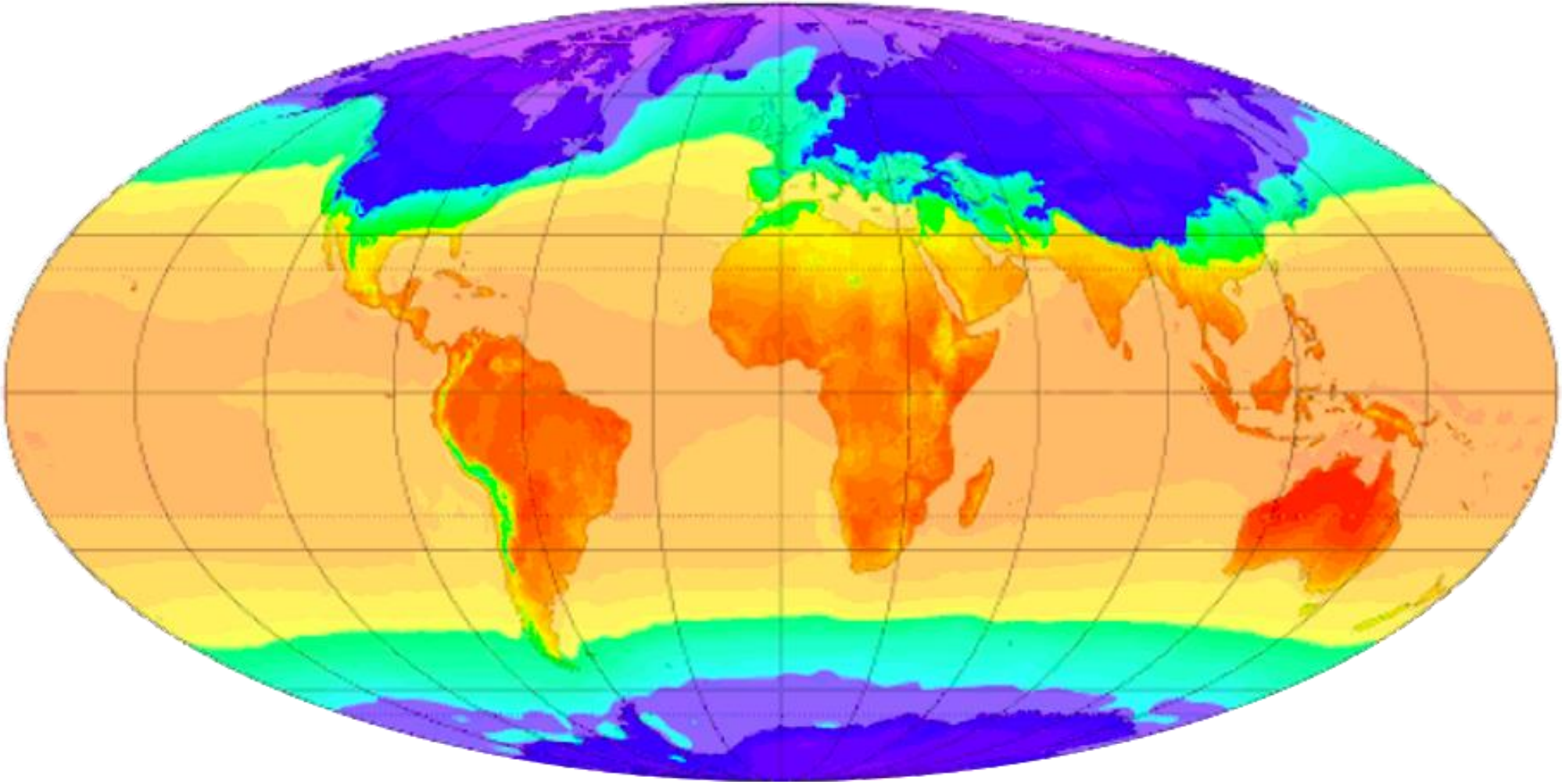
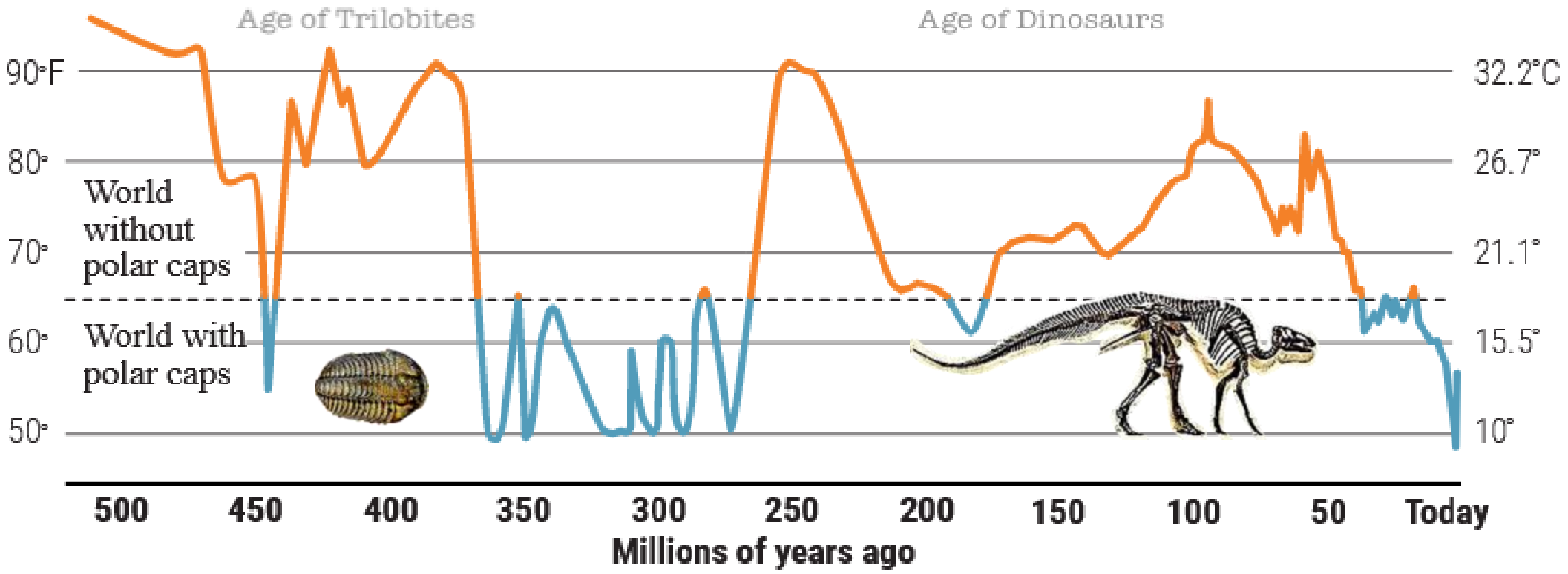
Climate Change



Earth's climate has always been changing: Prior to 50 million years ago, the Earth was mostly ice-free.



SMITHSONIAN INSTITUTION NATIONAL MUSEUM OF NATURAL HISTORY, ADAPTED BY N. DESAI/*SCIENCE*

Graph downloaded from https://www.science.org/content/article/500-million-year-survey-earths-climate-reveals-dire-warning-humanity

To a lesser extent, climate also changed during recorded history. During the “Medieval Warming Period,” the Vikings were able cultivate all of these crops in Greenland.

The Greenland settlement lasted from 985-1450 AD. The settlement was abandoned shortly after the start of the “Little Ice Age.”

- Barley
- Rye
- Oats
- Cabbages
- Onions
- Garlic
- Leeks
- Turnips
- Beans
- Peas

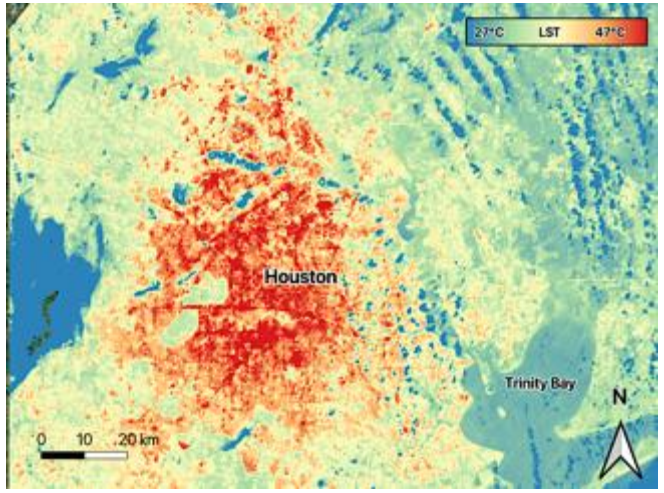
Crop list from: https://www.historyonthenet.com/life-on-a-viking-farm

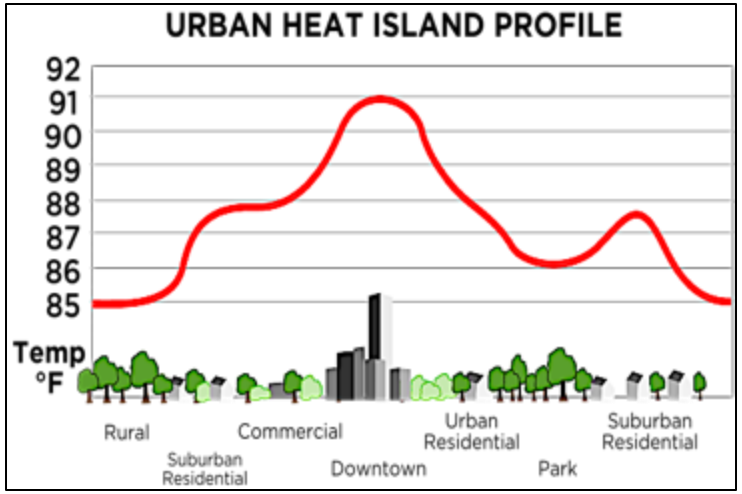
Settlement dates from: https://www.history.com/news/why-did-the-viking-disappear-from-greenland

Not all climate change is natural: Humans have been altering local climates ever since they started clearing the land.

Today, major cities like Houston are subject to a "heat island effect" as the result of vast surfaces of uninterrupted pavement and concrete.

These impacts on climate are localized, but are current levels of human population and technology now affecting climate on a *global* scale?



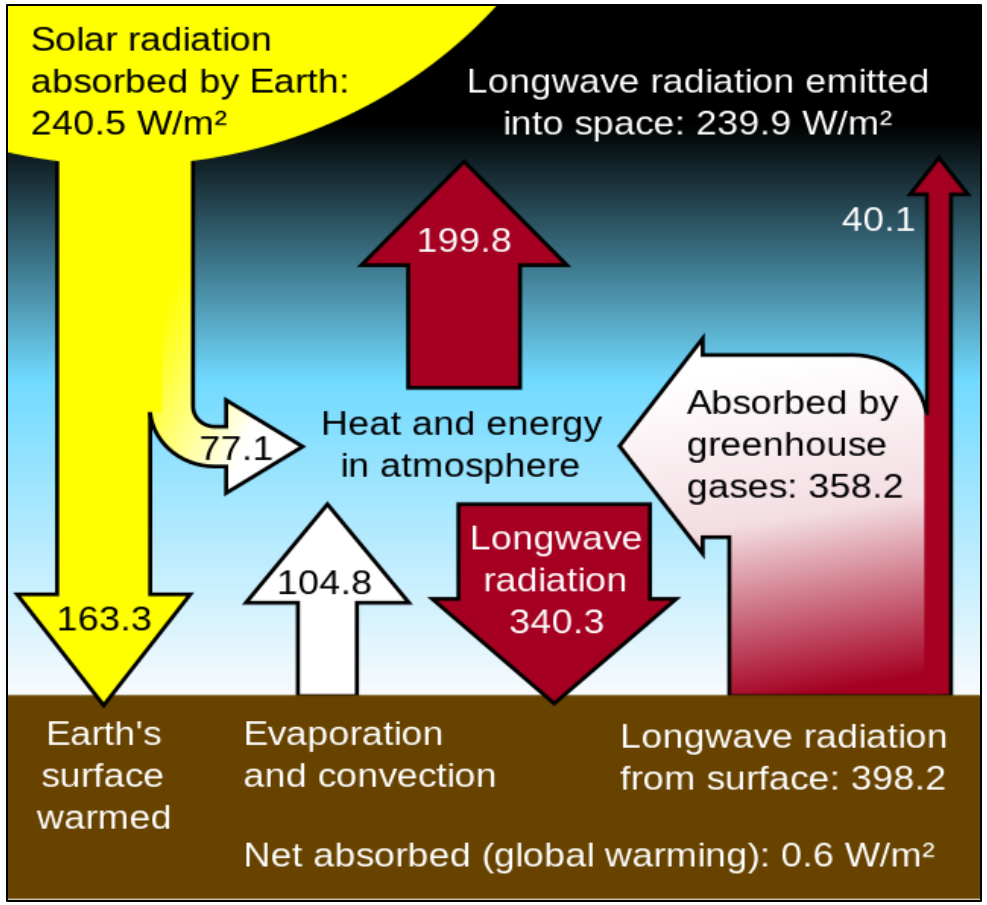


The sun drives the climate, but the moon has no climate because sunlight alone cannot generate weather conditions.

The Earth has weather only because the solar energy that reaches the Earth is mediated by the atmosphere and the ocean.

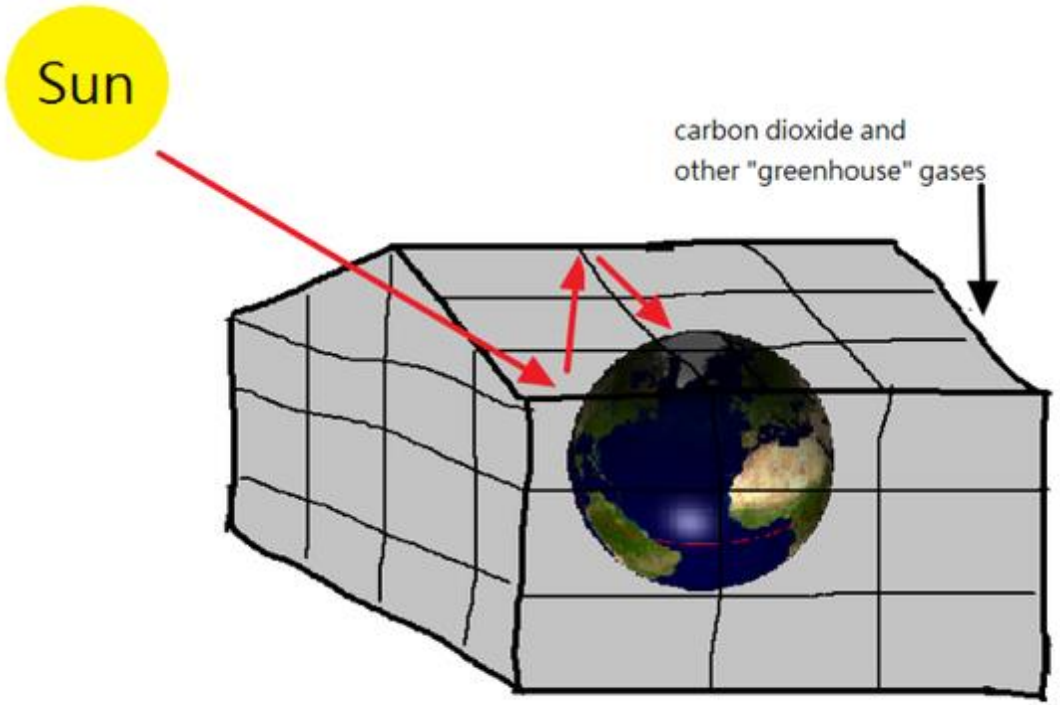
The solar energy that reaches Earth is either reflected back into space or absorbed.

The balance of what is absorbed depends on the color of the surface and the composition of the atmosphere.



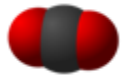
Greenhouses retain heat because the solar radiation that passes through the glass panels is absorbed by the opaque interior. “**Greenhouse gases**” like carbon dioxide have a similar effect on global temperatures due to their ability to **absorb heat** and then radiate it in all directions.

In sharp contrast, **White aerosols** from **volcanos** or **industry** have a **cooling effect** because they reflect this energy back into space.



Greenhouse Gases You Need to Know:

Carbon dioxide (CO_2) is generated through the processes of respiration and combustion. There are concerns that humans are generating unprecedented amounts of CO_2 through the **burning of fossil fuels**.

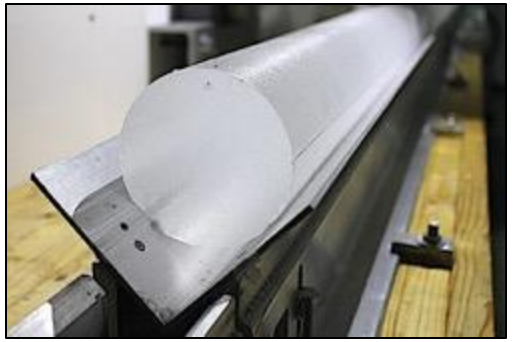


Methane (CH_4) is naturally generated through anaerobic processes that take place in wetlands. Human activities like **feedlots and gas drilling** also contribute to atmospheric methane.

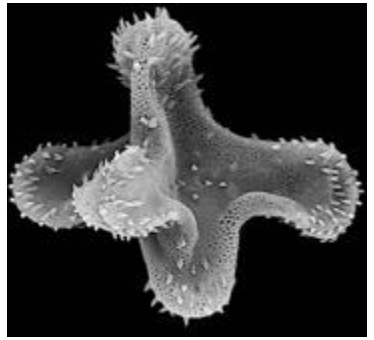
Water vapor (H_2O) is by far the most abundant of the greenhouse gases, and even though it is stronger than CO_2 in its ability to retain heat, water vapor **can also has a cooling effect when it forms white clouds**. This makes the role of water vapor impossible to predict.

Proxy measurements are used to estimate climactic trends that took place prior to the existence of temperature records. These measurements include ice cores, sediment cores, tree rings, coral reef samples, and even fossilized pollen.

Ice core analysis is particularly valuable because ice caps contain **trapped gas bubbles** that allow researchers to obtain “snapshots” of the Earth’s atmosphere over a period of nearly million years.

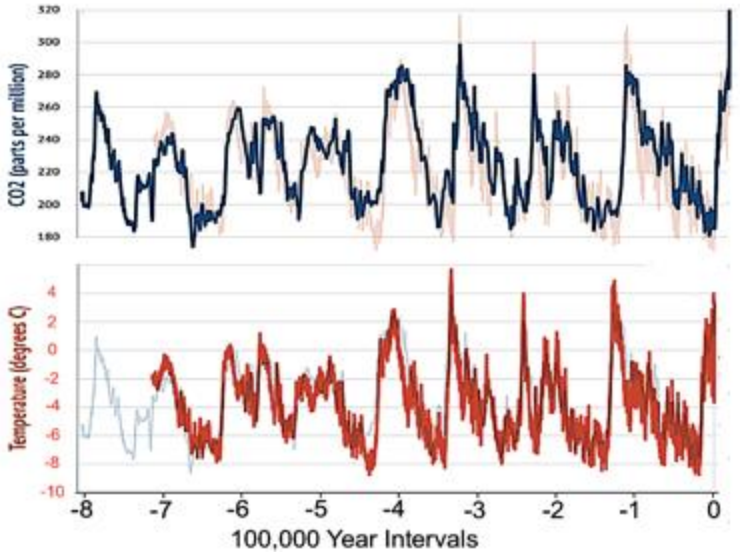





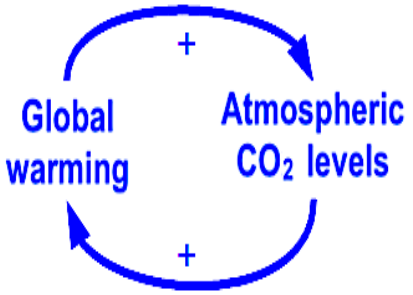


Carbon dioxide levels are **correlated with temperature** estimates. The fact that this trend covers nearly a million years raises three questions:

- If we assume CO_2 levels were a major cause of this warming, what natural process generated these higher levels during these prehistoric times?
- High atmospheric levels of CO_2 can also be an *effect* of warming because CO_2 is less soluble in warm water. If past warming increased atmospheric levels of CO_2., what process generated these warming cycles?



- Could CO_2 levels be *both cause and effect,* whereby both processes simulate each other synergistically in a positive feedback loop?

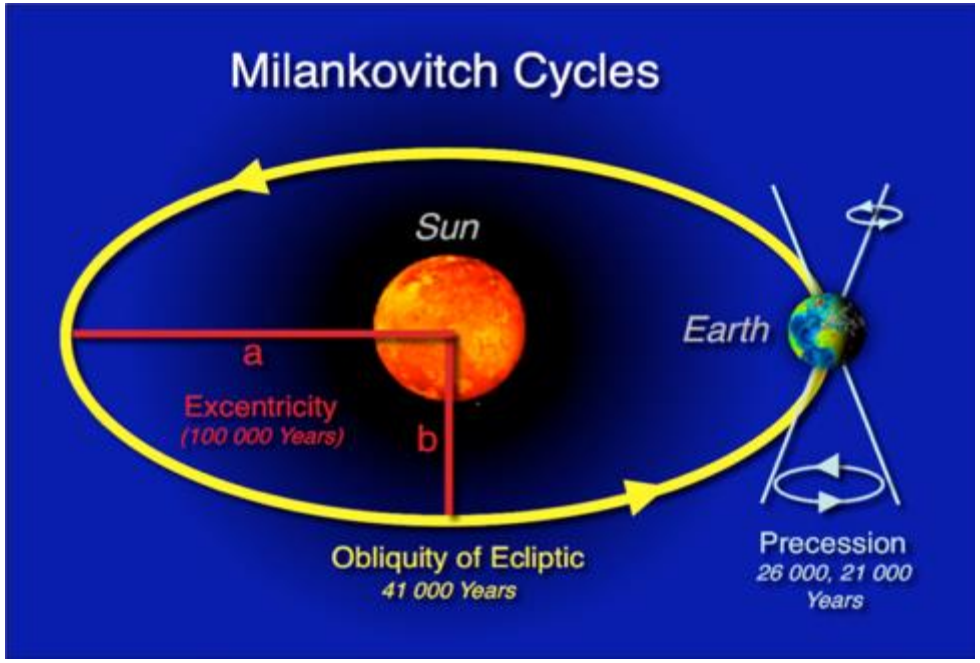


Graph downloaded from https://www.carbonbrief.org/explainer-how-the-rise-and-fall-of-co2-levels-influenced-the-ice-ages/

Early in the 20th century, Serbian geophysicist Milutin Milankovitch calculated cyclical variations in the Earth's orbit that could profoundly affect climate.

Milankovitch Cycles are now the widely accepted explanation for the pre-historic cycling of Earth's climate.

Image of Milutin Milankovitch on Serbian currency.

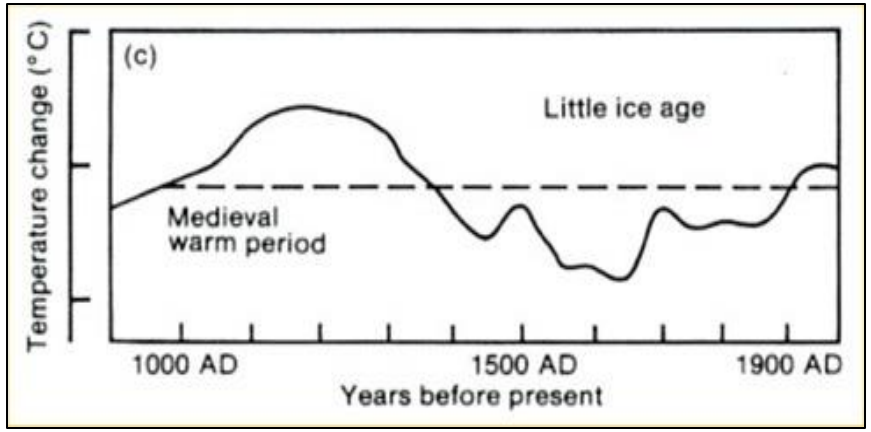


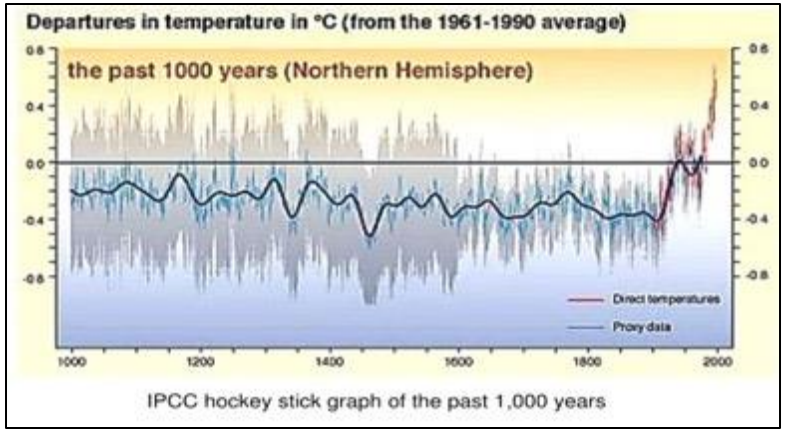
In 1988, the **Intergovernmental Panel on Climate Change** was formed in order to provide policymakers with timely information on climate.

In 1990 the IPCC published its first report based on the best available data.

In 2000 the IPCC published a second report which is widely known as the "**hockey stick**." In this newer version most of the warming occurs during a **rapid expansion of fossil fuel use in the 20th century**.

Concerns have been raised over the accuracy of each report, but the second version is more widely accepted by policymakers.



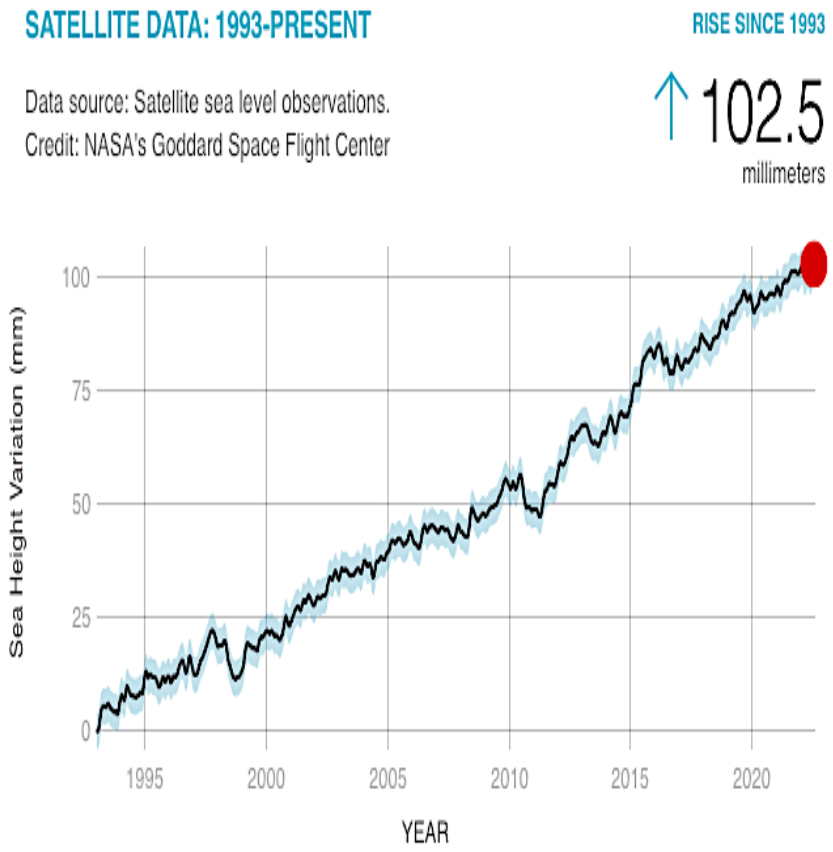


IPCC hockey stick graph of the past 1,000 years

Some of the climate models predict desertification in tropical regions and worsening coastal storms, but the greatest concern is **rising sea levels** as the result of **melting ice caps**.

This polar bear with twin cubs on a rotting iceberg may have drifted for hundreds of miles and

Can we predict how far sea levels will rise by 2100 based on this data from NASA?



https://climate.nasa.gov/vital-signs/sea-level/

1. This graph from NASA covers 30 years. How many mm per year?

   102.5 mm ÷ 30 years = ?

2. How many total mm by the year 2100?

   (2100-2023) X mm per year = ?

3. If 1 inch = 25.4 mm, how many total inches by the year 2100?

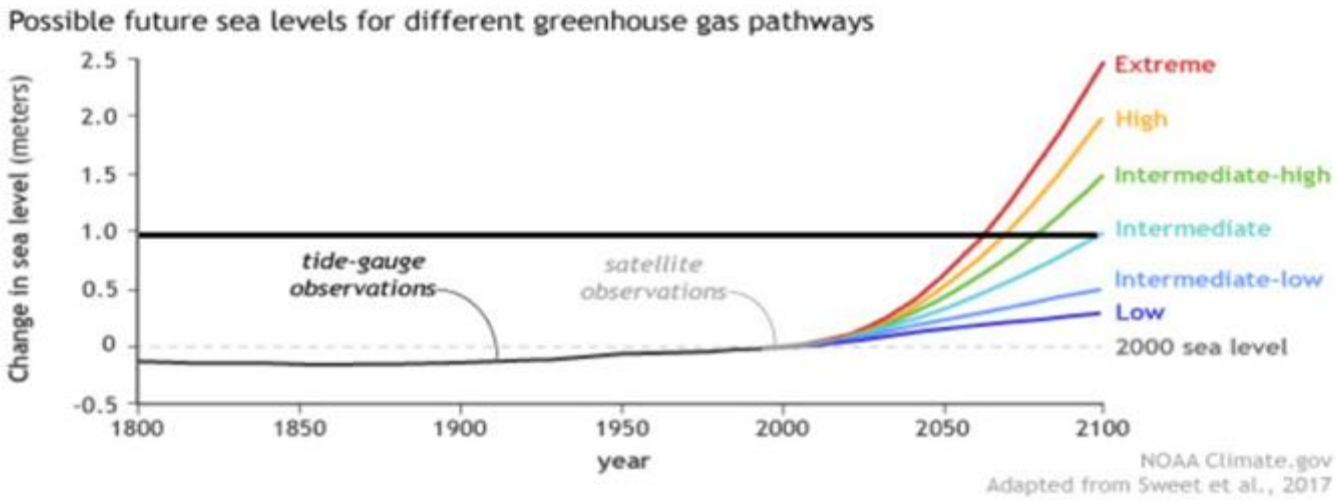
   total mm from 2023-2100 ÷ 25.4 mm/inch = ?

Is this estimate reliable? What did you need to assume?

NOAA projects sea level increases that vary from a few inches to about 7 feet by 2100.

How does this square with your calculations?

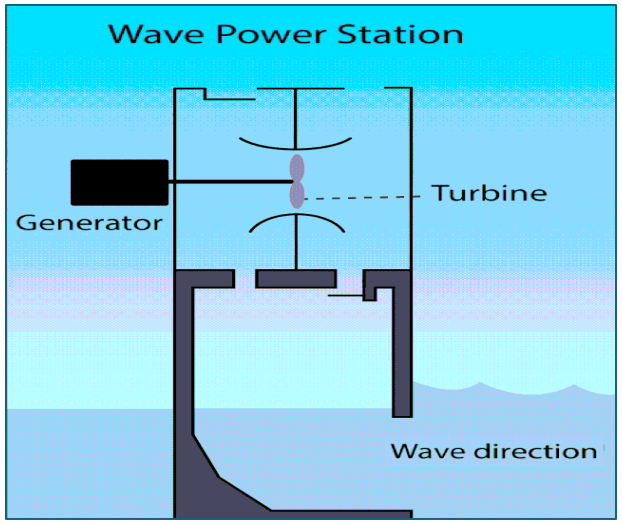
Both the low-end and "worst-case" possibilities were revised upward in 2017 following a review by the U.S. Interagency Sea Level Rise Taskforce. Based on their new scenarios, global sea level is very likely to rise at least 12 inches (0.3 meters) above 2000 levels by 2100 even on a low-emissions pathway. On future pathways with the highest greenhouse gas emissions, sea level rise could be as high as 8.2 feet (2.5 meters) above 2000 levels by 2100.



Observed sea level from tide gauges (dark gray) and satellites (light gray) from 1800-2015, with future sea level through 2100 under six possible future scenarios (colored lines). The scenarios differ based on potential future rates of greenhouse gas emissions and differences in the plausible rates of glacier and ice sheet loss. NOAA Climate.gov graph, adapted from Figure 8 in Sweet et al., 2017.

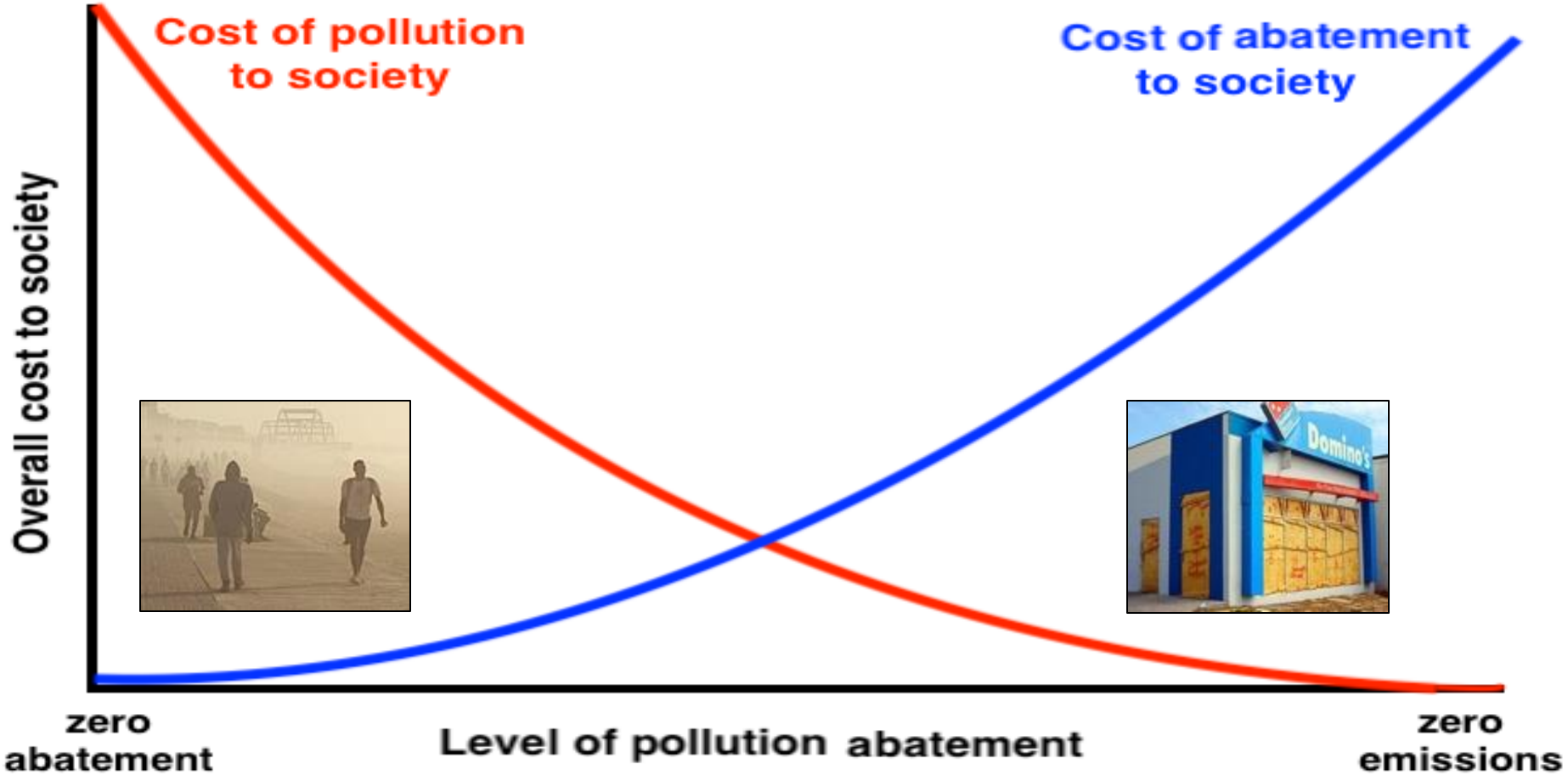
The magnitude of anthropogenic climate change is uncertain, but at the very least we can implement policies that provide undisputed benefits to both the environment and human society. These include:

- Cleaner sources of energy.
- Energy-saving products.
- Access to public transportation.
- Walkable communities.
- Re-forestation.
- Regenerative farming.



conserves carbon
captures carbon

Whatever policy you choose, be mindful of the tradeoffs. Do not overlook the law of unintended consequences!



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