The Crisis in Climate Science

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My fellow scientists are ignoring provocative new data showing that average global temperatures will cool gradually over future decades. We can burn fossil fuels safely provided we minimize pollution.

Average global temperatures have risen nearly one degree Celsius since 1950 as shown by the black line in Figure 1. Most climate scientists are convinced that this warming is caused primarily by increasing emissions of greenhouse gases due to increased burning of fossil fuels. Many teams of climate scientists have developed sophisticated computer models based on greenhouse-warming theory and have tuned these models to fit observed warming. These models predict average global temperatures are highly likely to increase several more degrees by 2100, as shown by the red line, unless significant action is taken to reduce fossil-fuel use, shown by the blue line. In addition, many climate scientists are convinced that there is a growing threat of reaching climate tipping points that could lead to abrupt and irreversible warming. They argue that greenhouse-gas emissions must be reduced immediately.

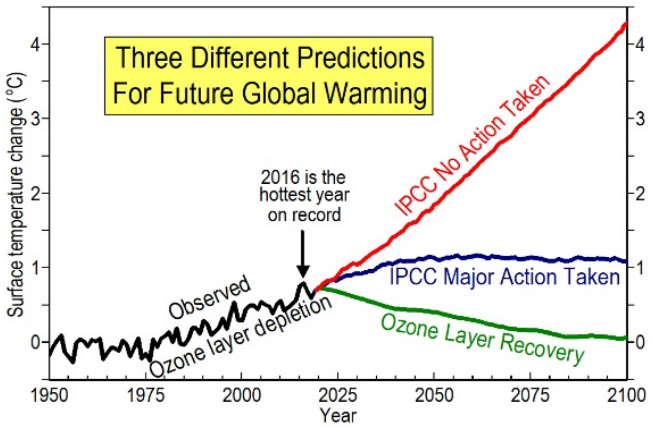

Figure 1: Average global temperatures rose nearly one degree since 1950 (black line). Climate models compiled by the Intergovernmental Panel on Climate Change (IPCC) predict several degrees of warming by 2100 (red line). They predict that if major action is taken immediately to reduce greenhouse-gas emissions, warming might be kept to only one additional degree (blue line). Ozone depletion theory, on the other hand, can explain observed warming in detail and predicts gradual cooling of climate over the next several decades unless there is an unexpected major new source of ozone depletion (green line).

Because of this predicted warming, the United Nations established the Intergovernmental Panel on Climate Change (IPCC) in 1988. The primary procedure specified for the IPCC was "to use all best endeavors to reach consensus." The impressive depth and breadth of the consensus developed by the IPCC made it possible for world leaders to agree in Paris on 12 December 2015 "that climate

change represents an urgent and potentially irreversible threat to human societies and the planet." World leaders agreed to work together to hold "the increase in the average global temperatures to well below two degrees Celsius."

The scope and cost of the action required to reduce greenhouse-gas emissions sufficiently are not well quantified, but most estimates involve spending trillions to tens of trillions of dollars over many years, a significant proportion of world gross domestic product, which currently is 81 trillion dollars each year. Some argue that these costs are small compared to the costs of dealing with a much warmer world.

But science is not done by consensus. Science is not done by popular vote. Science is always subject to improvement. Science is never settled. It is now becoming clear that the crisis we all face is not in climate—the crisis is in climate science, the unwillingness of leading climate scientists to seriously consider the possibility that greenhouse-warming theory might be mistaken.

Science advances by collection of new data, providing new detail, and by development of new insights explaining old data more accurately. The greatest revolutions in scientific thinking typically involve a fundamental change in paradigm—a new way of thinking about "well-established" ideas. It now appears that the physics of greenhouse-warming theory is mistaken, and that global temperature changes shown by the black line in Figure 1 are explained in far greater detail and with greater accuracy by ozone-depletion theory.

For example, greenhouse-warming theory cannot explain the details of recent warming. All major analyses of global temperature data show essentially no global warming from 1950 to 1970, warming of 0.6°C (1.1°F) from 1970 to 1998, essentially no global warming from 1998 through 2013, very rapid warming of 0.3°C (0.5°F) from 2014 through 2016, and no warming since. Meanwhile concentrations of carbon dioxide and other greenhouse gases continue to rise at ever increasing rates, showing no relationship to sudden changes in rates of warming observed around 1970, 1998, 2014, and 2016. Computerized climate models have typically been predicting warmer temperatures than observed, especially during the well-known global warming hiatus from 1998 through 2013 when global temperatures changed very little.

Meanwhile, the ozone layer, 15 to 35 kilometers (9 to 22 miles) above Earth, was depleted as much as 70% due to production of chlorofluorocarbon gases (CFCs) from 1970 to 1998 and by the largest basaltic lava eruption since 1783 that caused increasing ozone depletion between 2014 and 2016. Throughout Earth history, major flows of basaltic lava have been contemporaneous with periods of major warming—the larger the lava flow, the greater the associated warming.

Global temperatures are determined by the physics of how thermal radiation is converted into air temperature. Yet the modern, extensive consensus organized by the IPCC and supported by tens of thousands of peer-reviewed papers, does not include a single paper seriously questioning the basic physics of greenhouse gases. How is current thinking about the physics of global warming mistaken?

Flux of heat: Greenhouse-warming theory was first quantified by Svante Arrhenius in 1896 based on a theory of heat first described by Benjamin Thompson in 1798, long before scientists understood the atomic and molecular nature of matter. Thompson defined heat as a flux, an amount of thermal energy flowing each second through a surface. He assumed the greater the net amount of thermal energy flowing into a body of matter per second, the greater the body's temperature would become. In 1822, Joseph Fourier described the assumption that Earth would become hotter if it did not lose to space an amount of heat per second as great as the amount of heat per second Earth absorbed from Sun. Both of these assumptions regarding flux and balance of amounts of thermal energy seem reasonable. Most climate scientists today believe they are correct. These assumptions form the foundation of greenhouse-warming theory. But both turn out to be mistaken. That is simply not the way heat is observed to flow.

Defining heat as a flux, which is an amount of thermal energy flowing per second, sidesteps the question of what heat is physically. What physically is flowing? What physically is happening inside a body of matter that gives that body a physical property that we measure as temperature? What physically must be absorbed by that body for it to become warmer? What physically must be lost by that body for it to become cooler?

Oscillation of all the bonds: Today, physicists understand that temperature of matter is caused by physical oscillation of all the bonds holding matter together. These bonds are not rigid. They are observed to oscillate at frequencies measured in terahertz, trillions of cycles per second (10^{12} hertz), and with amplitudes of oscillation measured in picometers (10^{-12} meters).

In 1900, Max Planck showed that the frequencies of oscillation of all these individual bonds form a very broad spectrum of frequencies known as the electromagnetic spectrum. He showed that the most intense frequencies are determined by the temperature of the radiating body. Most importantly, he showed that as the temperature of matter increases, the amplitude of oscillation at each and every frequency of oscillation increases. Thus, what is physically being transferred simultaneously as heat is actually amplitude of oscillation at each and every frequency of oscillation.

We observe that amplitude of oscillation is physically being transferred by resonance, a fundamental property of oscillating systems. When two oscillators oscillating at the same frequency are within line-of-sight or physically connected in some way, the oscillator with the greatest amplitude of oscillation is observed to share amplitude with the oscillator with the least amplitude of oscillation. In the simplest case, both oscillators end up with the same amplitude of oscillation. Their amplitudes are averaged.

In this way, the physical properties of matter that change with temperature are determined at the sub-microscopic level. You can subdivide a body of matter into numerous pieces of different sizes and each piece will initially have the identical temperature. Temperature is not a function of amount of matter. There is no such physical thing as an amount of temperature. Temperature that we perceive and measure is the result of a level of thermal energy, not an amount of thermal energy as currently assumed. Plus, temperatures are not additive. They are averaged. If you connect together thermally two bodies that are identical in every way except for temperature, the resulting temperature will be the average of their initial temperatures, not the sum. Averaging temperature is done in Nature by resonance.

All curves plotting temperature as a function of time, approach their final temperature asymptotically, which means at a slower and slower rate. These curves show unequivocally that flux of heat is a function of difference in temperature. Heat flows very quickly when there is a large difference in temperature. At zero difference in temperature, there is no flow of heat—flux equals zero. Flux is proportional to the difference between of the current temperature and the final temperature. This difference is determined in Nature by resonance.

We also observe clearly that the temperature of the body absorbing radiation can never become hotter than the temperature of the body emitting the radiation. This means that a body of matter cannot be heated by absorbing even large amounts of its own radiation. Yet greenhouse warming theory assumes that, in one way or another, radiation from Earth, absorbed by greenhouse gases, causes Earth's surface to get warmer. Heat cannot physically flow from a colder atmosphere to a hotter Earth's surface. You cannot get warm standing next to a cold stove.

So how is air warmed? We only know of three physical choices: conduction, photo-dissociation, and photo-ionization, where photo means physical and chemical reactions caused by absorbing high-frequency, high-energy, electromagnetic radiation.

Conduction: Every day from sunrise to sunset, Earth's surface is heated by absorbing solar radiation. Air touching Earth's surface is then heated by conduction—much like air above a hot frypan. This warmer air rises by convection,

carrying heat upwards and away from Earth's surface. Sunshine is most intense in the tropics and least intense at the poles. The amount of warming varies widely as a function of such things as latitude, time of day, location, proximity to large bodies of water, the thermal properties of surface materials, humidity, the nature and extent of clouds and precipitation, and ocean and atmospheric currents.

The lowest layer of Earth's atmosphere, the troposphere (Figure 2), is thus heated quite irregularly from below so that it is dominated by convection and turbulence, containing almost all weather. Temperature decreases with increasing altitude at an average rate of about 6.5°C per kilometer (19°F per mile). The top of the troposphere, the tropopause, is on average around 17 kilometers (11 miles) above equatorial regions and about 9 kilometers (5.6 miles) above polar regions. The tropopause is the fundamental boundary between the troposphere, heated very irregularly from below by a sun-warmed Earth, and the stratosphere, heated very evenly from above by solar radiation.

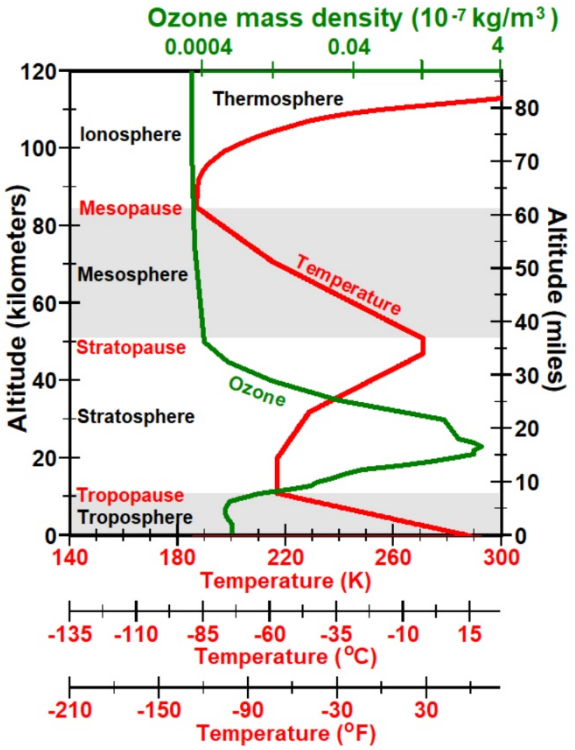

Figure 2: Average temperature and mid-latitude ozone concentration of Earth's atmosphere based on the U. S. Standard Atmosphere (1976). Temperatures are shown in degrees Kelvin, Celsius, and Fahrenheit.

Photo-dissociation: Every day from sunrise to sunset, Earth's stratosphere is heated by photo-dissociation. When a molecule of oxygen (O_2) absorbs solar ultraviolet-C radiation with frequencies around 1237 terahertz, the molecule is observed to be dissociated—the bond holding the two atoms of oxygen (2O) together breaks. The two oxygen atoms fly apart at extremely high velocity. Temperature of air is well-known to be proportional to the square of the average velocity of all its molecules and atoms. Photo-dissociation converts the energy bonding the atoms together immediately, completely, and efficiently into air temperature. The higher the frequency required for dissociation, the higher the energy, the greater the velocity, the hotter the temperature of air becomes.

The stratosphere is stratified because it is so evenly heated by solar radiation from above and because convection is not physically possible since temperatures increase from around -56°C (-69°F) at the tropopause to -2°C (28°F) at the stratopause, the top of the stratosphere, 50 to 55 kilometers (31 to 34 mi) above Earth's surface.

What makes photo-dissociation so important is that any two atoms of oxygen (2O) can collide, reestablishing the molecular bond (O_2) without changing air temperature. Then the new molecule of oxygen can be photo-dissociated again, raising air temperature, provided sufficient solar ultraviolet-C radiation still exists. By the time sunlight penetrates to the bottom of the stratosphere, all solar ultraviolet-C radiation is observed to have been absorbed. None is observed to reach Earth.

An atom of oxygen (O) and a molecule of oxygen (O_2) can also collide to form a molecule of ozone (O_3). Ozone is photo-dissociated by solar ultraviolet-B radiation with frequencies around 1176 terahertz, heating the ozone layer in the lower stratosphere. An oxygen atom and an oxygen molecule can then collide again forming a molecule of ozone, which is photo-dissociated again provided sufficient ultraviolet-B radiation still exists. Normally 97 to 99% of all solar ultraviolet-B radiation is absorbed in the ozone layer before reaching the tropopause. Normally only a small amount of ultraviolet-B radiation reaches Earth's surface where it causes slight warming and, with sufficient dosage, can cause sunburn, skin cancer, and mutations of DNA. Photo-dissociation is particularly effective at warming air because the increase in temperature is determined primarily by the amount of solar ultraviolet-B radiation available, not by the concentration of ozone molecules.

Photo-ionization: Every day from sunrise to sunset, Earth's uppermost atmosphere is heated by ionization, which is simply photo-dissociation of an electron. The highest energy, highest frequency radiation from Sun breaks the bond between an atom or a molecule and one of its electrons. The pieces fly apart at high velocity, heating the thermosphere, which essentially is the same thing as the ionosphere. The thermosphere has extremely low density—there are very few atoms, molecules, or electrons flying around.

Thus, there are three primary ways that air is warmed naturally every day: by conduction warming the troposphere, by photo-dissociation warming the stratosphere and mesosphere, and by photo-ionization warming the thermosphere (Figure 2).

Ozone depletion: When the ozone layer is depleted, which means that there is less ozone than normal absorbing solar ultraviolet-B radiation in the lower stratosphere, more ultraviolet-B radiation is observed to reach Earth's surface, cooling the ozone layer and warming Earth. In this way, the warming effects of photo-dissociation of ozone by ultraviolet-B radiation are moved from the lower stratosphere to the lower troposphere where ultraviolet-B dissociates ground-level ozone pollution. The greatest warming is observed in highly populated and industrialized regions where ozone pollution is greatest. Ultraviolet-B also penetrates oceans tens of meters so that it is absorbed efficiently, increasing ocean heat content as observed.

Humans began depleting the ozone layer in the 1960s by manufacturing large volumes of chlorofluorocarbon gases (CFCs) used widely for spray-can propellants, refrigerants, solvents, and foam-blowing agents. Three scientists earned the 1995 Nobel Prize in Chemistry for discovering in 1974 that when these highly inert gases reach the stratosphere, they can be broken down by ultraviolet radiation, releasing atoms of chlorine. They showed that one atom of chlorine, under specific circumstances, can destroy 100,000 molecules of ozone.

From 1970 to 1998, the average concentration of ozone became depleted by 5% while global average temperatures rose 0.6°C (1.1°F), particularly in the most populated and industrialized regions. The greatest increases in regional temperatures, however, were beneath the Antarctic ozone hole during late winter when and where ozone depletion is greatest.

Humans stopped the increase in ozone depletion by passing the United Nations Montreal Protocol on Substances that Deplete the Ozone Layer, which severely limited manufacturing of CFCs. Unfortunately, it will take many decades for these very inert CFCs to be removed naturally from the atmosphere. Thus, global temperatures are not expected to decrease back to pre-1970 levels for many decades as shown by the green line in Figure 1.

Ozone depletion is also observed following large volcanic eruptions emitting megatons of chlorine and bromine gases. The greatest warming is observed associated with large basaltic lava flows, like those seen in Hawaii, where extensive exposure to the atmosphere of very hot lava (1200°C, 2200°F) appears to drive convection of some of these gases up into the lower stratosphere. Warming of 0.3°C (0.5°F) from 2014 to 2016 appears to have been caused by a six-month eruption from Bárðarbunga volcano in Iceland, resulting in the largest basaltic lava flow since 1783. This period of warming was lengthened by the 2018 Lower Puna eruption in Hawaii that erupted half as much lava in three months. The good news is that global ozone depletion caused by basalts typically returns to normal in much less than one decade after the eruption stops.

Ozone depletion explains both warming since 1950 and warming throughout Earth history in exquisite detail. Essentially all documented periods of global warming appear to be contemporaneous with basaltic lava flows covering areas as large as millions of square kilometers that erupted for as long as tens of thousands of years—the more extensive the basaltic lava flow, the greater the warming, the longer the warming lasted, and the more intense the associated increases in ocean acidification and mass extinctions.

Climate scientists have dismissed ozone depletion as a primary cause of global warming because they do not realized the fundamental role of photo-dissociation for

heating air, because they do not realize that any amount of ultraviolet-B radiation is 50 times more energetic than any amount of infrared radiation absorbed most strongly by carbon dioxide, and because they calculate the thermal effects of ozone pollution while only thinking of ozone as a greenhouse gas.

But What About Greenhouse Gases? In 1859, John Tyndall, a prominent Irish physicist, documented in the laboratory that gas molecules containing three or more atoms absorb some infrared frequencies radiated by Earth—the more atoms, the more bonds, the more frequencies absorbed, and the more "potent" the greenhouse gas is calculated to be. Scientists have assumed since 1859 that if these gas molecules absorb thermal energy, they must make air hotter.

But in 1900, Knut Ångström, a Swedish physicist specializing in absorption of solar radiation by Earth's atmosphere and a friend of Arrhenius, showed by two experiments that increases in concentrations of carbon dioxide do not appear to increase air temperature. He showed that carbon dioxide absorbs less than 16% of the frequencies radiated by Earth. Meanwhile, Max Planck showed in 1900 that a body of matter can only be warmed if it absorbs 100% of all frequencies radiated by the warmer body. Thus, if the 16% of the frequencies radiated by Earth and absorbed by carbon dioxide were re-radiated and then absorbed by matter, they could not warm that matter even to the temperature of Earth.

We now know that these limited numbers of frequencies, these limited numbers of spectral lines of absorption, are absorbed into the bonds holding the molecule together, which has no direct effect on air temperature. One must assume that during a plethora of collisions, some of this bond energy is converted to velocity of linear motion and thus to air temperature. But such conversion cannot be very efficient if the energy is partitioned among all modes of oscillation as currently thought. And since the concentration of carbon dioxide in the atmosphere is only 0.04%, the energy converted for each molecule of carbon dioxide must be shared with 2500 other molecules and atoms.

Still to this day, it has never been shown by experiment, a cornerstone of the scientific method, that greenhouse gases absorbing infrared energy can physically cause observed warming. Infrared frequencies simply do not have enough energy to cause photo-dissociation or photo-ionization. Experiments described on Internet that claim to show greenhouse warming use heat sources thousands of degrees hotter than Earth. I have demonstrated in the laboratory, using an appropriate heat source, that air containing more than 20-times normal concentrations of carbon dioxide is not warmed any more than a similar volume of normal air under identical conditions.

Humans have unintentionally completed a major experiment, however, that clearly demonstrates the effects of ozone depletion. Humans accidently caused an increase

in warming beginning around 1970 by manufacturing CFC gases. Humans then stopped the increase in warming around 1998 by passing the United Nations Montreal Protocol on Substances that Deplete the Ozone Layer mandating substantial cutback in production of CFC gases beginning in January 1989. I have shown elsewhere that without the Montreal Protocol, average global temperatures today would probably be at least 0.5ºC warmer than observed.

After publication of Ångström's paper in 1900, most scientists lost interest in greenhouse-warming theory. In 1938, Guy Callendar, a British steam engineer, resurrected greenhouse-warming theory from the trash bin of history, but he summarily dismissed Ångström's paper without any discussion in his extensive notes. It was geochemists and an oceanographer who first brought greenhouse-warming theory to national attention in the United States in 1965.

Ångström was the only person trained in physics to question the physics of greenhouse-warming theory in the literature until I began to wonder about the physics of warming around 2010. Ångström's paper was written in German and is largely unknown to most modern climate scientists. This fundamental breakdown in communication between physicists and climate scientists from a broad spectrum of other scientific disciplines is a primary reason for current misunderstandings.

The other primary reason is that physicists today still do not understand the problems discussed above with defining heat as a flux, adding fluxes together, thinking of heat as an amount of thermal energy instead of a level of thermal energy, thinking in terms of a balance of fluxes, and the dominant role of photo-dissociation in determining atmospheric temperatures above the tropopause. Current thinking in thermodynamics works acceptably for small differences in temperature typical in most engineering applications but fails catastrophically when Sun is thousands of degrees hotter than Earth.

The closest things to truth in physics are direct observations of what is physically happening in Nature. Fundamental observations that do not require some theory to be interpreted. All the conclusions in this article are based on clear, unequivocal, direct observations of what is physically happening in Nature. The veracity of these conclusions should be demonstrated as global temperatures gradually decrease over future decades, the green line in Figure 1, rather than rapidly increase as shown by the red line in Figure 1.

The crisis in climate science: Global warming of nearly one degree Celsius since 1950, the black line in Figure 1, has caused problems with record high surface temperatures, drought, floods, and severe storms that we are having to deal with. But the reason most climate scientists consider climate change to be an existential crisis

is because their computer models predict that as much as four-times greater warming is highly likely to occur by 2100 as shown by the red line in Figure 1.

Computer models, however, are only as good as the assumptions used to construct them. Existing climate models are based on greenhouse-warming theory, a theory built upon numerous assumptions that turn out to be mistaken. There is no way known or demonstrated in physics by which observed increases in greenhouse-gas emissions could be the cause of observed global warming or could cause future predicted warming. Decreases in carbon dioxide concentrations during ice ages follow decreases in ocean temperature because colder oceans are well known to absorb more atmospheric carbon dioxide.

Ozone depletion, on the other hand, does provide a clear and detailed explanation for all observations of warming since 1950 as well as throughout Earth's history. Ozone depletion theory predicts that average global temperatures should trend downward in the future as the ozone layer gradually recovers, the green line in Figure 1, unless there is an unexpected major new source of ozone depletion. And if this new source is from a basaltic volcanic eruption, global temperatures should recover in much less than a decade after the eruption stops.

The good news is that we can burn fossil fuels safely, provided we minimize pollution, which we know how to do if we are willing to spend the money. We can meet the increasing needs for energy to power both expanding and developing economies.

The demise of greenhouse-warming theory is a major revolution in science. My fellow scientists are in a very uncomfortable position, especially because of the breadth and depth of the consensus forged over the past thirty-two years. Everything regarding climate that they have worked on so hard for so many years is suddenly in question. As one leading climate scientist exclaimed in disbelief: "Peter, there is no way that you could be right and all the rest of us are wrong."

But most revolutions in thinking, throughout the history of science, have typically started with new insights by one person. As Max Planck, the father of modern physics, wrote 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."

It often takes decades for an important new idea in science to gain widespread acceptance. But we do not have decades of time available because the IPCC, based on widespread consensus, has convinced world leaders of the need to spend trillions

of dollars immediately to reduce greenhouse-gas emissions. It is now quite clear that any money spent reducing greenhouse-gas emissions will have no significant effect on global temperatures and, therefore, will be wasted. Greenhouse-warming theory is rapidly becoming the most expensive mistake ever made in the history of science.

I have known the primary conclusions about greenhouse warming theory and ozone depletion theory since 2015. I have written a book, numerous papers, more than two dozen short videos, and two major websites trying to get my fellow scientists to think about these new insights and to either prove me right or wrong. I have interacted on this subject with more than 7000 scientists at national and international meetings. I describe the mistakes in the physics of greenhouse-warming theory at Physically-Impossible.com and have challenged thousands of leading climate scientists by personal email and in person to find any error on that webpage that could change the conclusions. The response so far has been essentially zero. How long will it be before some objective scientists begin to face physical reality?

Whether you are a leader in government or business, or just interested in solving the perceived climate crisis, now is the time for you to ask anyone defending greenhouse-warming theory to find any errors at Physically-Impossible.com that could change the conclusions.

Now is the time to move forward together, focusing our efforts on ways to minimize pollution, on ways to enhance energy resources sufficient to power the critical needs of both the developed and the developing worlds, and on ways to help our economies and citizens recover from a major pandemic. There is no scientific basis for continuing to spend both resources and funds on reduction of greenhouse-gas emissions.

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, leading a group of more than 140 scientists and staff and playing a lead role in establishing and initially leading a major national research program. He chaired a committee at the White House, worked on a committee for Vice President Gore, and testified before Congress in 2004 and in 1978. He earned two national awards for explaining science to the public. He and his work were featured on Good Morning America. More details about Ward can be found at WhyClimateChanges.com/About. Ward has worked full time in retirement, at his own expense, since 2006, carefully reexamining all the evidence and theories for why climate has changed throughout Earth history.

More Information

Article: Fundamental errors regarding the physics of heat

Article: We have already solved the global warming crisis

Article: The crisis in climate science

Book: What Really Causes Global Warming? Greenhouse Gases of Ozone Depletion?

Paper: The photochemistry of gas molecules in Earth's atmosphere determines the structure of the atmosphere and the average temperature at Earth's surface

Paper: Ozone depletion explains global warming

Paper: On the Planck-Einstein relation

Paper: Heat does not physically flow in the ways assumed by greenhouse-warming theory

Video: Listen up about climate change if you can bear it. I have some good news (1 minute)

Video: A most unexpected revolution in the physics of heat (13 minutes)

Video: TEDx talk: Volcanoes : A forge for climate change (18 minutes)

Video: The most expensive mistake ever made in the history of science (16 videos each 5 to 12 minutes)

Videos of talks at scientific meetings

Website: WhyClimateChanges.com

Website: OzoneDepletionTheory.info

Website: JustProveCO2.com

Website: Physically-Impossible.com