Introduction to Climate Change

Regardless of one's stance on climate change, here's what we know for sure:

(1) The Greenhouse Effect: Have you ever parked your car on a hot day only to come back an hour later to find that your car has now become a steaming oven? The Greenhouse Effect is a well-known phenomenon. It makes your car an oven on a hot day. It keeps plants warm in actual greenhouses. It's what keeps our planet warm enough to support life. How does it work?

Energetic solar rays pass easily through our atmosphere and get absorbed by the planet. They are then re-emitted as less energetic infrared radiation (or, "heat") into the atmosphere. The less energetic heat finds it more difficult to escape the atmosphere. The heat can be bounced back to the surface of the planet—especially when there are high concentrations of certain molecules in the atmosphere (e.g., carbon dioxide, methane, and water vapor). We call these "greenhouse gases". Having SOME of these gases is crucial to our existence. They keep our planet from being a frozen wasteland, inhospitable to life. But, it's possible to have too much of a good thing. If the greenhouse effect gets out of hand, Earth becomes a car-oven in a hot parking lot.

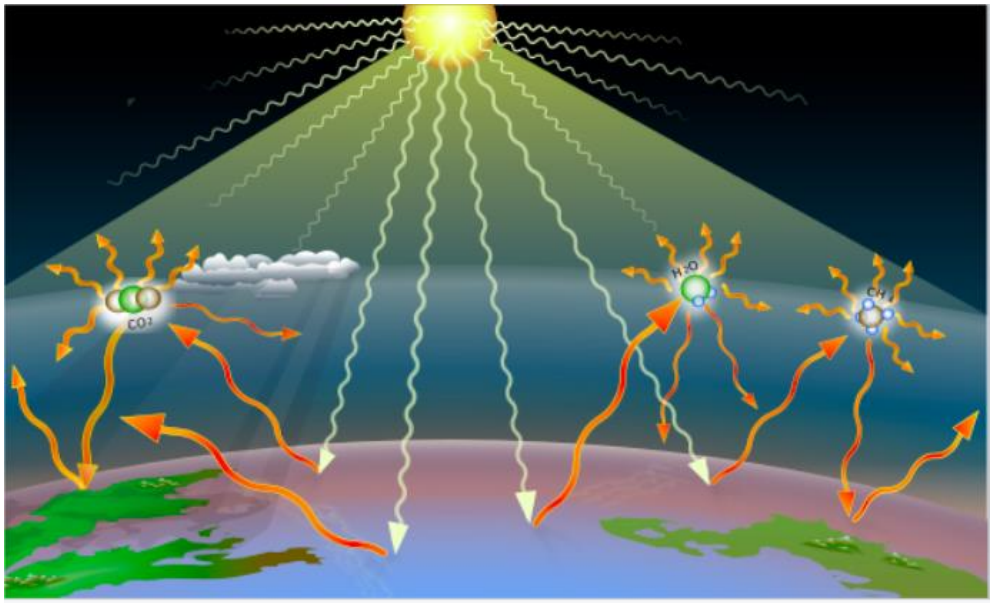
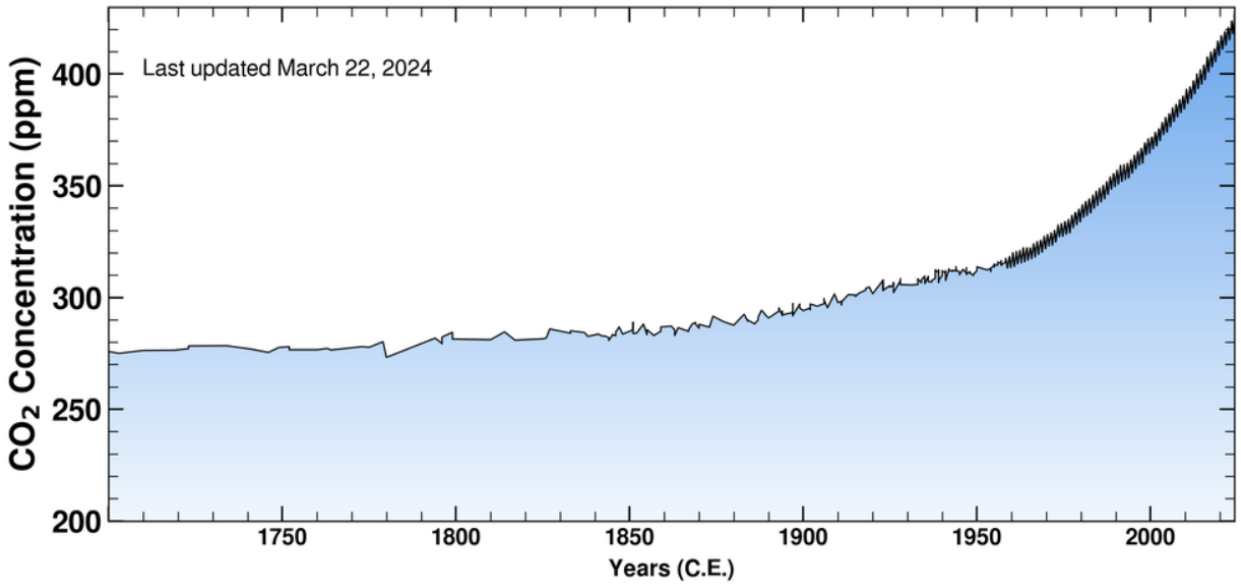


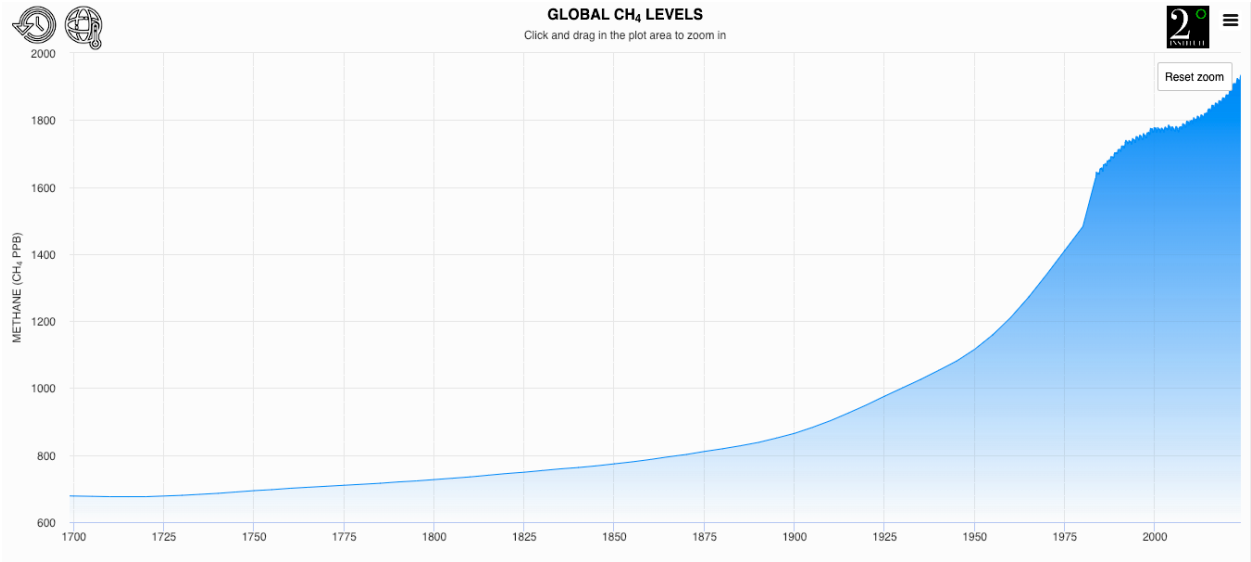
Diagram showing light energy (white arrows) emitted by the sun, warming the earth's surface which then emits the energy as heat (orange arrows), which warms the atmosphere and is then re-emitted as heat by three of the greenhouse gas molecules (water, carbon dioxide, and methane)

(2) Greenhouse Gas Concentrations Rising (Carbon): Data analyzing CO_2 levels in our atmosphere show that the amount of CO_2 has remained steady for the last 10,000 years—at around 275 parts per million (ppm). That is, until the 1800's, when it began steadily increasing. In 2013, that number hit 400 ppm for the first time—the highest known concentration of CO_2 in our atmosphere in at least 3 million years. By 2016, a global average CO_2 concentrations above 400 ppm and beyond had become the new normal. (data here)

Ice-core data before 1958. Mauna Loa data after 1958.

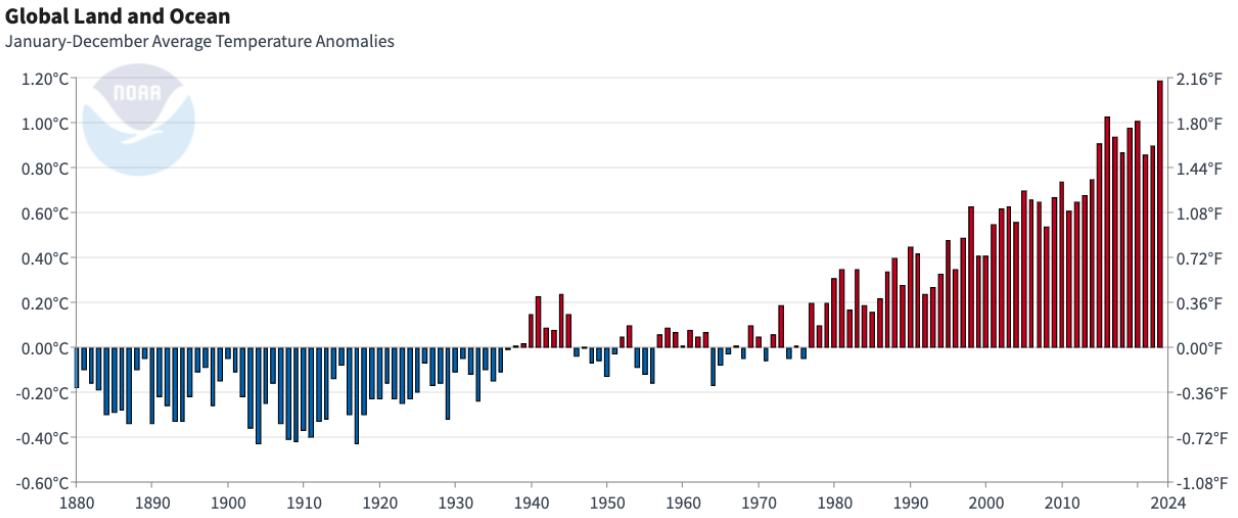


(3) Greenhouse Gas Concentrations Rising (Methane): Methane levels have also climbed dramatically over this same period, from around 700 parts per billion (ppb) to over 1900 ppb—the highest known concentration in 800,000 years. And, while there is about 200 times more CO_2 in the atmosphere than methane, the negative impact of that methane is only 2 or 3 times less. For, methane is MUCH better at trapping warmth. (Namely, over a 20 year period, X amount of methane traps 86 times more warmth than the same amount of CO_2.) (data here)



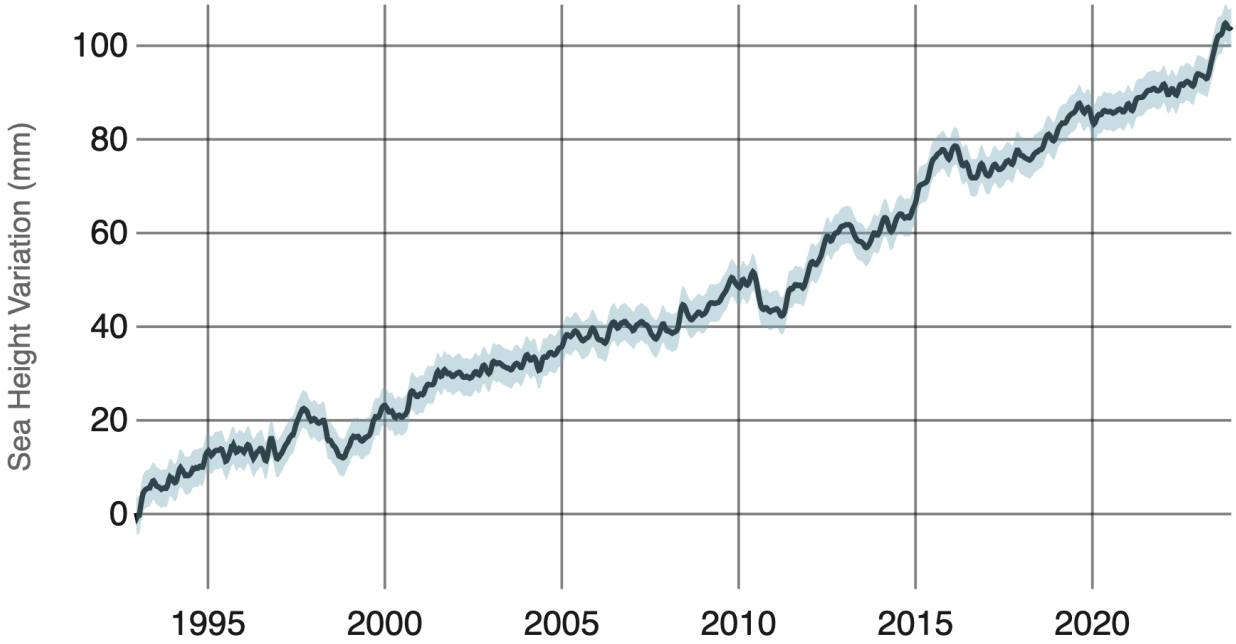
(4) Global Temperature is Rising: The average global temperature has risen over this same period as well, by about 1° Celsius (1.8° Fahrenheit). Presently, the average global temperature is increasing by about 0.18° C every 10 years (roughly one-third of a degree Fahrenheit).

The 10 most recent years* are the 10 hottest years on record (#1 is 2023, which was 2.14° F above the 20th century avg.; #2 is 2016 (+1.85° F). (data here) *(with complete data; i.e., 2014-2023)



Sliding graph for visualization, here: https://climate.nasa.gov/vital-signs/global-temperature/

(5) Sea Levels are Rising: Sea levels have risen over this same period—by at least 20cm (8 in.) since pre-industrial times, with *half* of that rise occurring in just the last 30 years. (data here)



(6) Rate of Extinction Increasing: Extinction is on the rise as well, with species now going extinct at a rate least 1,000 times faster than pre-industrial times. Conservative estimates state that one species goes extinct every hour. Scientists warn that we may be entering the sixth major extinction event in Earth's history (the Holocene, or Anthropocene Era).

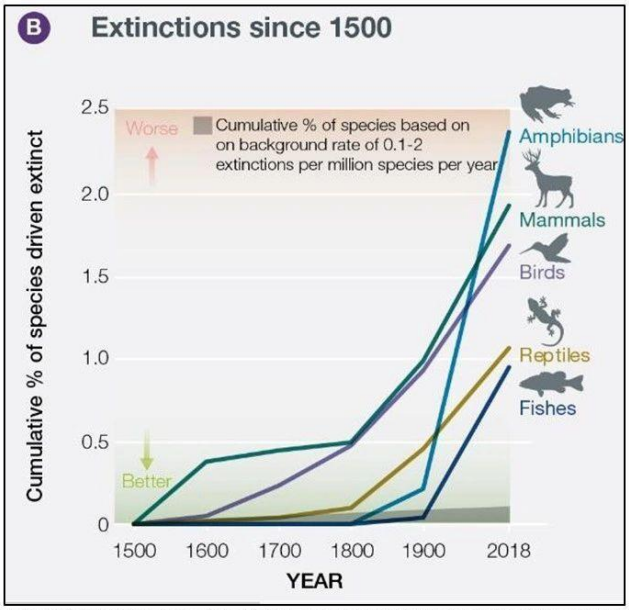
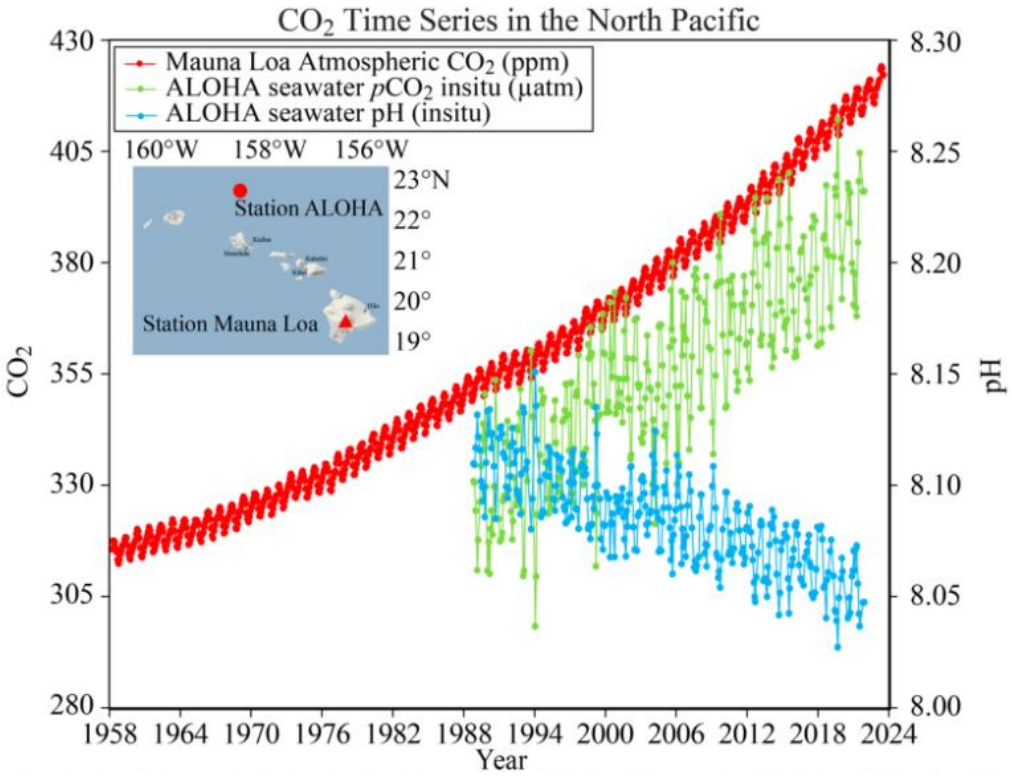


Figure 3 (B) - Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

(7) The Oceans are Becoming More Acidic: Increasing CO_2 levels cause an increase in carbonic acid in the ocean (it forms when carbon dioxide bonds with water). Rising acidity then kills off coral and shellfish. Note the decreasing pH levels of seawater, as CO_2 levels rise. (data here)



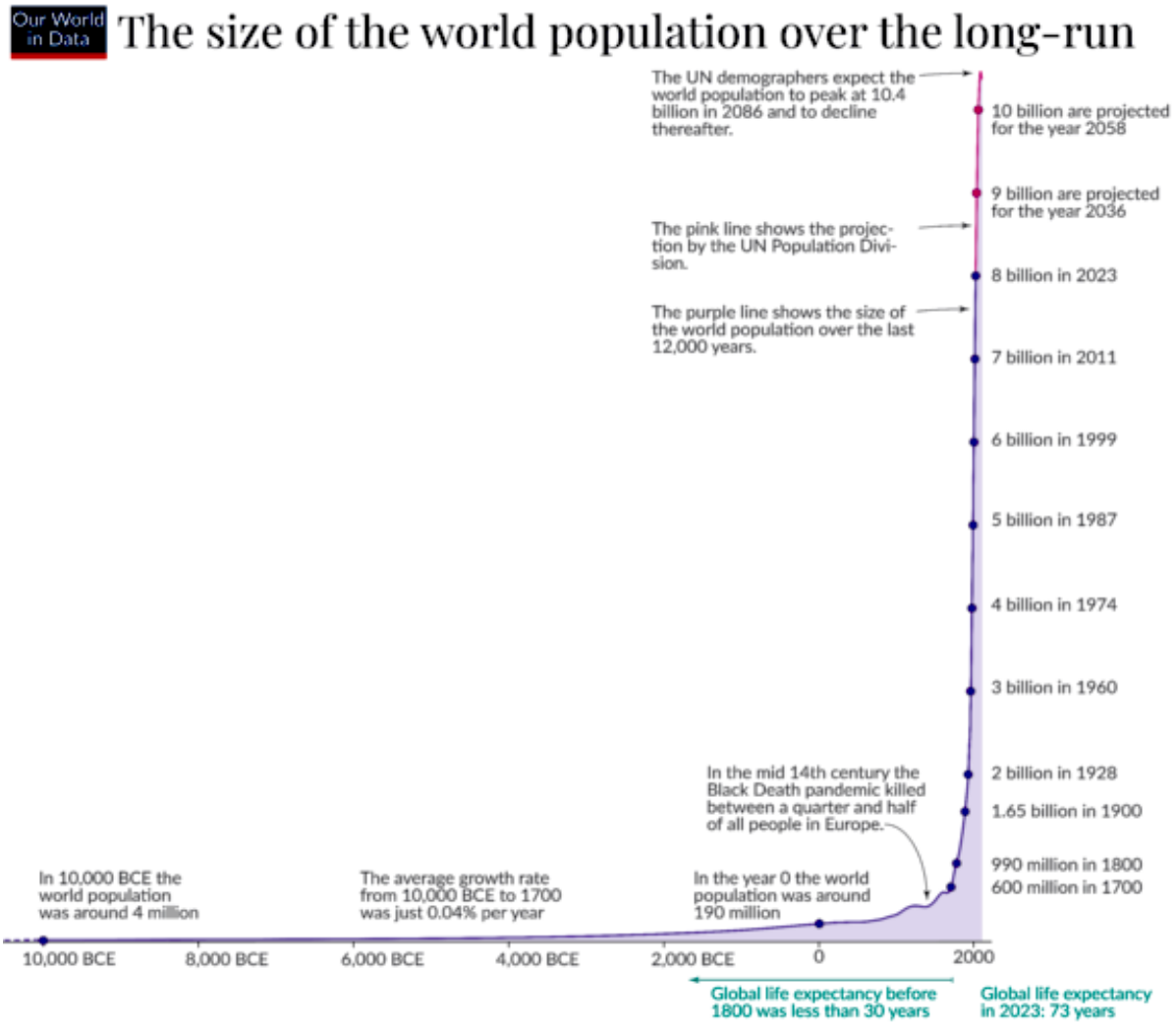
(8) The Polar Ice Caps are Disappearing: Since 2002, the Antarctic ice sheet has lost about 3 trillion metric tons of ice, and the Greenland ice sheet about 5 trillion tons. (data here)

In Antarctica, massive icebergs are now regularly breaking off of the ice sheet and floating away. For instance, iceberg A-76 in 2021 (larger than Rhode Island), iceberg A-68 in 2017 (larger than Delaware), and iceberg B-15 in 2000, half the size of New Jersey.

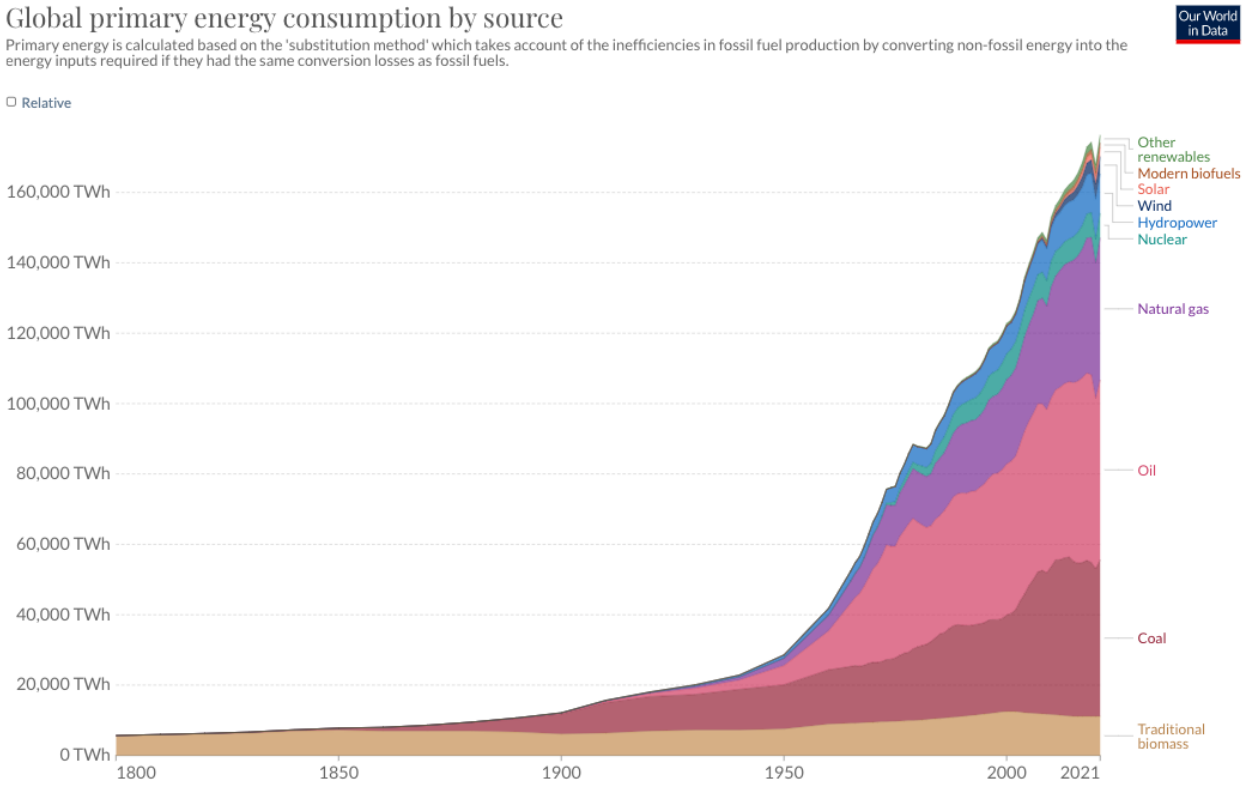
Arctic Sea ice has also been rapidly disappearing. (Time lapse of the Arctic ice sheet here.)

[**Feedback Loops.** There's also this to consider: The poles stay cooler because of their ice caps. Ice caps are white, and so reflect solar radiation like mirrors. As temperatures increase, they melt. As they melt, they darken. As they darken, they reflect less solar radiation. As they reflect less radiation, they melt MORE. And so on, in a self-reinforcing feedback loop.]

(9) Population is Increasing: The human species as we know it has been around for about 200,000 years. For the first 99.9% of our history, our global population was below 1 billion (until 1804). There are now over 8 billion human beings. We've been adding another 1 billion humans to the planet roughly every 12 years since 1960 (when the population was only 3 billion). This incredible statistic is perhaps better understood by watching this time-lapse video.



(10) Energy Consumption Increased: The Industrial Revolution occurred at the beginning of this period (from about 1760 to 1870). At that time, the world became more mechanized, largely thanks to the invention and widespread use of the coal-powered steam engine. Since that time, consumption of fossil fuels (coal, oil, and natural gas) has also increased dramatically.



(11) And Lots More… For more information, NASA's website is a great place to start.

What Should We Conclude?

Correlation vs. Causation: We have looked at the facts about climate change. Do you notice any similarities between all of these graphs? They all have the same exponential, upward slope, beginning around the same time in history (around 1800). This is called a **correlation**.

We often interpret correlation as CAUSATION. For instance, did you know that ice cream causes both drowning and wildfires? Statistically, as ice cream sales increase, so do the numbers of these other two things. So, I hope you will join me in the fight to **BAN ICE CREAM!**

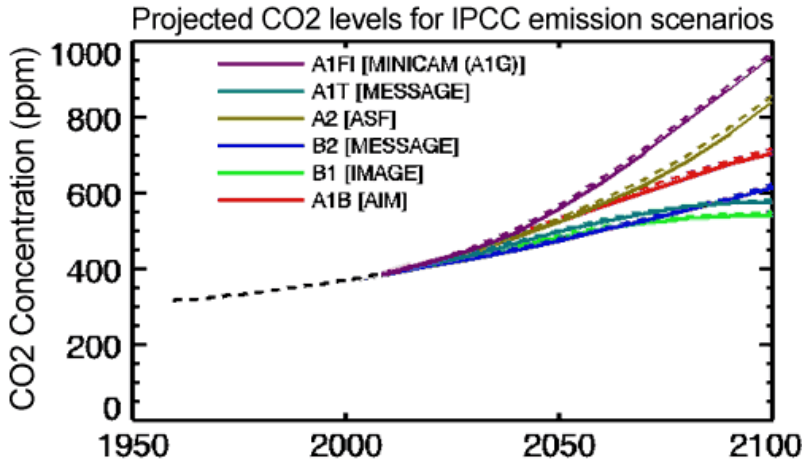
Seems fishy right? The truth is that ice cream sales go up when it's hot and sunny. Also when it's hot and sunny? …People go swimming more often (and therefore drown more often), and wildfires are more likely to start. This is a classic case of correlation without **causation**.

So, we should keep in mind that the MERE fact that the rise in human population and emission activity is CORRELATED with changes in the climate does not GUARANTEE that the former is a CAUSE of the latter. …Nevertheless, I should like to say two things:

(a) Keep in mind that the **consensus within the scientific community** is that human activity IS the cause of climate change.

(b) As it turns out, it may not matter morally if it turns out that we cannot be CERTAIN of this. The consensus among ethicists is that we are morally obligated to do something about climate change **even if we are uncertain that we are the cause of it**.

Predictions: That said, what does all this mean? Well, if the trends above continue, here is what you can expect within your lifetime. In the MOST OPTIMISTIC scenarios, CO_2 levels will double their pre-industrial level (to 550ppm) by 2100.



If that most optimistic scenario comes to pass, we can still expect:

- The Earth will warm by about 2.5 - 3° C (4.5° - 5.4°F)
- Regular extreme heat waves
- Dry regions get drier. Wet regions get wetter, leading to:
  - Severe droughts
  - Severe wildfires
  - Water scarcity affecting hundreds of millions
  - Severe flooding in other regions
- Fiercer weather events (e.g., hurricanes, due to increase in ocean temperature)
- Sea levels rise by several feet, displacing hundreds of millions of people (interactive map here)
- Mass human migration, so-called 'climate refugees', as lands become uninhabitable
- Mass extinction, and increase in invasive species
- Increased violence and war, as resources become more scarce, and migration increases

And this is if everything goes well. In the least optimistic scenario, it will be utterly disastrous.

One problem is that CO_2 stays in the atmosphere for centuries, so even if we stopped ALL emissions now, there would still continued warming for many years to come. We're already "locked in" to some extent. But, there's still time (precious little time) to avoid the worst case scenarios. The question we will ask in the following weeks is, "So? What should we do about it?"

The Perfect Moral Storm

The unfortunate fact is, presently no one is really doing much about climate change. We are emitting more and more GHG's every year, and the rate at which we are doing so is increasing. And it seems unlikely that we are going to start taking serious measures to prevent climate change any time soon. This is the "problem of political inertia". Why is this?

Answer: Morally, Stephen Gardiner calls climate change "**the perfect moral storm**". The following three "storms" seem to make the issue of climate change an especially messy one:

- **The Global Storm:** Climate change is a global issue. Many have likened the atmosphere to a "commons" which we all use some part of when we emit GHG's. As such, it falls susceptible to the "tragedy of the commons" where it is to everyone's benefit to over-consume, but ultimately when everyone over-consumes the results are disastrous. The motivation of this tragedy is further exacerbated by the fact that:

(a) Those who will suffer the worst consequences (impoverished nations) are not the same individuals who will reap the greatest benefits from over-consumption (developed nations).
(b) Those who stand to lose the most (impoverished nations) have the least amount of political power, globally, while those who reap the greatest benefits (developed nations) have the most political power—which makes political change difficult.

- **The Intergenerational Storm:** Since the full effects of our present emissions will not befall our planet for several decades, those who will suffer the worst consequences (future generations) are not the same individuals who will reap the greatest benefits from over-consumption (the present generation). Furthermore, future generations do not have LESS political power—rather, they have NO political voice at all. This makes it tempting to "pass the buck" of the costs/harms of climate change onto future people.

- **The Theoretical Storm:** The entire issue is immersed in a number of ethical issues, all of which are quite difficult to handle, theoretically. For instance, (a) scientific uncertainty, (b) international justice, (c) intergenerational justice, and (d) determining the appropriate relationship that humanity ought to have with nature, species, ecosystems, etc.