

Name:

Period:

CLIMATE CHANGE

Honors Research Packet



Research Question

- What is climate change?
- What facts are important for understanding climate change?
- What kinds of laws and regulations are people recommending to help combat climate change?
- What are the opinions of people who disagree with the laws and regulations suggested?
- What is your opinion on the issue?

ARTICLE 1

WHAT ARE CLIMATE AND CLIMATE CHANGE?

By Dan Stillman | December 18, 2016

The climate of a region or city is its typical or average weather. For example, the climate of Hawaii is sunny and warm. But the climate of Antarctica is freezing cold. Earth's climate is the average of all the world's regional climates.

Climate change, therefore, is a change in the typical or average weather of a region or city. This could be a change in a region's average annual rainfall, for example. Or it could be a change in a city's average temperature for a given month or season.

Climate change is also a change in Earth's overall climate. This could be a change in Earth's average temperature, for example. Or it could be a change in Earth's typical precipitation patterns.

What Is The Difference Between Weather And Climate?

Weather is the short-term changes we see in temperature, clouds, precipitation, humidity and wind in a region or a city. Weather can vary greatly from one day to the next, or even within the same day. In the morning the weather may be cloudy and cool. But by afternoon it may be sunny and warm.

The climate of a region or city is its weather averaged over many years. This is usually different for different seasons. For example, a region or city may tend to be warm and humid during summer. But it may tend to be cold and snowy during winter.

The climate of a city, region or the entire planet changes very slowly. These changes take place on the scale of tens, hundreds and thousands of years.

Is Earth's Climate Changing?

Earth's climate is always changing. In the past, Earth's climate has gone through warmer and cooler periods, each lasting thousands of years.

Observations show that Earth's climate has been warming. Its average temperature has risen a little more than 1 degree Fahrenheit during the past 100 years or so. This amount may not seem like much. But small changes in Earth's average temperature can lead to big impacts.

What Is Causing Earth's Climate To Change?

Some causes of climate change are natural. These include changes in Earth's orbit and in the amount of energy coming from the sun. Ocean changes and volcanic eruptions are also natural causes of climate change.

Most scientists think that recent warming can't be explained by nature alone. Most scientists say it's very likely that most of the warming since the mid-1900s is due to the burning of coal, oil and gas. Burning these fuels is how we produce most of the energy that we use every day. This burning adds heat-trapping gases, such as carbon dioxide, into the air. These gases are called greenhouse gases.

What Is The Forecast For Earth's Climate?

Scientists use climate models to predict how Earth's climate will change. Climate models are computer programs with mathematical equations. They are programmed to mimic past climate as

accurately as possible. This gives scientists some confidence in a climate model's ability to predict the future.

Climate models predict that Earth's average temperature will keep rising over the next 100 years or so. There may be a year or years where Earth's average temperature is steady or even falls. But the overall trend is expected to be up.

Earth's average temperature is expected to rise even if the amount of greenhouse gases in the atmosphere decreases. But the rise would be less than if greenhouse gas amounts remain the same or increase.

What Is The Impact Of Earth's Warming Climate?

Some impacts already are occurring. For example, sea levels are rising and snow and ice cover is decreasing. Rainfall patterns and growing seasons are changing.

Further sea-level rise and melting of snow and ice are likely as Earth warms. The warming climate likely will cause more floods, droughts and heat waves. The heat waves may get hotter and hurricanes may get stronger.

What Is The Difference Between "Climate Change" And "Global Warming"?

"Global warming" refers to the long-term increase in Earth's average temperature.

"Climate change" refers to any long-term change in Earth's climate or in the climate of a region or city. This includes warming, cooling and changes besides temperature.

How Does NASA Study Climate Change?

Some NASA satellites and instruments observe Earth's land, air, water and ice. Others monitor the sun and the amount of energy coming from it. Together, these observations are important for knowing the past and present state of Earth's climate. They are important for understanding how Earth's climate works. And they are important for predicting future climate change.

What Is Being Done About Climate Change?

The United States and other countries are taking steps to limit or reduce greenhouse gases in the atmosphere. These steps include using energy more efficiently and using more clean energy. Clean energy is energy that puts less or no greenhouse gases into the atmosphere. The sun, wind and water are sources of clean energy.

Many nations, states and communities are planning for climate change impacts that may be unavoidable. For example, some coastal areas are planning for flooding and land loss that may result from rising sea levels.

What Can You Do to Help?

You can help by using less energy and water. For example, turn off lights and TVs when you leave a room. And turn off the water when brushing your teeth. You can help by planting trees, which absorb carbon dioxide from the atmosphere.

Another way to help is by learning about Earth and its climate. The more you know about how Earth's climate works, the more you'll be able to help solve problems related to climate change.

ARTICLE 2

HUMANS CAUSE CLIMATE CHANGE 170 TIMES FASTER THAN NATURAL FORCES

By Melissa Davey | February 12, 2017

For the first time, researchers have developed a mathematical equation to describe the impact of human activity on the earth, finding people are causing the climate to change 170 times faster than natural forces. The equation was developed in conjunction with Professor Will Steffen, a climate change expert and researcher at the Australian National University, and was published in the journal *The Anthropocene Review*.

The authors of the paper wrote that for the past 4.5bn years astronomical and geophysical factors have been the dominating influences on the Earth system. The Earth system is defined by the researchers as the biosphere, including interactions and feedbacks with the atmosphere, hydrosphere, cryosphere and upper lithosphere. But over the past six decades human forces "have driven exceptionally rapid rates of change in the Earth system," the authors wrote, giving rise to a period known as the Anthropocene.

"Human activities now rival the great forces of nature in driving changes to the Earth system," the paper said. Steffen and his co-researcher, Owen Gaffney, from the Stockholm Resilience Centre, came up with an "Anthropocene Equation" to determine the impact of this period of intense human activity on the earth. Explaining the equation in *New Scientist*, Gaffney said they developed it "by homing in on the rate of change of Earth's life support system: the atmosphere, oceans, forests and wetlands, waterways and ice sheets and fabulous diversity of life".

"For four billion years the rate of change of the Earth system has been a complex function of astronomical and geophysical forces plus internal dynamics: Earth's orbit around the sun, gravitational interactions with other planets, the sun's heat output, colliding continents, volcanoes and evolution, among others," he wrote. "In the equation, astronomical and geophysical forces tend to zero because of their slow nature or rarity, as do internal dynamics, for now. All these forces still exert pressure, but currently on orders of magnitude <human impact." According to Steffen these forces have driven a rate of change of 0.01 degrees Celsius per century.

Greenhouse gas emissions caused by humans over the past 45 years, on the other hand, "have increased the rate of temperature rise to 1.7 degrees Celsius per century, dwarfing the natural background rate," he said. This represented a change to the climate that was 170 times faster than natural forces. "We are not saying the astronomical forces of our solar system or geological processes have disappeared, but in terms of their impact in such a short period of time they are now negligible compared with our own influence," Steffen said.

"Crystallising this evidence in the form of a simple equation gives the current situation a clarity that the wealth of data often dilutes. "What we do is give a very specific number to show how humans are affecting the earth over a short timeframe. It shows that while other forces operate over millions of years, we as humans are having an impact at the same strength as the many of these other forces, but in the timeframe of just a couple of centuries.

"The human magnitude of [climate change](#) looks more like a meteorite strike than a gradual change." Gaffney and Steffen wrote that while the Earth system had proven resilient, achieving millions of years of relative stability due to the complex interactions between the Earth's core and the biosphere, human societies would be unlikely to fare so well. Failure to reduce anthropological climate change could "trigger societal collapse", their research concluded.

ARTICLE 3

THE UNPREDICTABLE HUMAN FACTOR

By Justin Gillis | September 19, 2017

As Hurricane Harvey bore down on the Texas coast, few people in that state seemed to understand the nature of the looming danger.

The bulletins warned of rain falling in feet, not inches. Experts pleaded with the public to wake up. J. Marshall Shepherd, head of atmospheric sciences at the University of Georgia and a leading voice in American meteorology, wrote ahead of the storm that "the most dangerous aspect of this hurricane may be days of rainfall and associated flooding."

Now we know how events in Texas turned out.

Dr. Shepherd and his colleagues have spent their careers issuing a larger warning, one that much of the public still chooses to ignore. I speak, of course, about the risks of climate change.

Because of atmospheric emissions from human activity, the ocean waters from which Harvey drew its final burst of strength were much warmer than they ought to have been, most likely contributing to the intensity of the deluge. If the forecasts from our scientists are anywhere close to right, we have seen nothing yet.

In their estimation, the most savage heat waves that we experience today will likely become routine in a matter of decades. The coastal inundation that has already begun will grow worse and worse, forcing millions of people to flee. The immense wave of refugees that we already see moving across continents may be just the beginning. Scientists urged decades ago that we buy ourselves some insurance by cutting emissions. We yawned. Even today, when millions of people have awakened to the danger, tens of millions have not. So the political demand for change is still too weak to overcome the entrenched interests that want to block it.

In Washington, progress on climate change has stalled. The administration has announced its intent to withdraw from the global Paris climate accord. And top Trump appointees insist that the causes of climate change are too uncertain and the scientific forecasts too unreliable to be a basis for action.

This argument might have been halfway plausible 20 years ago -- or, if you want to be generous, even 10 years ago. But today?

Today, salt water is inundating the coastal towns of the United States, to the point that they are starting to put giant rulers in the intersections so people can tell if it is safe to drive through. The city leaders are also posting "no wake" signs -- not on canals but on the streets, to stop trucks from plowing through the water so fast as to send waves crashing into nearby homes.

We all see the giant storms, more threatening than any in our lifetimes -- and while scientists are not entirely comfortable yet drawing links between the power of these hurricanes and climate change, many people are coming to their own common-sense conclusions.

As the challenges in the real world worsen, some senior Republicans continue to question the link between human-caused emissions and rising temperatures. Scott Pruitt, the head of the Environmental Protection Agency, said this on CNBC in March:

"I think that measuring with precision human activity on the climate is something very challenging to do and there's tremendous disagreement about the degree of impact, so no, I would not agree that it's a primary contributor to the global warming that we see." Note that he acknowledges the planet is warming. Note that he offers no alternative hypothesis about the cause of that warming -- nor will he ever, for the simple reason that there is no plausible alternative. But still, he clings to uncertainty as a reason to do nothing.

To be sure, fair-minded people can and should ask: What are the real uncertainties? They exist in climate science, and despite claims to the contrary made by climate denialists, nobody hides them. You can spend long days at conferences, as I have, hearing from the scientists themselves about all the error bars of their studies and all the weak points of their computer models.

We are not entirely sure, for instance, how much the planet will warm in response to a given level of emissions. That is a pretty basic question, and the inability of climate science to narrow it down has been one of the great frustrations of the field these past few decades.

In the 1970s, the experts made a best guess about how sensitive the Earth would be to greenhouse gases, and as evidence accumulates, that early estimate is holding up pretty well. Forecasts from the 1980s and 1990s about the rate of warming have proven fairly accurate, too, give or take 20 percent.

In fact, to the degree our scientists have made a systematic error, it has been to understate how quickly things would unravel.

The sea ice in the Arctic is collapsing in front of our eyes. Even more ominously, land ice is melting at an accelerating pace, threatening a future rise of the sea even faster than that of today.

Huge forest die-offs are beginning, even as the remaining forests work overtime to suck up some of the carbon pollution that humans are pumping out. We are already seeing heat waves surpassing 120 degrees Fahrenheit, sooner than many experts thought likely. Yet, it is true, the list of uncertainties is still long and vexing. Scientists have trouble, for instance, turning their broad global forecasts into specific predictions for a given locality. Want to know what the average temperature is going to be in Athens, Ga., in 2050? Wonder how the Asian monsoon, whose rains feed billions, will hold up in the 2070s? Those forecasts exist, but even the scientists who made them are not going to advise you to put much stock in them.

Yet here is the crucial point, and one you never hear the climate denialists own up to: the uncertainties cut in both directions.

Every time some politician stands up and claims that climate science is rife with uncertainties, a more honest person would add that those uncertainties could just as easily go against us as in our favor.

And if they do go against us? We might be looking at, oh, 80 or 100 feet of sea-level rise in the long haul, a direct result of the failures of this generation to get emissions under control. What kind of shape do you think Miami -- or for that matter, New York -- is likely to be in after 80 feet of sea-level rise?

The truth is that the single biggest uncertainty in climate science has nothing to do with the physics of the atmosphere, or the stability of the ice, or anything like that. The great uncertainty is, and has always been, how much carbon pollution humans are going to choose to pump into the air.

In fact, calculations have been run on this. If you want, say, a forecast for global temperature in 2100, the uncertainty about how much pollution we will spew out is at least twice as large as any uncertainty about the physical response of the climate to those emissions.

So despite arguments like Mr. Pruitt's, a century of climate science has brought us to the point where we can say this definitively: We are running enormous risks. We are putting nothing less than the stability of human civilization on the line.

And yet most of us have still not bestirred ourselves to care, much less to march in the streets demanding change. We are like the people in Texas who did not take those flood warnings seriously enough, except that the stakes are so much larger.

Is this failure to act the legacy our generation wants to leave for the generations yet to come?

ARTICLE 4

CLIMATE CHANGE IS NOT RESPONSIBLE FOR MORE HURRICANES

By Whitt Flora | September 11, 2017

The writers and talkers at elite East Coast media outlets — The New York Times, Washington Post, NBC, CNN and their many associates — wasted no time in rushing to judgment.

Heavy rains were still flooding a huge area of southeast Texas when the media proclaimed Hurricane Harvey a prime example of devastating climate change.

They received standing applause from Al Gore and his group of federally funded climate doomsayers across the country. But they were jarringly wrong.

Hurricane Harvey is a horrible, extreme case of the weather that typically ravages Texas' Gulf Coast but it has nothing to do with global climate change.

Some in the growing climate disaster industry claim that Harvey was directly caused by man-made climate change, or, at the very least, was made significantly worse by it.

Senator Bernie Sanders, for example, said, "Is some of the intensity and the magnitude of this related to climate change? I think most scientists believe it is."

And he's been joined by countless others making frenzied calls for more government action and saying climate change will make extreme storms more severe.

But for some historical perspective, consider what happened in 1900. The worst hurricane in American history roared into the port of Galveston, destroying thousands of buildings and killing an estimated 6,000-12,000 people. Harvey, thus far, has accounted for less than 100 fatalities.

University of Washington atmospheric scientist Cliff Mass said climate change did not cause Hurricane Harvey.

"You can't really pin global warming for something this extreme," Mass said.

William Happer, a former director of energy research for the U.S. Department of Energy, is also highly skeptical of global warming as generally explained by mainstream media.

"Climate has been changing since the Earth was formed — some 4.5 billion years ago," he wrote in an opinion piece earlier this year. "Climate changes on every time scale — whether decades, centuries or millennia.

"The climate of Greenland was warm enough for farming around the year A.D. 1100 but by 1500 the Little Ice Age drove Norse settlers out. There is no opportunity for a hoax, since climate change is so well documented by historical and geophysical records." Debate between skeptical academics like Happer and his undoubting colleagues doing research with money from the government will likely continue.

In the meantime, tens of thousands of Texans are homeless, hungry and quite possibly shell-shocked.

ARTICLE 5

US CLIMATE REPORT SAYS HUMAN ACTIVITY WILL DETERMINE PACE OF CLIMATE CHANGE

By Daniela Hernandez | November 3, 2017

Past three years have been warmest years on record, government scientists say

A new U.S. government report drew a direct line between human activity and the quickening pace of climate change, saying the future emissions of greenhouse gasses would determine how warm the earth gets and how quickly sea levels rise.

“The last three years have been the warmest years on record for the globe,” [according to National Climate Assessment](#). “Many lines of evidence demonstrate that it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.”

The report was produced by the Global Change Research Program, which is mandated by federal law to produce a comprehensive climate assessment. The report was crafted by scientists from 13 federal agencies, including the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the Energy Department and the Environmental Protection Agency. The findings are based on scientific, peer-reviewed research, plus publicly available data sets and assessments of previous reports written by federal agencies, according to the report.

The report's statement that reductions in greenhouse-gas emissions could mitigate the expected rise in global temperatures comes as the Trump administration has rolled back U.S. efforts to limit emissions. Most notably, President Donald Trump moved to [pull the country from the Paris climate accord](#), the global push to slow carbon emissions, saying it stepped on U.S. sovereignty and constrained American industry.

Without major reductions in greenhouse-gas emissions, global temperatures could stand at 9°F (5°C) or above preindustrial levels by the end of the century, according to the new Climate Science Special Report. With deep cuts in emissions, the change could be limited to 3.6°F (2°C) or less, the report said. It noted that in 2014 and 2015, the pace of carbon-emissions growth did slow, but not at a fast-enough rate to significantly slow future temperature rises. The report doesn't make policy recommendations.

“The magnitude of climate change beyond the next few decades will depend primarily on the amount of greenhouse gases (especially carbon dioxide) emitted globally,” the report said.

Among its findings was that the global average sea level has risen by about seven to eight inches since 1900, but nearly half of that increase has happened in the past 25 years or so. That is already affecting cities in the U.S. along the Atlantic and Gulf coasts, where tidal flooding is becoming more commonplace, according to the report.

Looking ahead, the report says sea levels are expected to rise by at least several inches in the next 15 years and by one to four feet by 2100.

Average surface air temperature has increased by about 1.8°F over the past 115 years, with recent years serving “record-breaking, climate-related extremes,” according to the report. Heavy rains, heat waves, and forest fires are becoming more frequent, the report said. Last month, California experienced [some of the most savage fires on record](#), leaving many without homes and dozens dead.

Scientists have also observed changes in ocean temperatures, plus melting glaciers and diminishing snow cover and sea ice, according to the report, which was released Friday. Wednesday, NASA published maps showing that two to four times as many of Greenland's coastal glaciers are at risk of accelerated melting as previously thought. This summer, a massive iceberg [broke off from Antarctica](#). Scientists disagree over the role of climate change in that event.

The change in climate will also affect human health and productivity, according to the report and other studies. In its Countdown 2017, the medical journal The Lancet published data showing rising temperatures have resulted in a 5.3% decrease in the global labor capacity of rural workers between 2000 and 2016. The capacity of mosquitoes to spread dengue fever has increased globally by almost 10% since 1950 and in Southeast Asia, air pollution contributed to more than 1.9 million deaths in 2015. The Lancet also reported that 125 million more people over the age of 65—an already vulnerable population—were exposed to heat waves in 2016 than in 2000.

In the federal report, scientists say they expect the number of days with temperatures above 90°F (32°C) will rise, while the number with below-freezing temperatures will decline. President Trump was an outspoken skeptic of climate change before he entered politics, calling it an “expensive hoax” and a concept invented by the Chinese. Since entering the Oval Office, Mr. Trump has backed steps to reverse policies meant to combat climate change, but largely has avoided stating his position on the science.

In June, Mr. Trump announced that the U.S. would exit the Paris climate accord, while leaving open the possibility of negotiating the deal or crafting a new one on better terms. The U.S. has the world’s second highest level of greenhouse-gas emissions, behind China. Under the Paris agreement, the U.S. aimed to cut carbon-dioxide emissions by 26% to 28% below 2005 levels by the year 2025.

United Nations Ambassador Nikki Haley subsequently said Mr. Trump “believes the climate is changing. And he believes pollutants are part of the equation.” She added: “Just because we got out of a club doesn’t mean that we don’t care about the environment.”

This week, the EPA barred scientists receiving agency grants from serving on its scientific advisory boards, a move critics charged was unnecessary and aimed at eroding the influence of scientists in general.

FINDINGS IN THE CLIMATE REPORT

Source: National Climate Assessment

- Current period is warmest in the history of modern civilization
- U.S. average annual temperatures expected to rise by about 2.5°F in U.S. by 2050
- Heatwaves have become more frequent in the U.S. since the 1960s
- Major cuts in carbon emissions could limit rise in global temperatures
- Sea level has risen by about seven to eight inches since 1900, with nearly half of increase coming since 1993
- By the year 2100, sea levels are expected to rise by another one to four feet; eight feet can’t be ruled out
- Heavy rainfall will continue to increase in intensity and frequency in U.S. and globally
- CO2 levels now in range last seen three million years ago, when earth was warmer

- Davey, Melissa. "Humans Causing Climate to Change 170 Times Faster than Natural Forces" *The Guardian*. 12 February. 2017.
- Flora, Whitt. "Climate Change is not Responsible for More Hurricanes." *Tribune News Service*. 11 September 2017.
- Gills, Justin. "The Unpredictable Human Factor." *The New York Times*. 19 September. 2017.
- Hernandez, Daniela. "US Climate Report Says human Activity Will Determine Pace of Climate Change." *The Wall Street Journal*. 3 November, 2017.
- Stillman, Dan. "What are Climate and Climate Change." *NASA.gov*. 26 October 2017.