The Climate Change Crisis

A Brief Primer for Educators






CFT *A Union of Educators & Classified Professionals*

The Climate Change Crisis: A Brief Primer For Educators

This brief primer about the climate change crisis is designed to provide a big-picture overview of the topic. The goal is for educators and others to be encouraged to take a more active role in contributing towards positive changes that will build resiliency for our students and labor. Developing ways to adapt to the changes in climate that are already in motion as well as methods to mitigate worsening climate change are part of an essential paradigm shift that will provide students, labor, and to a larger extent, humanity, the greatest opportunity to have a healthy, productive, and sustainable future.

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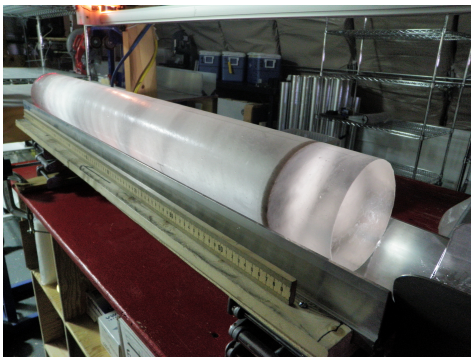
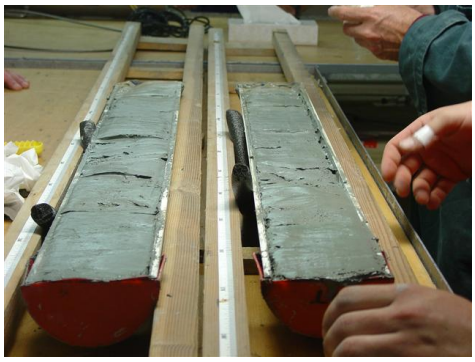
How Do We Know It Is Happening? (The Evidence)

That climate change is happening, and with a virulence that is cause for alarm, has been recognized through a wealth of empirical scientific data collected and analyzed over the past century from independent studies all over the world.

Even without diving into the scientific literature however, everyday informal observations by people noticing change in their own lifetime further contribute to the overwhelming conclusion that a climate change crisis is upon us. The fact that significant change can now be observed within a person's lifetime and at the scale of human memory is acknowledged in current scientific research that has shown the rate of change in Earth's environmental systems over just the past few decades is, in a number of instances, exponentially greater than the change observed over the century before.

Have you noticed fewer bugs on the windshield of your car in summer while driving on rural roads, hotter days in summer, more extreme droughts and wildfires, or more dramatic flooding? These and other changes noticed in the context of everyday life have been linked to trends identified through scientific research that are a consequence of climate change.

Regarding empirical scientific data, key datasets that have provided a wealth of understanding about our changing climate include sediment and ice cores obtained from drilling into the sea floor and ice sheets.

Left: Ice core drilling from Combatant Col, British Columbia, Credit: Doug Clark, Univ. of Washington, Source: LINK, accessed Fall 2019; Middle: An ice core from the West Antarctic Ice Sheet Divide showing a dark band of volcanic ash from 21,000 years ago, Credit: Heidi Roop, NSF, Source: LINK, accessed Fall 2019; Right: An Antarctic Geological Drilling (ANDRILL) project ocean sediment core, Credit: NSF, Source: LINK, accessed Fall 2019)

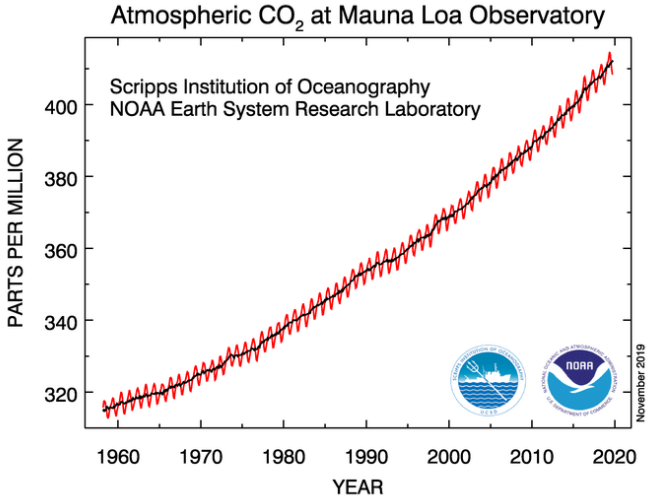
Based on the premise that newer materials accumulate on top of older materials, a fundamental law of Geology called the Law of Superposition, ice and sediment cores contain a rich history of past climate on planet Earth, including data about atmospheric temperature and composition, past sea levels, the extent of deserts, volcanic activity, forest fires, and precipitation. (LINK, accessed Fall 2019). Ice core data has revealed information about past climate extending as far back as 500,000 years ago, while sediment core data has enabled scientists to understand conditions as far back as 200 million years ago.

Confidence in the data is enhanced when compared to other research such as volcanic ash deposits around the world, fossil records of past mass extinctions and explosions of life, and tree-ring data from the science of dendrochronology to name a few.

Regarding past mass extinctions when the biosphere has seen major losses, including species extinction and loss of the abundance of life, five events over the past 500 million years of time all have some striking similarities. Those similarities include a loss of the majority of the more complex living organisms that were alive at the time. Moreover, all five previous events involved abrupt climate change, major fluctuations in the carbon cycle and carbon content of the atmosphere, and rapid changes in ocean chemistry — all of which are characteristics of our current climate change crisis to some degree. This suggests, and is substantiated by current research on the loss of species and abundance, that Earth is facing a sixth mass extinction now. It is also the premise for the dawn of a new geologic time epoch, shifting us out of the Holocene and into the Anthropocene, a period defined by major changes to a number of Earth system process due to human activity that is of a magnitude comparable to the effects of natural processes. Humans are now a geologic force.

In addition to the historic record of past climate on planet Earth, modern-day observations and research have enabled scientists to understand how climate is changing today. Temperature measurements of the ocean and atmosphere have been recorded around the world with some records extending a century or longer, and in some cases with a continuous record of direct observation daily. Those datasets reveal an increase in global average temperatures. In addition, greenhouse gas concentrations have been monitored for changes.

The Scripps Institute of Oceanography in Southern California in concert with the National Oceanographic and Atmospheric Administration's (NOAA) Earth Systems Research Laboratory has been monitoring concentrations of one of the primary greenhouse gases in the atmosphere, carbon dioxide (CO_2), since 1958 at an observatory at Mauna Loa in Hawaii. Direct measurements have provided a window into the unprecedented rate of CO_2 increase since the latter half of the 20th century, revealing a magnitude greater than at any previous point in time in human history.



Graph showing the change in CO_2 concentrations in the atmosphere, as recorded at Mauna Loa Observatory in Hawaii, expressed in parts per million (PPM) concentration, for the period 1958-2019. Source: Earth Systems Research Laboratory, NOAA. (LINK, accessed Fall 2019)

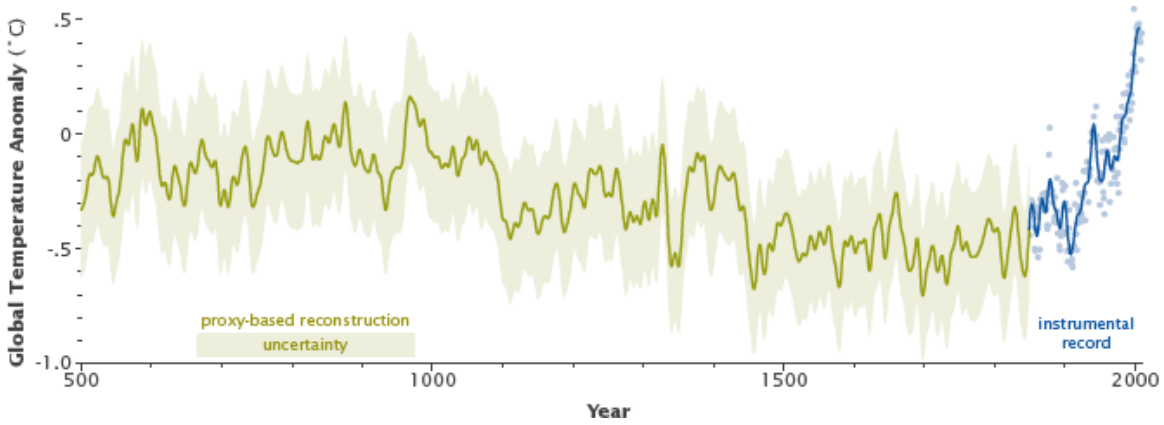
What was considered to be a maximum safe concentration limit that would maintain Earth systems in a functioning capacity comparable to that which civilization developed without major catastrophic consequences, a concentration of 350 PPM, was surpassed in 1988. Since that time, the rate of increase has accelerated, and the concentration of CO_2 in the atmosphere has surpassed 410 PPM.

It is through these foundational datasets, including historic records such as those from ice and sediment cores combined with the research based on modern-day direct observations, that the overwhelming consensus of the scientific community is that climate change is currently happening, and at a pace and magnitude that is cause for great and immediate concern, with significant impacts to life, property, and the environment happening now, and continuing to get significantly worse within a span of time that no longer references only future generations, but rather also the current population.

What Makes it a "Crisis"? (The Urgency)

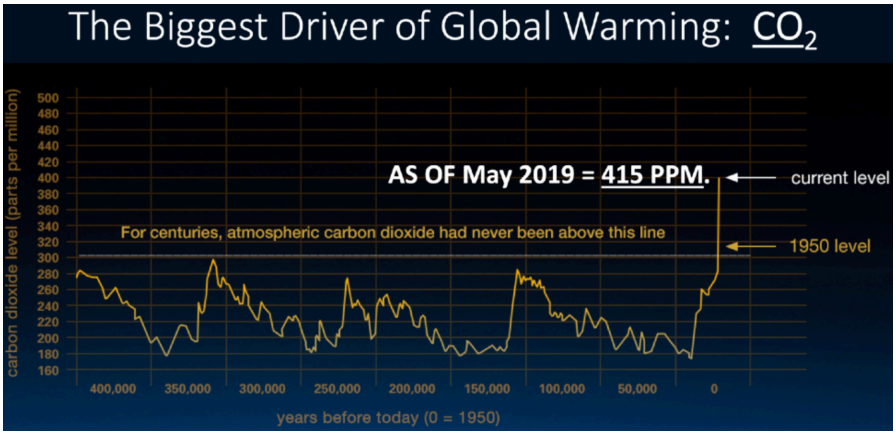
Modern research involving direct observation of the climate today and over the past century have revealed sudden and rapid changes over the latter half of the 20th century and continuing into the first two decades of the 21st century. The exponential increases in key indicators of the occurrence of climate change, even when just looking at the period of the first two decades of the 21st century, show rates of change in CO_2 concentrations and global average temperature increase to levels beyond that which has existed in human history.

According to NASA's Earth Observatory, the accelerated pace of increased greenhouse gas concentrations in the atmosphere has translated to an increase in global average temperature, now at levels warmer than it has been in at least the past 1,000 years. When global warming has happened at various times in the past two million years, it has taken the planet about 5,000 years to warm 5 degrees. The predicted rate of warming for the next century is at least 20 times faster than at any previous time in the past 2 million years. (LINK, accessed Fall 2019)



Graph showing the past 1,500 years of temperature variation, including reconstructed and instrument-record data, indicating that global average temperatures now are higher than they have been in the past 1000 years or more. Graph adapted from Mann et al., 2008). Source: NASA Earth Observatory (LINK, accessed Fall 2019).

Carbon dioxide concentrations have seen similar dramatic increases over the last several decades as well. Current levels of atmospheric CO_2 concentration are higher than at any time in approximately the past 3 million years. According to NASA, over the past 650,000 years, seven cycles of glacial advance and retreat have occurred, coinciding with changes in climate that are likely a response to small variations in Earth's orbit influencing the amount of sunshine Earth received. However, the current warming trend is a result of human activity and mostly from the 1950s onward. The rate at which CO_2 concentrations have increased since the 1950s is unprecedented over decades to millennia (LINK, accessed Fall 2019).

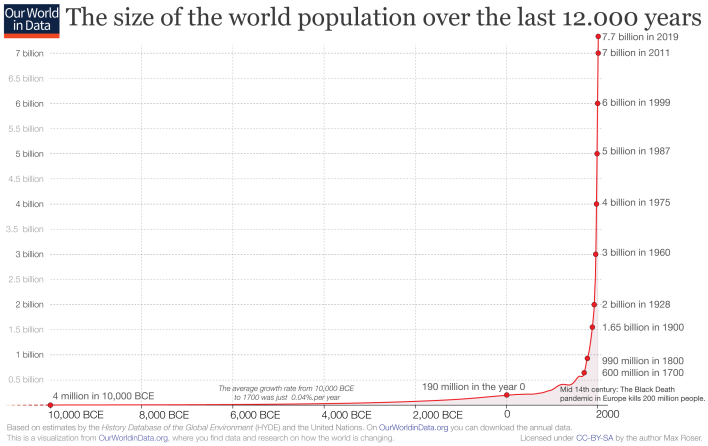


Graph indicating levels of carbon dioxide concentration in the atmosphere over the last 400,000 years. Source: NASA (LINK, accessed Fall 2019)

While the rates of CO_2 and temperature increase observed over the last several decades is certainly alarming, even more concerning is how just in the second decade of the 21st century, record-level global temperature and CO_2 concentrations have been broken year-over-year. At the same time this is happening, the sources of human-caused emissions of CO_2 have continued to skyrocket. And, based on resonance times of atmospheric CO_2 and the lag in time that warming occurs once CO_2 gets into the atmosphere, we are doomed to see continued global warming based on current CO_2 levels, a likely situation even if we stopped emitting CO_2 today.

Despite that grim reality, projections show the world is on-track to increase CO_2 emissions continuing at least through the third decade of the 21st century. This is, of course, in spite of the global recognition of the problem and need to curtail greenhouse gas emissions immediately.

There are a number of challenges that are creating barriers to immediately addressing greenhouse gas emissions. Among them, the exponentially growing global population, with much of that growth occurring in China, has resulted in a growing demand for energy to satisfy the needs of that population.



Global population graph over the last 12,000 years indicating exponential human population growth over the last several centuries. As of 2019, global population had reached 7.7 billion. Source: (LINK, accessed Fall 2019)

Population is projected to continue to grow exponentially, with 2019 United Nations estimates approaching 10 billion people by 2050 and 11 billion by 2100. Even with the expansion of green energy sources, the demand for energy from fossil fuels continues to increase, resulting in growing emissions of greenhouse gases.

Coupled with overall population growth, additional demands for more energy are coming from the major shift of populations around the world from rural environments where energy demands are low per capita to urban living environments where energy demands per capita are exponentially higher. Estimates indicate that 80% of the world population will live in cities by 2050. To get there, cities around the world are growing at extraordinary rates, as estimates indicate globally one to three million people are moving from rural to urban environments every two months as of 2019.

The combination of factors mentioned here that are contributing to an accelerated pace of unprecedented change bring into sharp focus the malignancy of the crisis we face. Worse, results of recent research have further exacerbated the concern about our sobering situation — that some of the scientific models used to predict and understand such change are being found to potentially under-estimate significantly the time horizon until catastrophic events become commonplace, and/or the magnitude, intensity, and/or duration of those extreme events becomes intolerable.

What is the cause for such under-estimation? When consequences of climate change begin to contribute to further degradation of Earth's natural systems, positive feedback mechanisms can accelerate the pace of change beyond what the best predictive models could anticipate. Such mechanisms can alter the very foundational controls that are otherwise held constant in those models.

A good example of a positive feedback mechanism can be observed in the conifer forests of Western North America. As climate change has increased the average temperatures and length of summer, the longer and warmer summer season has provided opportunity for bark beetle populations to grow significantly larger and expand their range. Bark beetles bore into trees and inject a fungus that consequently stops the tree from moving sap, ultimately killing the tree.

In addition to the longer and warmer summer, more severe drought has weakened the ability of conifers to survive beetle infestations. Coupled with fire suppression practices over the years that have preserved populations of beetles, the beetle populations have grown at unprecedented rates, and have been killing off millions of acres of trees with extraordinary swiftness.

Left: Forest of dead trees due to bark beetle infestation. Middle: Close-up of a bark beetle. Right: Map of extent of beetle infestation in Western North America. Source of all 3 images: New York Times (LINK, accessed Fall 2019)

With British Columbia already having lost 33 million acres of lodgepole pine forest and virtually all 5 million acres of Colorado's forests of the same species gone, huge regions of North

America that once were a sink of CO_2 as trees absorbed the gas are now decaying and releasing CO_2. The shift of these forests from a carbon sink to a carbon source is troublesome, as now the forests are contributing to global warming, further exacerbating the problem in a positive feedback loop.

There are many other positive feedback mechanisms from melting permafrost to ocean dead zones to melting sea ice that are equally as concerning. The current climate change crisis is certainly the defining issue of our time and will require a paradigm shift in the relationship between humans and Earth systems that is immediate and comprehensive.

What Are the Consequences? (The Effects)

Since the 1970s, there has been some degree of widespread scientific concern for the potential effects of climate change on Earth systems. Many of the concerns were associated with the effects on natural systems, and the impacts to ecosystems with questions about future sustainability. The plight of the polar bear in the midst of declining Arctic sea ice became a symbol characterizing the focus of concern.

Perhaps to some degree, a sense of complacency by detaching the practical implications of understood changes inhibited an immediate response to concerns for the future of humanity and the consequences for future generations. If the concern was for impacts to future generations in centuries to come, or for species in far-removed locales, the paralyzing effects of an overwhelming problem bigger than the scale comprehendible or relatable to individuals perpetuated a paralysis to any comprehensive action.

Moreover, powerful political and economic forces profiting in a fossil-fueled economy showed little interest in rushing to conclusions about climate change, let alone promoting immediate action. In fact, some of those same forces intentionally spread doubt about climate change through maliciously-crafted propaganda.

By the early 2000s, the rates of change became so accelerated, and the effects of an already changing climate manifested in direct impacts to humans around the world so profoundly that a new reality of consciousness began to unfold. No longer did the concern for the effects of climate change belong to future generations or other species. The climate crisis became a crisis of humanity, of those living today, with extraordinary changes having catastrophic impacts on people around the world.

With global increases in temperature, humans begin to suffer from mental and physical health effects that have a range of consequences from reduced productivity to serious health problems or even death. People, communities, and even infrastructure can be impacted from the noted increased frequency and intensity of heat waves, both of which have increased in a number of places around the planet, including the United States, since the 1970s.

Global warming has also led to significant and accelerated melting of ice globally, including major reductions in Arctic and Antarctic sea ice. The subsequent addition of large volumes of water to oceans has resulted in sea level rise, and will continue to do so with estimates of as much as 3.5 feet of rise or more by 2100. Such increases in sea level will have profound impacts on people. Major populations of people around the world live at or near sea level in coastal cities. Within conservative estimates of sea level rise by 2100, well over half a billion people will be displaced from coastal low-lying cities.

As sea level inundates low lying cities, not only are people displaced, but infrastructure built in those same coastal zones could be rendered useless. That could include everything from power plants to water treatment facilities to sanitation systems — the very systems that people will be even more dependent upon in the face of a crisis.

Sea level rise has already had impacts when coupled with storm surges and high tides. The city of Venice, Italy has experienced more frequent flooding than ever before, with the worst flooding the city had experienced in the prior 50 years occurring in November 2019. That record is likely to be broken again soon. In California, the low-lying coastal town of Imperial Beach has already noted more frequent and extensive flooding in the past several decades.

Climate change has already put enormous pressures on natural ecosystems, with extraordinary losses of abundance and species extinctions. For example, in the United States, Monarch butterfly populations have declined by over 90 percent (a loss of 900 million individuals) in the first two decades of the 21st century. The Rusty-Patched bumblebee populations declined by 87 percent over the same time period, while the world's largest King penguin colony withered to only 12 percent of the population over a 35 year period. Another study on 529 bird species in North America discovered that populations fell by 29 percent, or a lost of almost 3 billion birds since 1970.

As major declines in insects are continuing to occur, the viability of the world's pollinators responsible for insuring that a large portion of the planet's flowering plants are able to reproduce and continue to survive are suddenly put into question. Those plants are the basis of food for most life, including humans.

Already, food insecurity is become an even bigger concern amidst the climate crisis. Climate change has created enormous challenges to the future sustainability of our industrial food production system according to the United Nations. Our assumptions about the availability of water, about the range of temperatures expected in various agricultural regions, and that pollinators will show up to do their part, are all put into question amidst the current climate crisis. In response to food and water insecurities, people have been forced to flee regions to escape extreme drought and lack of available food and water. These people are climate refugees.

Human displacement and migration will likely become much more prevalent and people escape extreme heat, repeated flooding, extensive drought, and wildfires.

The charred remains of a neighborhood in Paradise, CA after the Camp Fire of November 2018. (Photo by Josh Edelson/ AFP - Getty Images File. Source: NBC News (LINK, accessed Fall 2019)

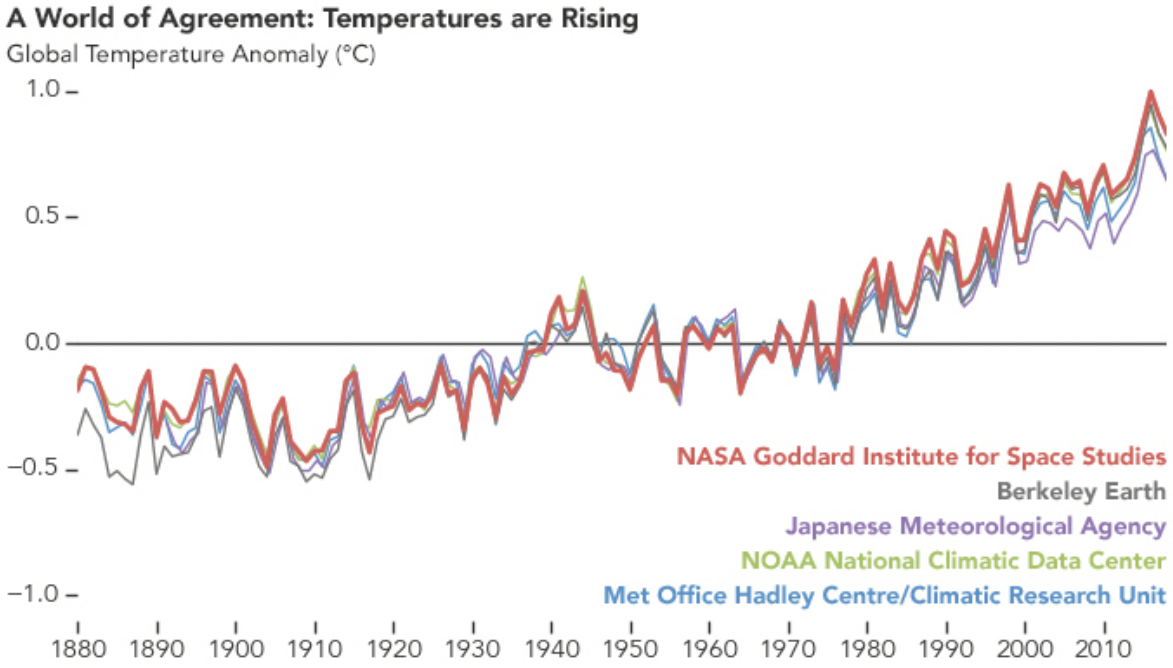
Natural disasters such as hurricanes, drought, flooding, and wildfires will likely become more extreme in terms of frequency, duration, and intensity in response to climate change.

While the effects of the climate change crisis are far reaching and will only get worse, especially without immediate action to drastically reduce greenhouse gas emissions, major impacts are already happening directly to humans with profound consequences.

We are out of time. It is no longer about "stopping climate change". It is too late for that. Any hope for humanity lies in quickly adjusting through a full-scale cultural paradigm shift in the way we live and interact with Earth systems, coupled with efforts to adapt to a changing climate.

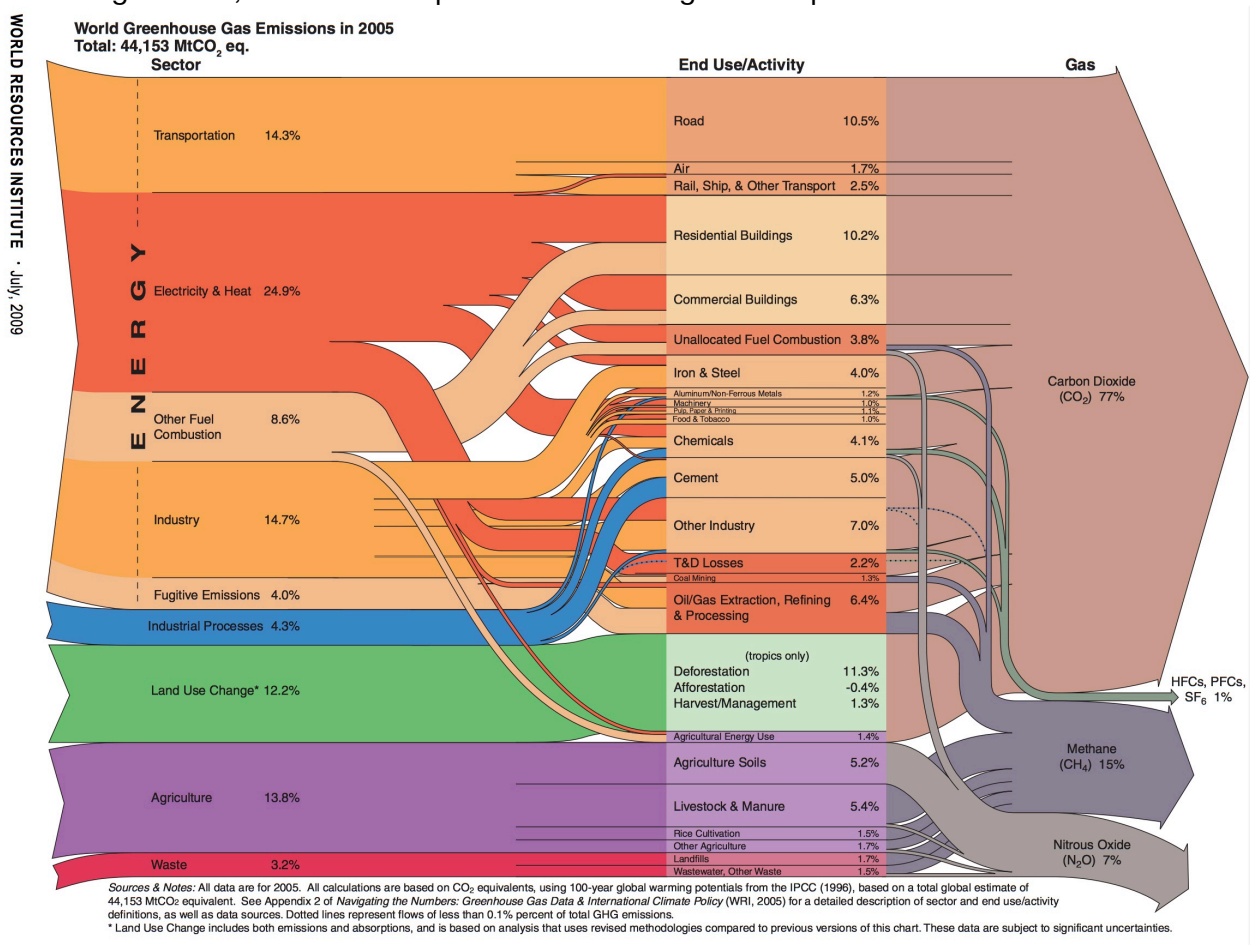
Can We Trust The Data? (Scientific Consensus)

Independent scientific research from all over the world provides overwhelming consensus that not only is climate change happening currently, but that it is happening at a pace faster than at any previous time in the history of modern civilization. More importantly, the consensus also shows that the current climate crisis is primarily a result of human activities, and without immediate changes to how humans interact with the environment, irreversible disastrous consequences for humanity are likely coming, with effects continuing to impact people as early as the coming decades, and certainly within this century.



The above graph indicates global temperature anomaly in degrees C from 1880 to 2018. While 2016 was the warmest year throughout the entire 139-year record, even more alarming is that the ten warmest years in the entire record all have occurred since 2005, and the five warmest years are the most recent five years. This indicates the accelerated pace of warming to now unprecedented rates. All of the independent data sources plotted on the graph agree on these trends. Credit: NASA's Earth Observatory

Some of the main contributions of human activity to climate change include the combustion of fossil fuels and subsequent emission of greenhouse gases for the production of energy (transportation, electricity and heat, industry, etc.), land use change including deforestation, animal agriculture, and industrial processes including cement production.



The diagram above indicates sources of global greenhouse gas emissions as of 2005. Credit: World Resources Institute, July 2009.

The state of California's Governor's Office of Planning and Research maintains a list of over 200 global scientific organizations that hold the position that human activity is causing the current climate change crisis (Link, accessed Fall 2019).

In addition, direct research on the scientific consensus about climate change has been conducted, including a publication in IOP Publishing entitled, "Consensus on Consensus: A Synthesis of Consensus Estimates on Human-Caused Global Warming" (Cook et al, 2016). This research indicates that the scientific consensus about humans causing recent global warming is between 90 and 100 percent, and also cites other research that indicates consistency on the consensus being 97 percent.

The level of confidence that climate change is happening and that it is human-induced is so high that it is as reliable as well-established scientific theories such as the theory of plate tectonics. As such, educators can move forward with presenting the topic with confidence in the same manner that other basic scientific principles are taught. That is, educators can play an important role in moving the narrative forward from concern about having to debate climate

change to focusing on action-oriented mitigation and adaptation given that it is an accepted reality. This new context puts into perspective how the topic of climate change no longer warrants debate in the same manner as the topic of whether the Earth is flat or a sphere warrants no more obligation on the part of the educator to address, other than perhaps to point out the basis for why the conversation is moving forward given the overwhelming consensus.

What Can We Do As Educators? (Crisis Response)

The threats presented by the climate crisis are serious, overwhelming, and have created a situation more urgent than ever before. Moreover, the pace at which the situation is worsening and the growing magnitude of the problem are so alarming that any attempts to get ahead of the problem have thus far been inconsequential.

California has a rich history of being a leader in research, education, and innovation in identifying the need for, and implementing, environmental protections. With one of the best educational systems in the United States, if not the world, California is uniquely poised to take a leading role in climate change education.

Because climate change is progressing at an unprecedented rate, the time to initiate such a leadership role in climate change education in California is now. And, that includes a focus on the development of climate change literacy throughout our educational system, beginning with kindergarten through Community College to promote an informed and better-prepared citizenry to be able to cope with the significant challenges to come.

Furthermore, as California educators, we should consider it a moral obligation to convey to students in our classes the urgency and severity of the problem along with solutions to empower students to contribute to a sustainable future. After all, how well are we preparing students for their future if they are not learning in school about how to adapt to the impending effects of climate change and how to contribute towards solutions?

Our best chance of responding to the urgent need to take action in the face of the climate crisis is by initiating climate literacy in our schools immediately. Certainly, the topic of climate change is not reserved for science classrooms. Rather, a comprehensive approach towards developing climate change literacy would include the incorporation of the topic across disciplines and into all classrooms. The subject should be ubiquitous within the curricula, within school activities, and integrated into all aspects of what we do at our institutions. A short list of ideas about how to begin developing climate change literacy is provided as a starting point for consideration.

1. Develop curriculum, including new courses.

2. Work with counterparts at the state level to adopt articulation agreements and core curriculum.

3. Introduce the topic to your class (regardless of discipline).

4. Create a club on your campus.

5. Help develop and implement a local school board resolution on climate change literacy or climate change action.

6. Develop a one-campus theme about climate change.
7. Invite speakers/experts to your campus for a talk on climate change related issues.
8. Participate in activities/demonstrations/calls to action.
9. Partner with local climate change/environmental organizations.
10. Provide colloquia and public events to educate the community.
11. Develop best practices for how to integrate sustainability and climate change solutions into school operations.

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