

Our Faustian Bargain

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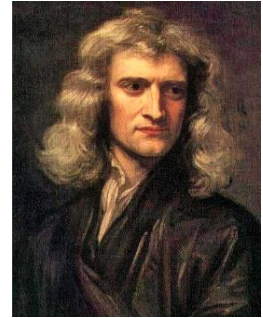
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Have We Unwittingly made a Faustian Bargain?

This is an account of events that have led to our ever-growing climate crisis. Young people wonder if they have a future. How is it that climate scientists discuss such an outcome of advancements in technology and the comforts associated with them? This is about the consequences of the use of coal, oil, and gas for fuel as well as about the science that has enlightened us. These fuels drive heat engines that provide motive power and electricity to run our civilization, which has thus far been to the benefit of all of us. Is there a cost looming ahead? If so, how might we avoid that cost?

I start with Sir Isaac Newton (1642-1727).² In the **1660's** he discovered three laws of motion plus the law of gravitation, which requires the concept of action at a distance, a concept that scientists of his day reacted to with horror. Yet without that strange action at a distance there would be no way to explain the motion of planets.



The main law is $\text{Force} = \text{Mass} \times \text{Acceleration}$. This is a differential equation that must be integrated twice to obtain position. Newton was an English mathematician, physicist, astronomer, theologian, and author. Before him, no method of integration existed, so he had to develop a method. Newton's method was complex and difficult to use, but almost simultaneously German polymath, logician, mathematician, and natural philosopher Gottfried Wilhelm Leibniz (1646-1716) developed the method of integration called calculus that we use today. British mathematicians were slow to adopt Leibniz's method and thus set back the development of science in Britain by about a century.



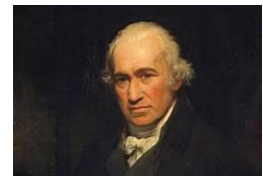
With the laws introduced by Newton and the mathematical tool developed by Leibniz, during the 18th century many mathematicians, scientists and engineers contributed to the development of the sciences taught in engineering schools today. They form the scientific basis for the steadily expanding

INDUSTRIAL REVOLUTION.

Also, in the 18th century, Thomas Newcomen (1664-1729), an English inventor, invented the steam engine in **1712**, driven by high-pressure steam generated by burning coal.

Joseph Black (1728-1799), a Scottish physicist and chemist in **1754** discovered carbon dioxide, CO₂, a product of burning coal.

James Watt (1736-1819), a Scottish inventor, mechanical engineer, and chemist in **1765** added a separate condenser to the steam engine that enabled it to be mounted on a moving vehicle.



² Pictures thanks to Wikipedia.

Robert Fulton (1765-1815), an American inventor and engineer, invented and in **1807** operated the first commercially successful steamship, which was powered by coal, which when burned releases CO₂. Steamships, often called “steamers,” and later burning oil, increased in size and number and today, as airplanes have taken over long-haul passenger travel, move ocean freight and are used for pleasure cruises.



John Blenkinsop (1783-1831), an English mining engineer, in **1811** invented the first steam locomotive with its coal cars trailing behind. They increased in size and number until in the 1950s were almost all converted to diesel, which when burned also emits CO₂.



Michael Faraday (1791-1867) a British physicist and chemist is best known for his discoveries in the **1820**'s of the principles of electromagnetic induction and electrolysis. He invented the principle of the electric motor and, running it backwards, the electric generator, which is the tool needed for commercial generation of electricity, without which our lives would be quite different. The generator is a rotary machine driven by a steam turbine, which is driven by high-pressure steam produced by burning a fossil fuel. Faraday is considered one of the greatest discoverers of all time. The SI unit of capacitance, the farad, is named after him.



Up to a few years ago the 2238-megawatt electrical-power generator in Becker, Minnesota, required four one-mile-long train loads of coal from Montana every day. Around the world there are now over 2 million megawatts of such facilities, all releasing CO₂. Natural gas is now used in the Becker plant, which is equivalent in CO₂ release to about 60% as much coal, but it leaks methane, CH₄.

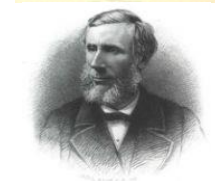
Joseph Fourier (1768-1830), a famous French mathematician, in **1824** found that certain gases allow sunlight to pass unimpeded but absorb heat radiation.



Eunice Newton Foote (1819-1888)³, an American physicist and inventor, was the first to do experiments that led to the conclusion that increases in the proportion of CO₂ in the atmosphere will increase its temperature. Her results were presented in an AAAS paper in **1856**.



John Tyndall (1820-1893), an Irish natural philosopher and physicist of renown, in **1859** based on experiments speculated on how water vapor and carbon dioxide relate to climate change.



³ See her biography in Wikipedia.

1859 Petroleum: In Alberta, Azerbaijan, Pennsylvania, and Romania oil production was started close to this date. Petroleum and coal had been known and burned for thousands of years, but it took the steam engine, the electric-power generator and the internal-combustion engine, discussed below, to vastly increase the use of these fuels, which has vastly increased the release of CO₂ into the atmosphere.

Adolfo Bartoli (1851-1896), an Italian physicist, discovered radiation pressure. James Clerk Maxwell (1831-1879), a Scottish mathematical physicist in the **1860**'s, based on the work of Faraday formulated the equations of the electromagnetic field and found that radiation pressure followed from his equations. Thus, it is called Maxwell-Bartoli pressure. Understanding of radiation pressure is necessary to understand the energy balance that determines the earth's temperature.



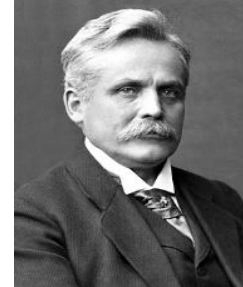
Josef Stefan (1835-1893) and his student Ludwig Boltzmann (1844-1906), both Austrian physicists, discovered in **1884** the law of nature $E = 5.67037T^4$ in which E is the energy radiated from a Black Body in watts per square meter and T is the absolute temperature of the body's surface in degrees Kelvin. The Stefan-Boltzmann law is essential in calculating the temperature of the Earth's surface needed to radiate enough energy to balance the energy input from the Sun.



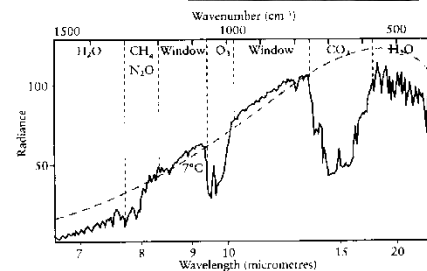
The Internal-Combustion Engine enormously expanded the use of refined oil. In the 19th Century many engineers contributed to its development. In **1886** German engineer Karl Benz (1844-1929) began the first commercial production of vehicles using the ICE. The ICE replaced the horse and led to freedom of the road. It became so popular that there are now more than 1.2 billion ICE-driven vehicles worldwide, a number growing quickly. 99.8% of them release CO₂ into the air. The rest are run by electricity.



Wilhelm Wein (1864-1928), German physicist, in **1893** discovered the Law of Black-Body radiation, which states that $\lambda_{max}T = 0.288cmK$, where λ_{max} is the maximum wavelength in a statistical distribution and T is absolute temperature. This law shows that the maximum wavelength of radiation pressure from the surface of the earth lies in the range of wave lengths absorbed by CO₂, water vapor, methane, nitrous oxide, and ozone.



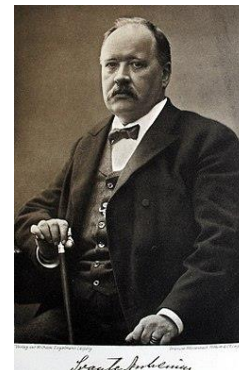
This chart, taken from Professor Peter Wadham's book,⁴ shows Radiance (or Radiation Pressure) vs. Wavelength as measured by a satellite travelling over the Mediterranean Sea. The distribution is close to Wein's statistical distribution for 7°C. The absorption band for CO₂ is seen to



⁴ A Farewell to Ice: A Report from the Arctic, Oxford, Fig 5.1, 2017.

be by far the largest and is near the maximum wavelength, which is why CO₂ is the most important greenhouse gas.

Svante Arrhenius (1859-1927) was a Swedish scientist and student of Boltzmann. In developing a theory to explain the ice ages Arrhenius in **1896** used properties of CO₂, the Stefan-Boltzmann Law and the Wein Law to calculate the extent to which increases in atmospheric CO₂ will increase the earth's surface temperature through the greenhouse effect. Now it was known quantitatively how much increasing CO₂ will increase the temperature of the earth's atmosphere and why the lack of trace gases in the earth's atmosphere will result in a temperature of minus18°C – too low to support life.

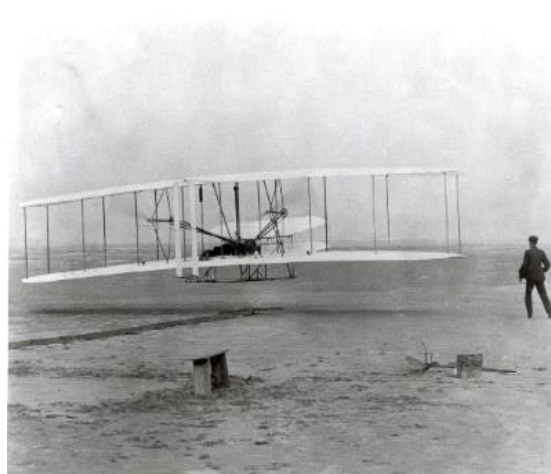


In the mid 2020's there was an average of about 417 molecules of CO₂ per million molecules of air in our atmosphere. This is only 0.042%. Climate deniers have argued that such a small percentage cannot possibly have any effect, but without it the earth's surface temperature would be too low to support life.

Nitrogen, N₂; and Oxygen, O₂; are 2-atom molecules. Experiments show that they have no vibration modes in the infrared region of the spectrum from where radiation from the earth is released. These molecules make up more than 99.9% of the atmosphere.

Carbon Dioxide, CO₂; Water, H₂O; Nitrous Oxide, N₂O; and Ozone, O₃ are 3-atom molecules. From experiments they are found to have vibration modes in the infrared region of the spectrum. They absorb and reradiate in all directions energy radiated from the earth. For thousands of years the amount of these gases in our atmosphere has been neither too great nor too small to permit a healthy temperature for humankind. Now, without thought of consequences, they have been allowed to increase! Methane is a 5-atom molecule. It is a much more powerful greenhouse gas.

Flight: The Wright Brothers are shown here experiencing in December **1903** the first sustained flight of a heavier-than-air aircraft. Because it was soon believed that aircraft would be useful in war, in 1915 the United States Congress established the National Advisory Committee for Aeronautics (NACA) to study problems of flight. In the late 1950s NACA was recommissioned as NASA. In World War I and then World War II the art of flight advanced rapidly. Today there are about 39,000 aircraft carrying about 4.1 billion passengers per year. These aircraft are all fueled by a CO₂-releasing fuel. Stopping flight now to reduce CO₂ would stop civilization in its tracks!⁵ An alternative being tested is to use hydrogen as the fuel.



⁵ With the Coronavirus upon us that may be close to happening.

Guy Stewart Callendar (1898-1968) was an English steam engineer and inventor. His main contribution to knowledge was his **1938** advancement in the theory that linked rising carbon dioxide concentrations in the atmosphere to rising global temperature. He thought this rising temperature would be beneficial by delaying the return of an ice age.

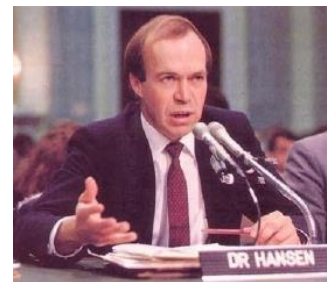


Gilbert Plass (1920-2004), a Canadian physicist, made predictions in the **1950s** about the increase in atmospheric CO₂ and its effect on the temperature of the planet.⁶

From page 36 of *The Global 2000 Report to the President*, published in **1982**:

“Another environmental problem related to the combustion of fossil fuel is the increasing concentration of carbon dioxide in the earth’s atmosphere. Rising CO₂ concentrations are of concern because of their potential for causing a warming of the earth... The CO₂ content of the world’s atmosphere has increased about 15 percent in the last century and by 2000 is expected to be nearly a third higher than preindustrial levels. If the projected rates of increase in fossil fuel combustion (about 2 percent per year) were to continue, a doubling of CO₂ content of the atmosphere could be expected by the middle of the next century; and if deforestation substantially reduces tropical forests (as projected), a doubling of atmospheric CO₂ could occur sooner. The result could be significant alterations of precipitation patterns around the world, and a 2°-3° C rise in temperatures in the middle latitudes of the earth... Even a 1°C increase in average global temperature would make the earth’s climate warmer than it has been any time in the last 1,000 years.”

In **1988** physicist and climate scientist Dr. James E. Hansen,⁷ from 1981 to 2013 Director of the NASA Goddard Institute for Space Studies, testified before Congress on the urgent necessity to stop the increasing level of CO₂ in the atmosphere. He headed a group that had the scientific talent and tools needed to study the problem in the necessary detail. He has been and continues to lecture widely on the climate crisis and its critical importance for humankind.⁸ What will happen if CO₂ continues to increase?



In **2006**, former Vice President Al Gore published his book *An Inconvenient Truth: The Planetary Emergency of Global Warming and What we can do about It*. He said, “I vowed to make the climate crisis the top priority of my professional life.” While not a scientist himself, he spent a great deal of time talking with climate scientists, which becomes evident from reading his book. If we had taken him seriously in 2006, the earth would be much better off and perhaps we could have averted some of the consequences of the climate crisis. Al Gore trains young people to lecture on the climate crisis through www.climaterealityproject.org.

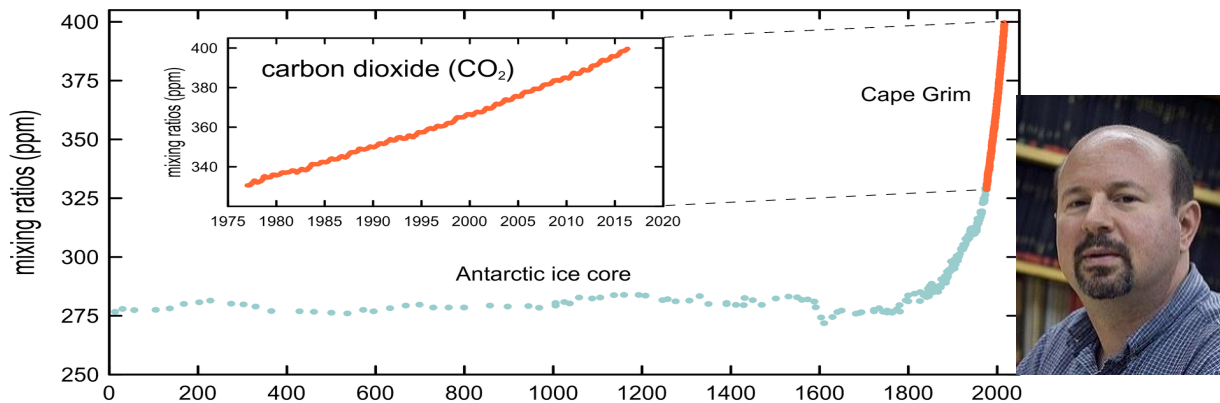


⁶ Go to the Wikipedia article “History of Climate Change Science” for more about climate science.

⁷James Hansen, *Storms of my Grandchildren: The Truth about the Coming Climate Catastrophe and Our Last Chance to Save Humanity*, Bloomsbury, 2009.

⁸ Please watch Dr. Hansen’s TED talk to learn more about the need to reduce CO₂.

The following chart shows CO₂ in parts per million (ppm) vs. time in years. It shows the “hockey stick” behavior first reported by climate scientist Michael E. Mann,⁹ which was strongly criticized by climate deniers but has been confirmed by many scientists. It shows how much the growing Industrial Revolution, beginning with the steam engine and the electricity generator, has contributed through burning of coal, oil, and natural gas to the increase of CO₂ in the atmosphere. Since 1957 the level of CO₂ has been measured daily at 11,135 ft at the Mauna Loa Observatory on the Island of Hawaii and more recently at Cape Grim in Tasmania, as well as in other places.



The average level of CO₂ in mid-2020 was about 417 ppm and it is rising at a rate of about 2.4 ppm per year.

Dr. Peter Wadhams, Emeritus Professor of Ocean Physics in the Department of Applied Mathematics and Theoretical Physics at Cambridge University¹⁰, released in **2017** his book *A Farewell to Ice*, referenced on page 5. In Chapter 14: “A Call to Arms” he says “*The discovery in 2015¹¹ of very high long-term climate sensitivity¹² of the planet to greenhouse gases is of utmost importance in clarifying what should be **our priority as human beings in the crisis that faces us.** It shows that the existing level of carbon dioxide in the atmosphere is enough to cause unacceptable amounts of warming in the future. We no longer have a ‘carbon budget’ that we can burn through before feeling worried that we have caused massive climate change. We have burned through the budget and are causing the change now.*



*We have destroyed our planet’s life support system by mindless development and misuse of technology. A mindful development of technology, first for geoengineering,¹³ then for **carbon removal**, is now necessary to save us. **This is the most serious and important activity in which the human race can now be involved, and it must begin immediately.**” (He said this in 2016.)*

⁹ Michael E. Mann, *The Hockey Stick and the Climate Wars: Dispatches from the Front Lines*, Columbia, **2012**.

¹⁰ There have been about 90 Nobel Laureates at Cambridge University.

¹¹ Dr. David Wasdell, *The Harsh Reality of Now*, 2015, www.apollo-gaia.org.

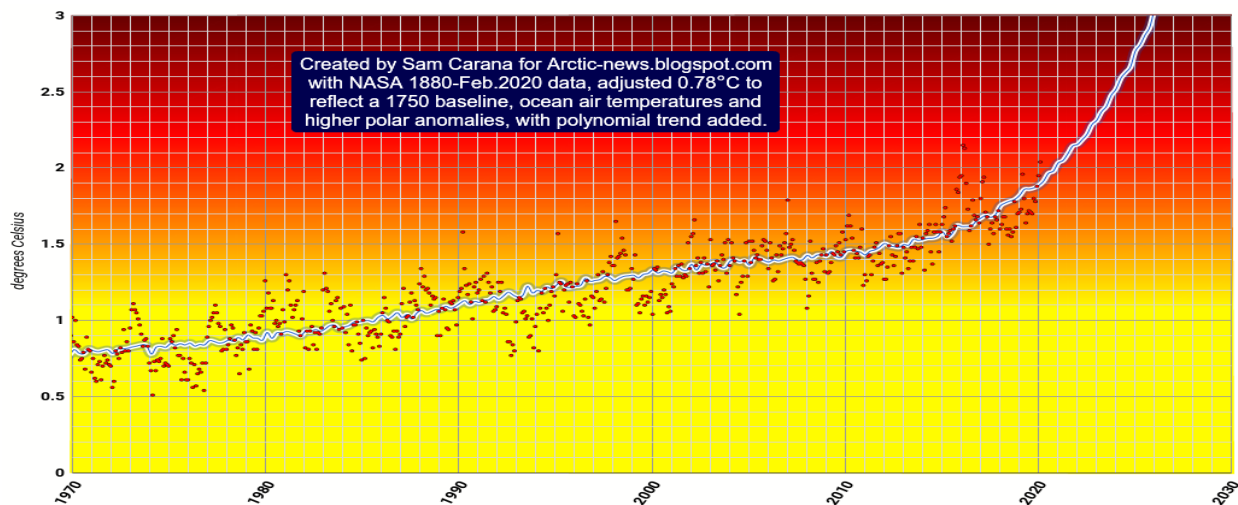
¹² Climate sensitivity is the temperature increase with doubling of CO₂.

¹³ Professor Wadhams was concerned about geoengineering but said that we have no choice.

Dr. David Wasdell, Director of the ten-year London-based Apollo-Gaia study referenced in footnote 11, concluded: “Detailed analysis of historical planetary response to change in concentration of carbon dioxide reveals an eight-fold amplification of CO₂ forcing in contrast to the three-fold amplification predicted by the IPCC climate modeling computer ensemble. Applying the corrected value of Climate Sensitivity multiplies the previously predicted temperature rise by more than 2½ times in response to any given change in CO₂ concentration.”



The IPCC’s prediction that the earth’s mean temperature must be held to a rise of no more than 1½°C means that an IPCC predicted rise of 1½°C would really be 1.5×2.5 = 3.75°C, whereas the IPCC estimated that a rise of only 2°C will be catastrophic.



As shown in the above chart the Earth’s mean temperature is now rising at an increasing rate. I can point to three events that in 2019 were much different than in 2018:

- A nephew of mine runs a farm near Pocahontas, Iowa. He told me that 2019 was close to catastrophic because there was so much rain.
- A friend of mine owns a farm 35 miles north of Detroit. He told me that his tenants and other nearby farmers were unable to plant their corn and soybeans in 2019 because fields were too wet during the entire planting season.
- Meteorologists say that the rain in the USA in 2019 set a record high.

Compared with the summer of 2018, the above events stand out. Warmer air holds more water. Because the temperature in the Northern Hemisphere is rising at an increasing rate, we can expect the changes and effects from 2019 to 2020 will be greater than they were from 2018 to 2019. If the temperature follows the above-shown polynomial trend, the rise now is about 1.8°C per decade and the changes are very noticeable. If CO₂ is not removed from the air, the temperature will continue to increase with eventually catastrophic consequences for all life on earth!

Concern about the climate is increasing rapidly. Thanks to Swedish student Greta Thunberg hundreds of thousands of young people have staged demonstrations, the biggest on March 15, 2019 and more in the fall of 2019, but CO₂ keeps rising¹⁴. Methane does too. There is much less of it, but it is a much more powerful greenhouse gas.



Extinction Rebellion started in London in the fall of 2018. There are now chapters in many countries and teams of them often lay down on busy streets to call attention to the need for serious action. www.TheClimateMobilization.org has formed, declaring that the **Climate Emergency** requires a World War II level of commitment starting immediately.¹⁵ www.sunrisemovement.org. www.350.org. <https://citizensclimatelobby.org>. There are many more. Before the coronavirus crisis, we could not turn on the radio without hearing the latest about the climate, and CO₂ keeps rising.

Where is our public? Ford Motor Company has decided to manufacture almost only F-150 pickup trucks because so few people want their much lighter-weight sedan. General Motors has decided to close a plant that has made their smallest sedan because the public they see only want larger and hence heavier vehicles, which release more CO₂. No one is telling them that they need to release less CO₂ to save our climate and us!

For the earth's mean temperature to remain steady, the energy radiated away into space must match the energy absorbed from the sun. Eight hundred thousand years of ice-core data have shown how the earth's mean temperature has risen and fallen in step with the amount of carbon dioxide (CO₂) in the air.¹⁶ Beginning over 240 years ago due to burning of coal, then oil, and now natural gas the amount of CO₂ in our atmosphere has risen, slowly at first and then more and more rapidly each year. It is now 50% higher than the maximum during the previous 800,000 years and rising at a rate of about half of one percent a year.

CO₂ is the main absorber of energy radiated away from the earth's surface. As CO₂ in the atmosphere increases more of the energy radiated away from the earth's surface is captured by that CO₂ and less is radiated into space from the top of the atmosphere. To restore balance between energy coming in and going out the surface temperature of the earth increases, but it takes time for that to occur – at least a decade.¹⁷

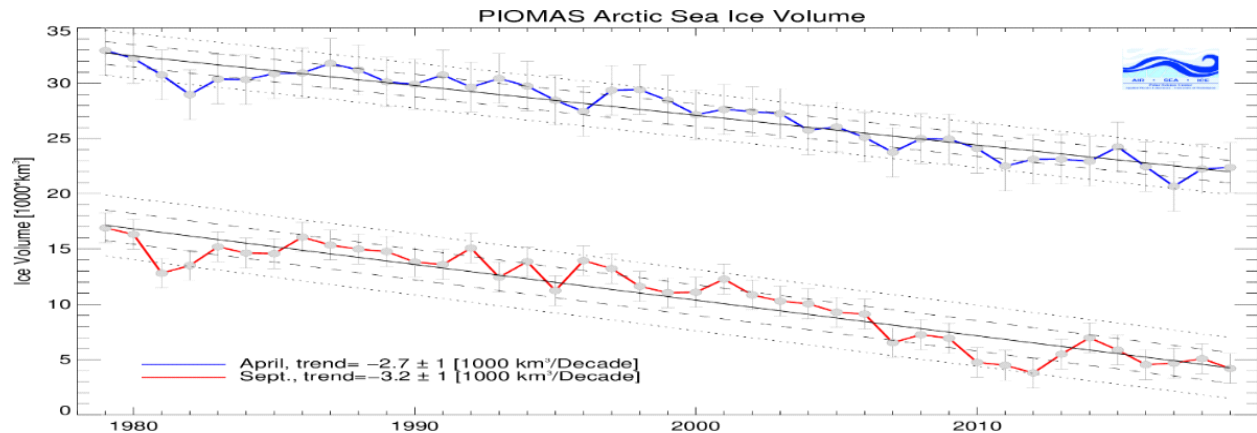
The solar energy absorbed by the earth is increasing even more because, as shown in the following chart, ice cover in the Arctic Ocean is decreasing, which means that every year an increased amount of solar energy reaching the arctic is absorbed rather than reflected into space. This additional energy heats the atmosphere even more.

¹⁴ See pages 20 and 21.

¹⁵ Margaret Klein Solamon, *Facing the Climate Emergency*, 2020.

¹⁶ In his TED talk, Dr. Hansen explains why, because of temperature lag, the temperature often leads the CO₂.

¹⁷ Katherine L. Ricke & Ken Calderia, "Maximum warming occurs about one decade after CO₂ emission," *Environmental Research Letters*, Volume 9, Number 12.



An enormous amount of methane is locked in the Arctic Ocean floor and is bubbling to the surface.¹⁸ Scientists who study the problem are concerned that when the temperature in the shallow portions of the Arctic Ocean reaches a certain tipping point, likely not far away because the amount of summer arctic ice is now so low, the rate of release of methane will increase enough to raise the earth's temperature rapidly. But when will there be enough concern to cause serious action?

As the CO₂ content of our atmosphere continues to rise, our atmospheric temperature continues to rise, with a lag of about ten years. Because of the time it takes for these changes to take place, today's temperature is lower than the level it will reach, which continues to rise as the CO₂ content continues to rise. At some point human intervention will no longer be able to control further temperature increases, if it can now, and life on earth will in time disappear. Since the amount of ice in the Arctic Ocean is now so low, this point may not be far away. Arctic scientists are terrified. Most folks are not because they have not viscerally absorbed the problem.

Most people are not educated in the sciences and when faced with a totally new situation are not likely to believe anything that is not directly in front of them. Many will not act on what climate scientists have warned will happen until it happens, and by then it may be too late for life on earth to continue for very long. I am reminded of the crew of the **Pequod** in *Moby Dick*. Many people are too busy with current activities to think about an unprecedented problem. Moreover, many people depend on the fossil-fuel industry for their livelihood and will fight and have fought every thought of reducing CO₂. Abandoning fossil fuels, the largest industry in the World, is enormously difficult and the climate deniers they fund tell us daily what we want to hear: "No problem. Just keep doing what you're doing."

BUT CO₂ KEEPS RISING!¹⁹

¹⁸ The Arctic Atmospheric 'Methane Global Warming Veil'. Its Origin in the Arctic Subsea and Mantle and the Timing of the Global Terminal Extinction Events by 2040 to 2050 - A Review by Malcolm P.R. Light, Harold Hensel and Sam Carana, www.arctic-news.blogspot.com. June 8th, 2014

¹⁹ The coronavirus has not yet slowed the rate of CO₂ rise.

Are we trapped? Is there a way out? Do we have enough time to save ourselves? What will it take? Wind and solar power are unreliable and intermittent. We need a non-polluting 24/7 steady source of power²⁰ and we must remove CO₂ from the air.

StarTribune

Most dire climate warning

The U.N. report describes worsening food shortages, Arctic melting without action.

By CHRIS MOONEY and BRADY DENNIS • Washington Post

The world stands on the brink of failure when it comes to holding global warming to moderate levels, and nations will need to take “unprecedented” actions to cut their carbon emissions over the next decade, according to a landmark report by the world’s top scientific body studying climate change.

With global emissions showing few signs of slowing and the United States — the world’s second-largest emitter of carbon dioxide — rolling back a suite of Obama-era climate measures, the prospects for meeting

the most ambitious goals of the 2015 Paris Accord look increasingly slim. To avoid racing past warming of 1.5 degrees Celsius (2.7 degrees Fahrenheit) over preindustrial levels would require a “rapid and far reaching” transformation of human civilization at a magnitude that has simply never happened before, the group found.

“There is no documented historic precedent” for the sweeping change to energy, transportation and other systems required to reach 1.5 degrees Celsius, the U.N. Intergovernmental Panel on Climate Change, or IPCC, wrote in a

See **CLIMATE** on A10 ►

WHAT A HOTTER WORLD WOULD LOOK LIKE

Temperature change +1.5°C

Temperature change +2.0°C

Source: Intergovernmental Panel on Climate Change Associated Press

CLIMATE CHANGE

(a Letter to the Minneapolis Star Tribune, 2018)

It's here, and more is coming

The writer is a seventh grader at Hiawatha College Prep-Kingfield.

Something needs to be done about global warming because it's causing more natural disasters like droughts, floods and wildfires to happen. In fact, in 2015, there were 10 natural disasters in the U.S. that totaled \$1 billion in damages. This affects us because its is damaging homes, communities and buildings and it needs to change.

Global warming is making the earth dangerously hot. Earth's temperature has likely risen more in the years between 2000 and 2009 than it did in the previous 1,300 years. This means that the world will eventually become so hot we won't be able to live on the earth if we don't change.

LUKE FRELIX, Minneapolis

²⁰ George Erickson, *Unintended Consequences: The Lie that Killed Millions and Accelerated Climate Change*. Because of Erickson's concern, you can order his book free from www.tundracub.com. He shows why nuclear power is essential and why today's nuclear power (much different than the 1950's) is safe.

CLIMATE CHANGE

The future is terrifying; we have to act — now

We're young people worried about dire climate-change impacts. The feds aren't doing what's needed, so state and local governments must.

By SOPHIA MANOLIS, LIA HAREL, GABRIEL KAPLAN, MARCO HUNT, SHAZA HUSSEIN, KATIE CHRISTIANSEN, and SOFIA VALDES

We, Minnesota youth, are terrified for our future. By our middle-aged years, extreme weather events will be commonplace, intense drought and heat waves could occur regularly, major coastline areas could be submerged, millions will live with the threat of frequent storm surges and the incidence of certain illnesses may be substantially higher — all because of climate change.

Societal inequities will be exacerbated as climate impacts fall disproportionately on some. Costs of repairing climate-related infrastructure damage will be unupportable.

We ask Minnesota leaders and policymakers: Can you envision such a future through our eyes?

A new report released this week by the United Nations' Intergovernmental Panel on Climate Change (IPCC) says that countries will need to dramatically and urgently decarbonize their economies and lower human-caused greenhouse gas emissions to net zero by 2050 in order to keep global warming under 1.5 degrees Celsius — the target set by the 2015 Paris Climate Accords and the likely tipping point for the worst possible scenarios. This requires major changes during the next 10 years.

The science is unequivocal; the costs of delay will far outweigh the investment and sacrifices needed to make this transition.

Scientists and political leaders have understood for decades that the climate is changing unnaturally and that human activities are the cause. This was well described in the recent New York Times article "Losing Earth: the decade we almost stopped climate change," detailing the climate change knowledge of scientists and policymakers starting in the 1970s. Yet our current federal government continues to make decisions that exacerbate climate change and have dire implications for our futures.

In the absence of federal leadership, we need our state and local governments to take bold actions to decarbonize our economies and our way of living. Minnesota's leaders should focus not only on achieving the bipartisan Next Generation Energy Act of 2007 that calls for an 80 percent reduction in greenhouse gas emissions by 2050, but also act even more aggressively toward decarbonization. We cannot simply do what most deem politically possible; we have to do what is necessary — and young people are already leading in many ways.

We are presenting a "Youth Climate Inheritance Resolution" to the state Legislature to aim for net zero greenhouse gas emissions within a decade because Minnesota can't wait. Already we have presented this resolution to numerous legislators and

gubernatorial candidates Tim Walz and Jeff Johnson to ask for bipartisan support because climate change doesn't discriminate based on political affiliation.

Several of us are part of a group of 11 youths from across our state asking Minnesota to join 10 other states and several Canadian provinces in creating an enforceable greenhouse gas emission limit to support transition to a prosperous clean economy. We are calling on the next governor to take executive action directing the Minnesota Pollution Control Agency to create stronger rules to limit greenhouse gas pollution.

We must increase pressure on our leaders because their decisions now will shape our futures.

Finally, we are demanding that the Line 3 tar sands pipeline project be stopped. Line 3 exemplifies backward-looking fossil fuel infrastructure that ensures continued fossil fuel extraction for decades and forestalls the essential transition to a fossil-fuel-free economy. We represent the Youth Climate Intervenorers who are sharing leadership in opposing this short-sighted and dangerous proposal.

In addition to urgently demanding those actions, we declare our solidarity with the 21 young people who have initiated a lawsuit — Juliana vs. United States — which begins on Oct. 29 in Oregon. These youths are suing the federal government on the basis that — despite its ever-increasing body of knowledge about the causes and likely trajectory of climate change — federal leaders have not done enough to limit and reduce carbon emissions, thereby failing to protect the constitutional right of today's youth to life, liberty and happiness.

We need everyone's support in telling our leaders that they are not holding up their responsibility of representing us and protecting our future. We are rallying in front of the U.S. Court of Appeals on the afternoon of Oct. 28, and we need loud public support. We must increase pressure on our leaders because their decisions now will shape our futures. We must act now; we must make change. For if we don't, it will be too late.

Learn more about youth action and join us at www.mncantwait.com.

Sophia Manolis (Minneapolis South), Lia Harel (Hopkins), Marco Hunt (Breck), Shaza Hussein (Rosemount), Katie Christiansen (St. Louis Park) and Sofia Valdes (St. Anthony) are seniors at Twin Cities high schools. Gabriel Kaplan is a sophomore at St. Louis Park High School.

Some Final Thoughts



Here is a well-known picture of our earth taken from one of our spaceships. Our earth is almost 8000 miles in diameter and our activities take place within a spherical shell at the surface about 10 miles thick. Our earth circles around a massive sun 93,000,000 miles away. We are one of 9 planets that, with our sun, circle within a galaxy so large that it takes light travelling at 186,000 miles a second 25,800 years to move from the center of our galaxy to our position. Astronomers tell us that there are at least one to two trillion of such galaxies within the universe. *We indeed do live on a **tiny blue dot**²¹ in an incomprehensively vast universe.*

Our earth likely is not unique, but it has some remarkable properties. We have an atmosphere containing gases that for many thousands of years have kept us at a tolerable temperature, neither too hot nor too cold, and that shields us from deadly ultra-violet rays from our sun. The latter is the result of a layer of less than 10 ozone molecules per million air molecules in the upper atmosphere. The former is the result of several trace gases, the most important of which is carbon dioxide. Before the Industrial Revolution, our atmosphere contained about 280 carbon dioxide molecules per million air molecules. That is 0.028%. If these gases were not present, our temperature would be about minus 18°C (0°F) – too cold to support life. We now have 50% more CO₂, which is increasing by about 0.5% per year. If there were twice as much CO₂ in our atmosphere, according to Dr. Wasdell the average temperature would be too high to support life.

Over 240 years ago James Watt's steam engine began the Industrial Revolution. It has eased our lives while burning fossil fuels. The products of combustion include carbon dioxide. For several decades, no thought was given to the consequences of adding carbon dioxide to the atmosphere. Then, just before our Civil War, Eunice Newton Foote found from her experiments that increases in carbon dioxide in our atmosphere increase its temperature. The increase has been extremely gradual, but 126 years later, in 1982, serious warnings began and now the increase in temperature is beginning to cause great concern. We have benefited from burning fossil fuels, without which we would be riding in horse-drawn carriages and would not enjoy the benefits of electricity. Will a power source that does not release carbon dioxide save us,²² or will the fossil-fuel industry, the largest industry in the world, carry its fight for its existence to the point of no return? Since the steam engine went into practical use, the carbon dioxide in our air has increased by 50% and is increasing by about 0.5% per year. Like Faust, we have bargained that burning of fossil fuels will forever be to our benefit.

²¹ Carl Sagan first used this term when he asked NASA to take a picture of the Earth as far away as they could.

²² Modern nuclear power is both safe and essential. Read *Power to Save the World: The Truth about Nuclear Energy* by Gwyneth Cravens, Vintage Books, 2007. Unfortunately, nuclear power was not available until long after the Industrial Revolution began.

A Climate Emergency

*“Scientists have a moral obligation to clearly warn humanity of any catastrophic threat and to ‘tell it like it is.’ On the basis of this obligation and the geographic indicators presented below, we declare, with more than 11,000 scientists’ signatories from around the world, clearly and unequivocally that planet Earth is facing a **climate emergency**.”*

In a five-page document on www.ScientistsWarning.org entitled “World Scientists’ warning of a **climate emergency**,” from which the above paragraph was taken, **scientists declare an emergency**.²³ They say: “**An immense increase of scale in endeavors to conserve our biosphere is needed to avoid untold suffering due to the climate crisis.**”

The consequence of no action will be that the Earth’s temperature will increase enough to destroy life on Earth. The remedy must include marked reduction in use of fossil fuels. A problem that climate scientists understand but that is not often discussed²⁴ is that burning of fossil fuels leaves sulfur compounds in the air that reflect sunlight. Stopping burning fossil fuels will cause these compounds to fall out of the air in weeks and that will result in much more sunlight heating the air, which will cause the temperature to rise quickly.²⁵ By some form of geoengineering, we must avoid that outcome. If we fail, we will have to pay, like Faust, the price of our bargain with the Devil. In our case the price, the terrible price, will be loss of a livable Earth! We must not let that happen!

Eunice Newton Foote warned us, John Tyndall warned us, Svante Arrhenius warned us, *The Global 2000 Report* warned us, Jim Hansen warned us, former Vice President Al Gore warned us, Climate Scientist Michael Mann warned us, Arctic Researcher Peter Wadhams warned us, David Wasdell warned us, Guy McPherson warned us, Malcolm Light (see next page) warned us, George Erickson warned us, Greta Thunberg warned us, 11,000 scientists warned us, and many others warned us. Yet, most of us carry on our lives as if all is well!

Joe Biden is now our President. He has appointed former Secretary of State John Kerry as his Climate Czar.²⁶ This is good news. The new Administration will be devoted to solving the **Climate Emergency**. They must turn our National Labs and Military (see [dod/climate](https://www.dod.gov/section/climate)) on to the **Climate Emergency** full bore as if their lives depend on it, which they do.



They must bring all the Nations on Earth together to solve the **Climate Emergency**, recognizing that it is our common problem. There already are many groups working on it including the IPCC and the United Nations. We really do need **Planetary Cooperation**. The consequences of failure are beyond anything we have had to think about. All other problems pale in face of the Climate Emergency!

²³ As new people have joined, the wording has changed, but the message is the same.

²⁴ Guy R. McPherson, *Will COVID-19 Trigger Extinction of All Life on Earth?*, 24 Apr 2020; *The Myth of Sustainability*, July 2020, *Earth & Environmental Science Research & Previews*.

²⁵ With the Coronavirus upon us and with it a reduction in activity the concern is now.

²⁶ Punch into your computer “Joe Biden’s Climate Plan” for details.

We are now facing a devastating final show down with Mother Nature, which is being massively accelerated by the filthy extraction of fossil fuels by US and Canada by gas fracking, coal and tar-sand mining and continent-wide bitumen transport. The United States and other developed nations made a fatal mistake by refusing to sign the original Kyoto protocols. The United States and Canada must now cease all their fossil fuel extraction and go entirely onto renewable energy in the next 10 to 15 years, reducing their carbon dioxide emissions by 80% to 90% otherwise they will be guilty of planetary ecocide - genocide by the 2040 - 2050's. There must also be a world-wide effort to capture methane in the Arctic seabed and oceans and eradicate the quantities accumulating in the atmosphere.

Dr. Malcolm Light, Center for Polar Observation and Monitoring, London, 2014

Humanity is facing the final, western corporate capitalist, fossil fuel initiated, catastrophic Arctic methane hydrate destabilization and Permian style methane blowout – firestorm that will culminate in 1 to 4 years (2020 to 2023). We will all be boiled alive like lobsters in a massively humid atmosphere and converted into stardust.

Dr. Malcolm Light, 2019



Malcolm Light

Dr. Malcolm Light states clearly his conclusion that in a few years there will be no life on earth. Who is Malcolm Light? His biography can be found on the Internet. His parents were both meteorologists. He earned a PhD in geology from the University of London and while with the Center for Polar Observation and Monitoring in London spent 12 years studying the Arctic. He has monitored the huge threat that Gulf Stream heat poses in destabilizing Arctic methane hydrates and was first to warn about consequences. While at CPOM among other papers he coauthored with Harold Hensel and Sam Carana the paper listed in a footnote on page 11. He has spent years studying how to remove methane from the atmosphere. His credentials are solid. His work on the most important problem facing humankind is realistic. Why isn't there more news about his finding? It is shocking! Maybe that is why. The fraction of people aware of his finding must be exceedingly small. What warning signs may there be that he is correct? What effect may the coronavirus have on his finding?

More than 11,000 scientists are associated with www.ScientistsWarning.org. In their five-page summary paper I looked for statements about consequences. The most meaningful I found is in a paper that appears in the *Proceedings of the National Academy of Sciences*, August 14, 2018, 115 (33) 8252-8259 authored by Will Steffen (Professor at the Australian National University) and 15 colleagues. Especially worrying, they say, are *potentially irreversible climate tipping points and nature's reinforcing feedbacks (atmospheric, marine, and terrestrial) that could lead to a catastrophic **Hothouse Earth** beyond control by humans*. To avoid such a catastrophe, they say that collective human action is required *"to steer the Earth System away from such a threshold and stabilize it in a habitable interglacial-like state. Such action entails stewardship of the entire Earth System – the biosphere, climate, and societies – and includes decarbonization of the global economy, behavioral changes, technological innovations, new governance arrangements, and transformed social values."* How long will that take?

Now, almost four years after those words were written, we have until recently seen little sign that our leaders have taken heed and we are amid a coronavirus crisis with little being said about the climate. With the election of Joe Biden as President and his appointment of John Kerry as Climate Czar success may be possible. The reduction in traffic due to stay-at-home orders has been expected to reduce carbon dioxide emissions, but carbon dioxide in the atmosphere keeps rising. (See pages 20 & 21.) As Professor Wadhams has pointed out, we must do more than slow the increase of carbon dioxide, we must by some means reduce the amount of CO₂ now in the air. Due to human inertia, it seems possible that we might, like lemmings, follow the path projected by Dr. Light in his 2019 statement. We need to recognize that that is a possible path so that we are clear about what we absolutely must do.

Dahr Jamail, *The End of Ice: Bearing Witness and Finding Meaning in the Path of Climate Disruption*, 2019. In commenting on this book, Bill McKibben said: It is "a reminder of how magical the planet we're about to lose really is." For decades McKibben, founder of 350.org, has been trying to save it!



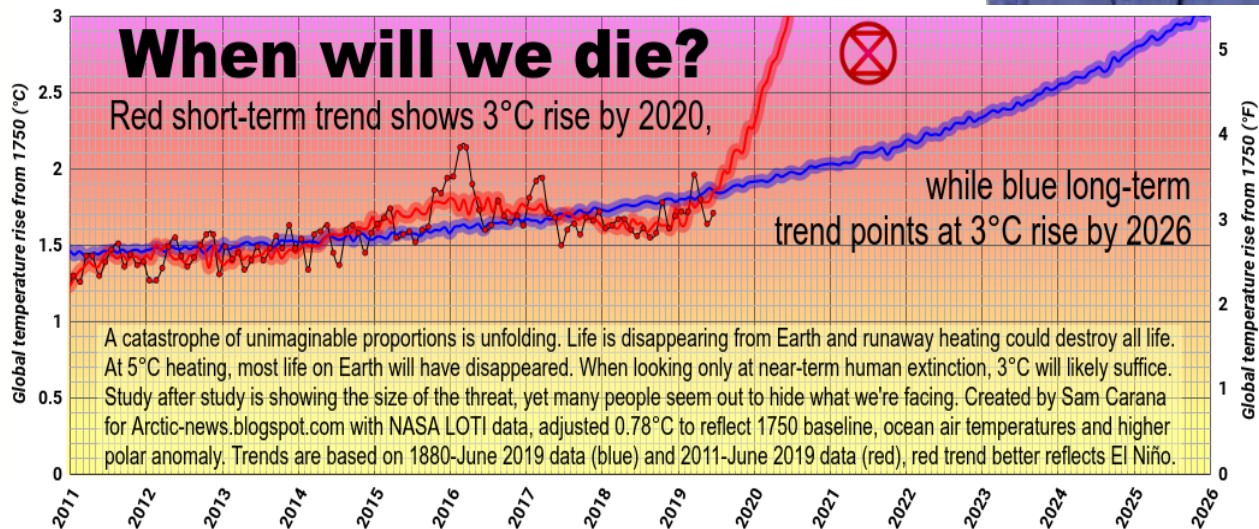
I reread Jonathan Schell's 1982 book *The Fate of the Earth*. Those of us who remember that time recall that President Reagan, based on advice from the Pentagon, proposed that the United States plan to fight and prevail in a six-month-long nuclear war with the Soviet Union. It was a tense period. I wrote a paper then with the title "Nuclear War Fighting means First Strike."²⁷ I gave three reasons why if you do not strike first, you will have no chance to strike second. Jonathan Schell goes on for 231 pages describing in exhaustive detail what terrible things such a war would mean for us. Such a possibility then was the result of five decades of high-tech development, and the fear subsided when the Soviet Union collapsed.

Now, the possible consequence is much worse and involves every country on Earth, this time all together. The current situation is also the result of technological development, in this case advancing slowly over a period of more than 24 decades and, notwithstanding warnings, has seemed by many to be to the benefit of everyone. In the past few decades, the consequences of temperature rise have become sufficient to be worrying, but not yet enough to make the necessary changes. Most folks, it seems, are either unaware of consequences or inhibited from talking about a dire situation. Yet, if we as an entire civilization do not take sufficient action very soon, we will be doomed to pay the terrible price of our **Faustian Bargain**.

Arctic News Blogspot recently began with discussions of 10 tipping points. Days later the tipping point discussion was preceded by an article by Andrew Glikson, Earth and Paleo-climate scientist at the Australian National University. He refers to the current situation as a



Climate Catastrophe.



LET US WAKE UP SOON ENOUGH TO SAVE OURSELVES!

²⁷ ASEE Annual Conference Proceedings, 1983.

We, the undersigned, served Republican presidents, but we have a message that transcends political affiliation: The United States must move now on substantive steps to curb climate change, at home and internationally. There is no longer any credible scientific debate about the basic facts: Our world continues to warm, with the last decade the hottest in modern records, and the deep ocean warming faster than the earth's atmosphere. Sea level is rising. Arctic Sea Ice is melting years faster than projected.

William D. Ruckelshaus, Lee M. Thomas, William K. Riley, and Christine Todd Whitman, former heads of the Environmental Protection Agency under Presidents Nixon, Reagan, George H. W. Bush, and George W. Bush, Aug. 1, 2013 (statement in the *New York Times*)

This statement can be found on page 53 of the book by Jeffrey Bennett entitled *A Global Warming Primer: Answering your Questions about The Science, the Consequences, and the Solutions*.
Big Kid Science, Boulder, CO, 2016.

For current information see www.arctic-news.blogspot.com.

Heat-trapping carbon dioxide in air hits new record high

Published June 5 | Associated Press

KENSINGTON, Md. — The world hit another new record high for heat-trapping carbon dioxide in the atmosphere, despite reduced emissions because of the coronavirus pandemic, scientists announced Thursday.

Measurements of carbon dioxide, the chief human-caused greenhouse gas, averaged 417.1 parts per million at Mauna Loa, Hawaii, for the month of May, when carbon levels in the air peak, the National Oceanic and Atmospheric Administration said. That's 2.4 parts per million higher than a year ago.

Even though emissions of carbon dioxide from the burning of fossil fuels dropped by as much 17% in April, it was a brief decline. Carbon dioxide can stay in the air for centuries, so the short-term reductions of new carbon pollution for a few months didn't have much of a big picture effect, said NOAA senior scientist Pieter Tans.

"It illustrates how difficult it is — what a huge job it is — to bring emissions down," Tans said. "We are really committing the Earth to an enormous amount of warming for a very large time."

Records with direct measurements go back to 1958. And carbon dioxide levels are now nearly 100 parts per million higher than then. That's a 31% increase in 62 years.

"The rise in atmospheric carbon dioxide levels is relentless, and this means the costs of climate change to humans and the planet continue to rise relentlessly as well," said University of Michigan environment dean Jonathan Overpeck.

A/6/2021

Carbon dioxide spikes to critical new record, raising fresh alarms

By MATTHEW CAPPUCCI
and JASON SAMENOW
Washington Post

For the first time in recorded history, the concentration of atmospheric carbon dioxide, or CO₂, was measured at more than 420 parts per million atop the Mauna Loa Observatory on the Big Island of Hawaii. It marks a disconcerting milestone in the continued human-induced warming of the planet, around the halfway point on our path toward doubling pre-industrial CO₂ levels.

The research station, at 11,135 feet elevation on the summit of a picturesque Hawaiian volcano, has been monitoring the weather and chemistry of the atmosphere continuously since the 1950s. Its location allows it to sample some of the purest air available, providing scientists an untainted representation of how humans are irreversibly influencing the climate.

When the station first began collecting CO₂ measurements in the late 1950s, atmospheric CO₂ concentration sat at around 315 parts per million. On Saturday, the daily average was pegged at 421.21 parts per million — the first time in human history that number has been so high. Previously, it had never exceeded 420 parts per million.

“We’re completely certain that the increase in CO₂ is warming the planet,” Kate Marvel, an associate research scientist at Columbia University, wrote in an e-mail. “I’m even more certain CO₂ causes global heating than I am that smoking causes cancer. The world is already more than 2 [degrees F] warmer than it was before the Industrial Revolution.”

In addition to the tem-

perature increase, a warmer atmosphere supports more instances of drought in some areas and flooding rains in others, along with stronger hurricanes and typhoons and the potential for more storms to rapidly intensify in dangerous and unpredictable ways.

Carbon dioxide emissions are a product of electricity production, transportation and industry. The United States alone emits more than 5 billion metric tons of CO₂ annually — the weight of 13.2 million fully loaded Boeing 747s, or roughly 68,000 Washington monuments.

Oceans absorb it, too

About half of emitted CO₂ remains in the atmosphere and induces warming, while more than a quarter is absorbed in the oceans, where it acidifies the water and disrupts marine ecosystems.

There is special significance in reaching and surpassing a concentration of 416 parts per million. It means we’ve passed the midpoint between pre-industrial CO₂ levels of around 278 parts per million, and a doubling of that figure, or 556 parts per million.

The record of 421 parts per million reached Saturday is just a single point and occurred when CO₂ levels are nearing their yearly peak. But the levels over the past two months over 417 parts per million signal that the annual average concentration is likely to exceed 416 parts per million.

“Although ‘halfway to doubled CO₂’ is not of any physical significance, it can nevertheless be considered a milestone that highlights how much humans have already altered the composition of the global atmosphere and increased the amount of a gas that warms the global

climate,” wrote the U.K. Met Office.

The anticipated doubling of atmospheric CO₂, which is likely by 2060, has been connected to a predicted 3 degree or greater warming of the planet.

A study released last year found doubling CO₂ levels will likely lead to a temperature rise of between 4.1 and 8.1 degrees Fahrenheit, ruling out more modest warming scenarios.

Even if greenhouse gas emissions were to plummet overnight, the planet would continue warming for years.

“CO₂ accumulates in the atmosphere,” wrote Zeke Hausfather, a climate scientist at the Breakthrough Institute in California, in an e-mail. “The amount of warming that the world is experiencing is a result of all of our emissions since the Industrial Revolution — not just our emissions in the last year.”

He noted that’s why CO₂ levels at Mauna Loa continued reaching new records despite a brief dramatic reduction in global emissions stemming from the COVID-19 pandemic. Emissions have since returned to near pre-pandemic levels.

Data obtained from glacial ice cores indicates that modern-day CO₂ levels are higher than during any point in at least the past 800,000 years.

Methane also rising

Methane, also a significant driver of the warming climate, has exhibited a “huge and unprecedented increase” too, wrote the British Antarctic Survey. Agriculture, specifically the raising of livestock and manure management, are primary sources of methane in the United States, followed by petroleum and natural gas production, as well as coal

mining and landfills.

Carbon dioxide is roughly eight times more abundant in the Earth’s atmosphere, but methane is more effective at heating the atmosphere.

Sulfur hexafluoride, a greenhouse gas that results from the production of insulators used on electrical grids, also reached all-time records of 10 parts per trillion. While its concentration remains orders of magnitude more dilute than that of most other major greenhouse gases, its rate of increase in the atmosphere has doubled since 2003.

It’s also thousands of times more potent — a single sulfur hexafluoride molecule can cause 23,900 times more warming than a molecule of CO₂. And a single molecule of sulfur hexafluoride can stick around in the atmosphere for more than three millennia.

At the midpoint toward doubling CO₂ levels, the planet has already warmed more than 2 degrees. 2020 rivaled the planet’s hottest year in modern records.

The World Meteorological Organization recently said there is at least a 1-in-5 chance of the global average temperature temporarily exceeding 2.4 degrees by 2024, which the Paris climate accord set out to avoid.

At a speech at Columbia University in December, U.N. Secretary General António Guterres said nations need to cut emissions by at least 6% annually through 2030 to avoid surpassing this 1.5-degree threshold.

“We can’t avoid climate change — it’s already here,” wrote NASA’s Marvel. But “it’s still possible to escape the worst with smart policy that recognizes the scale of the threat and the need for quick action.”