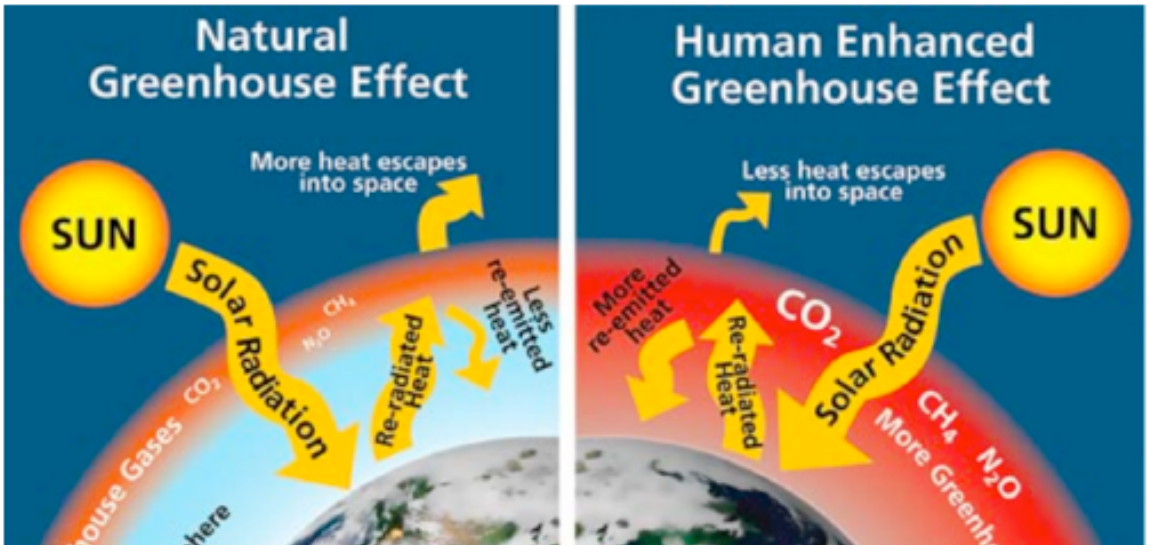
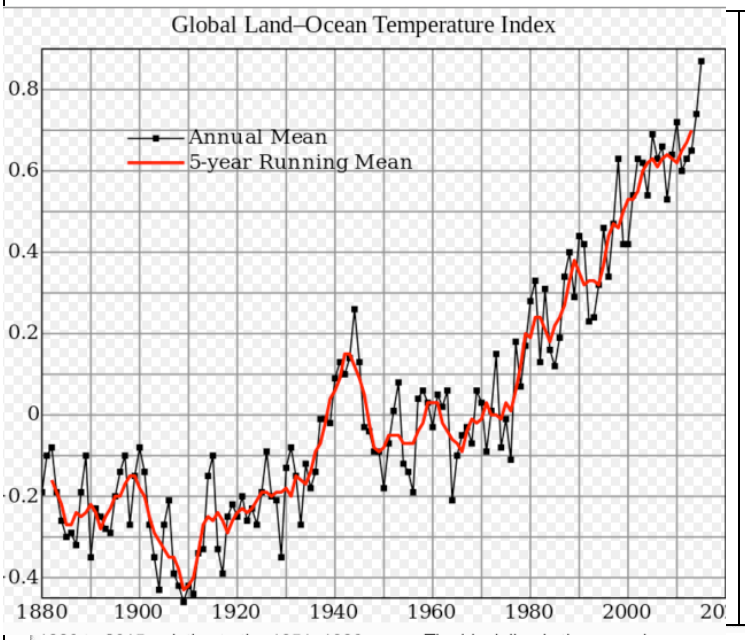
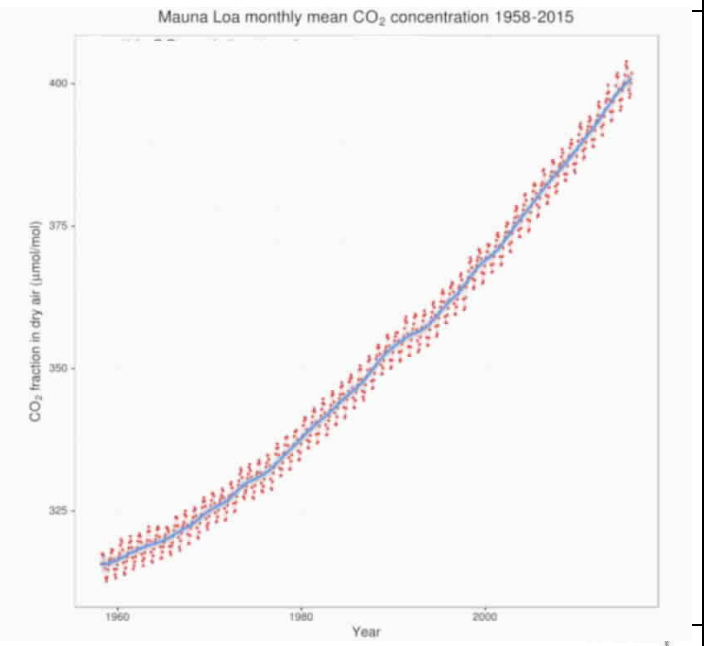
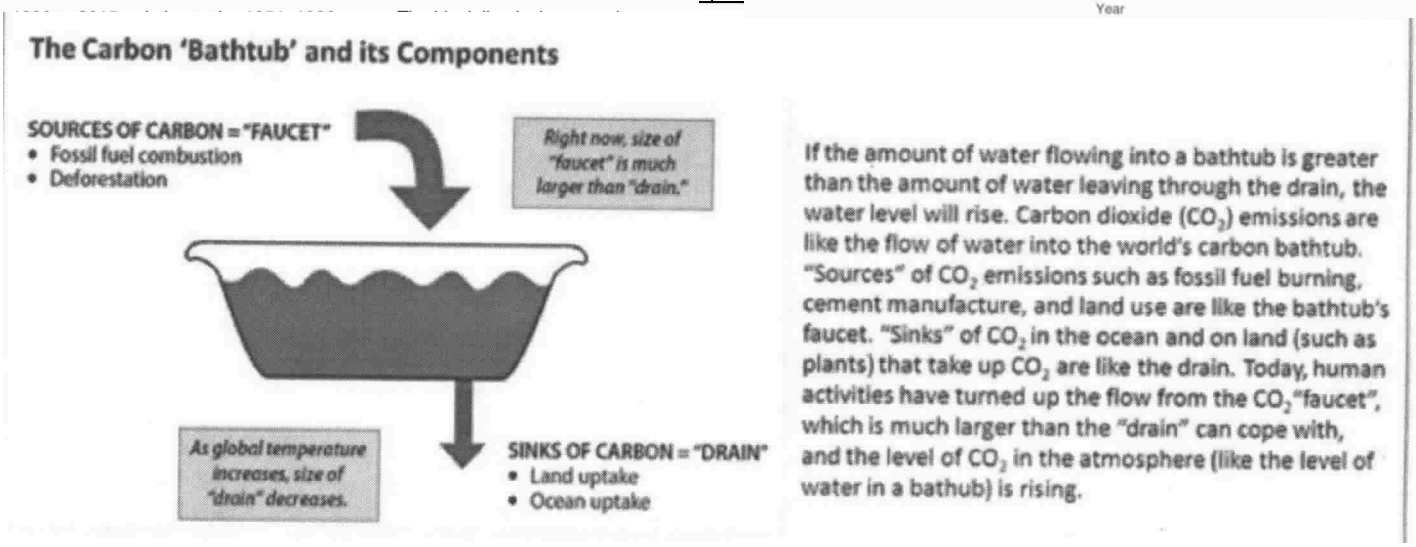
Climate Science Basics: top: greenhouse effect w/ analogy #1; middle: rising global temp & CO_2; bottom: bathtub analogy #2



Analogy: Think of greenhouse gases as a blanket. The natural effect warms Earth by 60°F. We are making the blanket thicker!







Human Activities are putting more CO_2 into the atmosphere than the planet's vegetation & ocean can remove.

Impacts will be severe if the trend continues

The amount of warming that occurs by the end of this century depends on our choices now. If we don't make much progress in curbing emissions, temperatures for the planet could rise between 4.7°F to 8.6°F (2.6°C to 4.8°C) by the end of the century, compared to the average temperature around the end of the 20th century (1986-2005). Warming in the United States is expected to be higher than the global average. Warming averaged across the country could be between 5°F to 10°F, assuming that emissions rates continue.

Although we have the opportunity to avoid some of this warming, we are still likely to face a number of impacts arising from climate change in the coming decades. In fact, we are already observing some of these impacts now.

- **Sea level rise** – Sea level has risen about 8 inches in the last 100 years, making coastal storms more damaging and accelerating erosion. Globally, future sea level rise is likely to range from 1 to 4 feet, and could be even higher if glaciers in Greenland or Antarctica melt especially quickly.
- **Polar ice** – Arctic sea ice during the summer has been shrinking, and sometime in the 21st century, perhaps within the next few decades, the Arctic will likely be ice-free in the summer. The ice sheets in Greenland and Antarctica have also been melting more rapidly in recent years, which could increase the rate of global sea level rise.
- **More heavy downpours** – More rain is coming in heavy precipitation events in many parts of the world, including the United States. This may contribute to stronger or more frequent floods.
- **More heat waves** – Heat waves have become more frequent and intense, threatening human health, stressing water resources, and increasing energy demands.
- **Threats to ecosystems** – Many plants and animals will be forced to shift their habitats to higher elevations or higher latitudes as warming makes it more difficult to thrive in their current locations.
- **Increased agricultural pests** – With milder winters, many pests and pathogens that affect plants and livestock have been able to migrate to new areas, posing problems to farmers and ranchers.
- **Ocean acidification** – Increased carbon dioxide in the atmosphere has caused the oceans to become more acidic. Further acidification could dissolve the shells of many organisms at the bottom of the food chain, threatening to disrupt the ocean ecosystem.
- **More infectious disease** – Climate change is accelerating the spread of disease and making it harder to predict outbreaks.

These impacts pose challenges to infrastructure, businesses, and communities, particularly in countries already struggling to meet the basic food, water, shelter, and security needs of their citizens.

In addition, rapid warming can increase the risk of climate "surprises" or "tipping points." Examples of these tipping points include the injection of methane into the atmosphere from thawing permafrost that could further accelerate warming, or the loss important ecosystems, such as large areas of the boreal or Amazon forests, that occurs as temperatures warm and precipitation patterns change. Although we don't know when some of these tipping points might be crossed, continued warming would raise the chances that they could occur.,

How do we know that human activity is causing greenhouse gas concentrations in the atmosphere to rise?

Several pieces of evidence make it clear that greenhouse gas concentrations in the atmosphere are increasing because of human activities:

- Ice cores from Greenland and Antarctica tell us that carbon dioxide and other greenhouse gas concentrations were relatively stable for thousands of years, but began to rise around 200 years ago, about the time that humans began to engage in very large-scale agriculture and industry. Concentrations for these gases are now higher than at any time for which we have ice core records, which stretch back 800,000 years.
- Some greenhouse gases, such as industrial halocarbons, are only made by humans. Their accumulation in the atmosphere can only be explained by human activity
- Scientists and economists have developed estimates of human sources of greenhouse gases. These estimates show that emissions have been increasing, consistent with the increases that are observed in the atmosphere.
- Carbon comes in different isotopes (carbon-12, carbon-13, and carbon-14; the numbers indicate the atomic weight). Carbon dioxide from fossil fuels has a certain isotopic "signature" that differs from other sources of CO_2. Scientists measure the different isotopes to confirm that the increase in carbon dioxide in the atmosphere is predominantly from fossil fuel combustion.

This evidence leaves no doubt that greenhouse gas concentrations are increasing because of human activities.

How reliable are climate projections?

https://science2017.globalchange.gov is where to find a summary of NCA4

Current computer models can faithfully simulate many of the important aspects of the global climate system, such as how global average temperature changes over many decades, the march of the seasons on large spatial scales; and how the climate responds to large-scale forcing, like a large volcanic eruption. So we can be confident that they correctly represent some of the "big picture" features of climate. However, simulations of climate at more regional and local scales, such as a country or state, can still be uncertain. Models also often have difficulty simulating year-to-year changes in the climate system, so a model run in 2014 is unlikely to precisely predict the global temperature in 2015 or 2016.

It is also important to note that projections for this century should not be viewed as predictions. Rather, they represent a range of possible futures, consistent with different concentrations of greenhouse gases in the atmosphere. If we emit a particular level of greenhouse gases in the coming decades, the projection provides us a glimpse of how different our climate might be.