Intro to Global Warming

By: Steven Gebhard and Barbara Fahmy

101 Fact Sheet

BROUGHT TO YOU BY: The Climate Justice Committee of TOGETHER COLORADO MEMBER OF FAITH IN ACTION

The ravaging results of earth's "greenhouse effect" has been a topic in local, national and global news with increasing urgency. It has resulted in climate variability (aka climate change). This is why we are seeing extreme weather events such as hurricanes, tornadoes, heatwaves, and polar vortexes that occur on an increasingly frequent basis. These events have not only caused loss of life, but major strains to the economy in the form of disaster relief, job loss, and weakening infrastructure.

Although climate scientists have been sounding warning bells with in-depth and credible scientific evidence, meaningful unified action has been painfully slow. It is a hot-button political issue. While most of the public accepts the expertise of scientists, engineers, and other environmental experts, a significant percentage denies the existence of the greenhouse effect and the resulting dangers of global warming and climate change.

So, what's the problem with having a "greenhouse effect?" Sounds like a good thing to me.

What is global warming, and how are humans contributing to it?

The term "greenhouse" is a bit misleading because, in a greenhouse used to grow plants, sunlight comes through the glass ceiling and walls, which warms the air, soil, pots, plants, etc. inside.

The physics of the "greenhouse effect" for the Earth's atmosphere, however, is quite different. Heat is trapped by molecules of greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4). These gases reduce the loss of heat from the Earth into space via infrared radiation (IR). Anything that is at a higher temperature (e.g., the Earth) will radiate toward a colder object (e.g., space) transferring energy in the process.

The sun warms the surface of the Earth (and the atmosphere to some extent), and then (especially at night) the Earth emits infrared radiation into space through the atmosphere (i.e., the energy flows from the warm Earth to cold space). Thankfully not all of the heat is lost because if it weren't for having *some concentration* of these molecules (primarily water vapor) in our atmosphere, there would be *too much cooling* and we would all freeze!

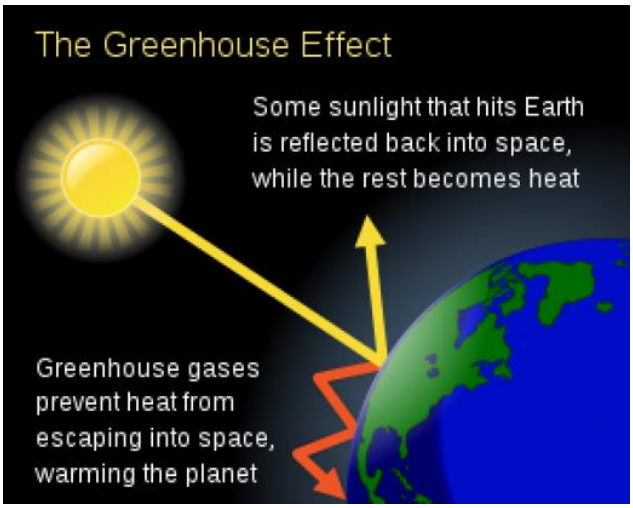

Figure 1. The greenhouse effect (Wikipedia)

The problem comes when ...the concentration of greenhouse gases in the atmosphere becomes too high (primarily because humans burn fossil fuels generating CO_2) and too much IR is "trapped." This "extra load" of greenhouse gases (mostly CO_2) is what causes unnatural and excessive global warming (Figure 1).

Radiative Forcing

The mechanism for the greenhouse effect is called "radiative forcing," which is simply the difference between the amount of energy from incoming sunlight minus the amount of energy that is eventually radiated to space. Figure 2 shows that humans have increased radiative forcing on Earth by more than 2 W/m² (watts per square meter) since the start of the "industrial revolution."

While this may not sound like much, given the size of the Earth, this is sufficient to increase *average global temperatures* by 1-2°C (1.8-3.6°F). The result is warmer oceans, melting glaciers and ice caps, more severe weather (some of which is due to warmer water in the oceans).

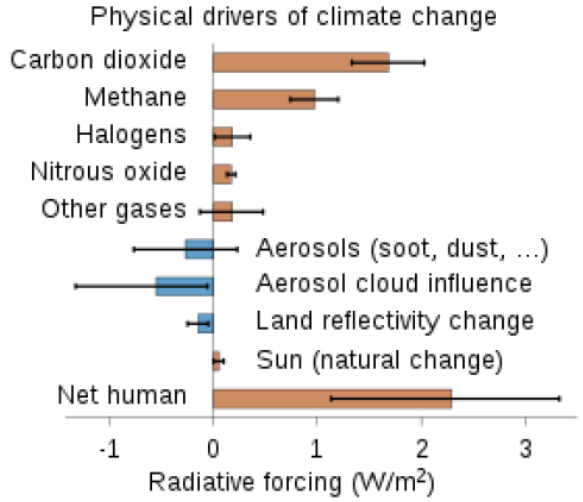

Figure 2. Net human increase of radiative forcing due to GHG emissions into the atmosphere; black lines are +/- uncertainty (Climate Change 2007).

Fossil Fuels and Other Producers of Greenhouse Gases

One of the major producers of excessive greenhouse gases in our atmosphere is fossil fuels. By continuing to use them, humans are pouring about 35 billion tons of carbon dioxide (CO_2) into Earth's atmosphere annually, causing it to warm. Carbon dioxide is not the only greenhouse gas (GHG), but is by far the largest contributor because of the enormous quantities involved. So how do CO_2 and other gases cause global warming?

Figure 3 shows a graph of the concentration of CO_2 in the atmosphere measured at the summit of Mona Loa in Hawaii (at an altitude of about 14,000 ft) between 1958 and 2020. The graph is named after Charles Keeling who started the monitoring program and oversaw it until he passed away in 2005. The graph shows that the CO_2 concentration has increased about 31% over this period of time. Various models have been developed by climate scientists to try and predict the effects of this increase (including predicting the corresponding global temperature increase), but there are, by necessity, many assumptions and uncertainties; however, the risk of doing nothing could very well be catastrophic (at least for our human biological niche).

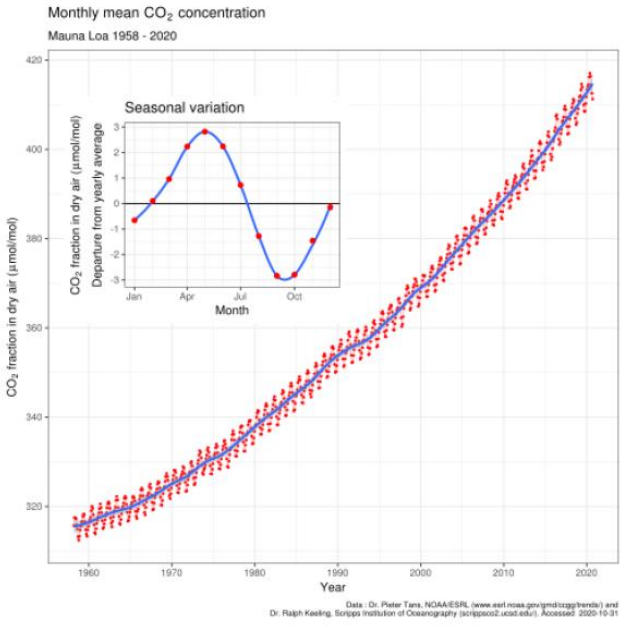

Figure 1. Keeling curve showing the CO_2 buildup (Wikipedia).

Increasing temperatures not only seriously disturb the delicate balance of the biosphere (https://climate.nasa.gov/effects/), there is a possibly of an equally serious problem because carbon dioxide is very soluble in water. When carbon dioxide dissolves in water it reacts with it to form carbonic acid (CO_2 + H_2O H_2CO_3), which is the same acid as that gives club soda (carbonated water) its bite. Thus, when CO_2 is emitted into the atmosphere by burning fossil fuels, some of it also reacts with water in lakes, rivers, seas and oceans, increasing their acidity (lowers the pH), which is toxic to many organisms and represents a serious threat to the food chain (https://www.ucsusa.org/resources/co2-and-ocean-acidification).

Some Specifics on Methane

When most of us think of methane, we think of natural gas, or gas that is associated with petroleum recovery that can be used as a fuel. When used as a fuel, natural gas (which is mostly methane) is burned in specially designed turbines to generate electricity (much more efficiently and with lower CO_2 emissions per unit of energy than coal, but still nowhere near zero). Low pressure methane that accompanies oil recovery is frequently flared (burned to CO_2 and H_2O) because it is uneconomical to purify and compress for sending via pipeline to power plants to generate electricity. Unburned methane from gas leaks is also a serious source of GHG emissions.

Most people are unaware that there is a lot of methane trapped in geologic formations that are not associated with oil and gas formations such as permafrost and what are called "methane hydrates" in the ocean. As the planet warms, these methane hydrates (methane molecules encapsulated in cages of water molecules) are destabilized and will release methane gas into the atmosphere leading to additional warming, potentially leading to a temperature runaway (Ruppel and Kessler, 2017). Visconti's advanced text discusses all of these topics in great detail (Visconti 2001).

More to Come

In future information papers, we will discuss the different greenhouse gases (GHG) in terms of why some are worse than others, their sources (some might surprise you). We will also give you details on the runaway greenhouse effect. This is when the average global temperatures increase enough so that it causes other, normally sequestered, sources of carbon (mainly methane, CH_4) to be released from natural repositories.

Stay tuned for valuable information on the many alternative forms of energy available to us. Undoubtedly, the research will continue. These new forms of energy will be cleaner, releasing either none or much less of the greenhouse gases that contribute to climate change.

References and Further Reading

- IPCC (2007) "Climate Change 2007: Synthesis Report" available online as a pdf at: https://www.ipcc.ch/report/ar4/syr/
- Lindsey, R. (2009) "Climate and Earth's Energy Budget," NASA Fact Sheet, https://earthobservatory.nasa.gov/features/EnergyBalance/page1.php
- Ruppel, C.D. and Kessler, J.D. (2017) "The interaction of climate change and methane hydrates," *Reviews of Geophysics*, Vol. **55**, 126-168, available online at https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2016RG000534
- U. Oregon (1998) "Greenhouse Effect," http://zebu.uoregon.edu/1998/es202/l13.html
- Visconti, G. (2001) Fundamentals of Physics and Chemistry of the Atmosphere, Springer Verlag (advanced textbook, highly technical and thorough)
- Wikipedia topics with more in-depth discussions that are good summaries include: Climate Change, Earth's Energy Budget, Radiative Forcing, Keeling Curve, Greenhouse Gas, Greenhouse Effect, Methane Clathrate