projected to 2100. From: Scientific Assessment of Ozone Depletion: 2018.

E) Research ways to impede the breakdown of CFCs by solar ultraviolet radiation releasing atoms of chlorine.

F) Research ways to reduce the destruction of ozone molecules by atoms of chlorine and bromine through heterogeneous chemical processes especially in the vicinity of polar stratospheric clouds and volcanic aerosols.

G) Research ways to produce more oxygen atoms in the ozone layer in a way that would lead to increased production of ozone molecules during late winter in polar regions.

H) Research what causes the peaks in ozone during the year of a major volcanic eruption and why maximum ozone depletion occurs in the second winter following major eruptions?

Another way to reduce the warming especially in densely populated areas is to substantially reduce ground-level ozone pollution so that more solar ultraviolet-B radiation is absorbed at Earth's surface, having much less effect on air temperatures. Reducing ozone pollution is already a high priority for the Environmental Protection Agency (EPA). Ozone pollution is the main ingredient in "smog." It is formed primarily by chemical reactions, driven by sunlight, between oxides of nitrogen and volatile organic compounds emitted primarily by cars, power plants, industrial boilers, refineries, and chemical plants. Breathing ground-level ozone can reduce lung function and inflame the lining of the lungs. It can worsen bronchitis, emphysema, and asthma. Worldwide, ozone is responsible for several hundreds of thousands of premature deaths and tens of millions of asthma-related emergency room visits annually." Ground-level ozone also damages vegetation, reducing crop yields and increasing susceptibility to diseases, pests, and harsh weather.

Every day, about 12% of ozone in the ozone layer (Figures 3 and 4) is being destroyed and then reproduced in the ozone-oxygen cycle, a very dynamic process that varies substantially by the minute, by the hour, by the season, by latitude, and with volcanic eruptions. Wherever there is ozone, the surrounding air is warmer. According to Reed (1950), Dobson and others from their earliest studies of ozone in the 1920s, noted that ozone concentrations have a direct relationship with weather. "Maximum positive deviations of daily [ozone] values from the 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." There is also tantalizing evidence of a relationship between ozone distribution and major ocean current oscillations such as the El Niño–Southern Oscillation and the North Atlantic Oscillation.

We are in an excellent position to make important advances regarding ozone because there is a robust ozone research community that has converged around the Montreal Protocol. Regular observations of ozone are being made from space, primarily by NASA and ESA, from balloons, and from earth. Global ozone observations are summarized in daily global maps. Reports by Assessment Panels under the United Nations Ozone Secretariat are being produced regularly, including Scientific Assessment Reports. Much research is underway by region, for example this work in China.

The Montreal Protocol has been remarkably effective in phasing out production of CFCs, replacing them with hydrofluorocarbons (HFCs). But then the scientists involved became concerned that HFCs are powerful greenhouse gases. This led to the Kigali Amendment committing countries to phase out use of HFCs. This amendment has been ratified by 125 countries and the European Union, but not by the United States. The Kigali Amendment is no longer relevant because greenhouse gases cannot cause warming as explained above.

(24) A Critical Moment of Truth for Scientists and for Scientific Leadership

On 9 August 2021, the United Nations Intergovernmental Panel on Climate Change (IPCC) released its 4000-page sixth assessment report on the physical basis for climate change based on greenhouse-warming theory. This authoritative report concludes "It is *very likely* [90-100%] that well-mixed greenhouse gases were the main driver of tropospheric warming since 1979." "Global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered. Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades."

United Nations Secretary-General António Guterres, called this report nothing less than "a code red for humanity. The alarm bells are deafening, and the evidence is irrefutable." He noted that the internationally-agreed threshold of 1.5 degrees above pre-industrial levels of global heating is "perilously close. We are at imminent risk of hitting 1.5 degrees in the near term. The only way to prevent exceeding this threshold, is by urgently stepping up our efforts, and pursuing the most ambitious path. We must act decisively now, to keep 1.5 alive."

World leaders are meeting in Glasgow Scotland from 31 October to 12 November 2021, for the 26th Conference of the Parties (COP26) under the United Nations Framework Convention on Climate Change (UNFCCC). The primary goal of COP26 is for all countries to come forward with more ambitious targets for reducing greenhouse-gas emissions by 2030. John Kerry, U.S. Special Presidential Envy for Climate, thinks the world is poised to make a big leap forward at the UN COP26 climate summit, with world leaders "sharpening their pencils" to make fresh commitments that could put the goals of the 2015 Paris agreement within reach.

The Environmental Protection Agency (EPA) is preparing to issue "a robust greenhouse gas rule for power plants, a stringent methane rule for oil and gas infrastructure, and sweeping emissions standards for new cars." "Ultimately, experts say Biden will need to show up to a United Nations climate summit in Glasgow, Scotland, next month with demonstrable progress toward his emission reduction targets."

On January 27, 2021, President Biden issued a Memorandum on Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policymaking stating "It is the policy of my Administration to make evidence-based decisions guided by the best available science and data. Scientific and technological information, data, and evidence are central to the development and iterative improvement of sound policies, and to the delivery of equitable programs, across every area of government."

But President Biden and other world leaders are not getting the best available science and data because climate scientists refuse to consider the overwhelming evidence that greenhouse-warming theory is mistaken. Greenhouse-warming theory is based on mathematical assumptions about what heat is physically and how heat flows that have no basis in physical reality. Heat does not exist as amounts of watts per square meter that are additive, as assumed throughout the IPCC reports.

We are in the midst of a scientific revolution in our understanding of what heat is and how heat flows. Such revolutions are not unusual according to Kuhn's widely-acclaimed book *The Structure of Scientific Revolutions (1962)*, but it often takes years to decades for revolutionary ideas in science to become widely accepted. We do not have the time. The greenhouse-warming freight train has been gaining speed and momentum for decades and is currently running at full throttle. The scientific establishment is arguing more and more stridently that we must reduce greenhouse-gas emissions immediately. Many members of cancel culture are seeking to ostracize anyone who does not agree with the party line.

Meanwhile, China is rethinking its path to climate goals due to an energy crisis. Europe, gripped by energy crisis, is considering turning to breaking climate promises and turning to coal. Australia wants a 'pause button' for its global climate change commitments.

Reality will eventually prevail. The primary questions are how long will it take, how much money and political capital will be wasted, and how much damage will be done to the public's trust in science?

More important, are scientists going to provide leadership
to help the world through this scientific crisis that they unintentionally created?

In this document, I have laid out, in a manner that I hope can be understood by most intelligent people, remarkably clear and unambiguous evidence that greenhouse-warming theory is mistaken and that ozone-depletion theory explains observations of global warming throughout Earth history in considerable detail. These two conclusions can be considered in IPCC terms as virtually certain (99-100%), although science is never settled.

It is time for world leaders to ask the IPCC to prove Ward wrong. It is time for national political leaders to ask the President's Science Advisor to convene urgently a group through the President's Science Advisory Committee (PSAC), the U.S. Global Change Program, or the National Academy of Sciences to prove Ward wrong. It is time for all of us to ask climate scientists to either prove Ward wrong or stop insisting that we must reduce greenhouse-gas emissions right now.

(25) More Information

A TEDx talk *Volcanoes: A Forge For Climate Change*

A 14-minute video *A most unexpected revolution in the physics of heat*

Sixteen short videos explaining why greenhouse-warming theory is becoming the most expensive mistake ever made in the history of science.

Scientific talks by Peter L. Ward about climate change

The photochemistry of gas molecules in earth's atmosphere determines the structure of the atmosphere and the average temperature at earth's surface, Peter Langdon Ward, 2020, American Journal of Physical Chemistry, 9(3), Pages 62-85, 10.11648/j.ajpc.20200903.13.

Ozone depletion explains global warming, Peter Langdon Ward, 2016, Current Physical Chemistry, 2016, 6(4), Pages 275-296. 10.2174/1877946806999160629080145.

What really causes global warming? Greenhouse gases or ozone depletion? Peter Langdon Ward, 2016, Morgan James Publishing, 237 pages, WhyClimateChanges.com/the-book, amazon.com/-What-Really-Causes-Global-Warming/dp/1630477982.

All papers and abstracts including those rejected without review with the Editor's comments are available at OzoneDepletion-Theory.info/publications-ozone-depletion/.

Primary Websites: WhyClimateChanges.com, OzoneDepletionTheory.info, JustProveCO2.com.