

## Biosphere: Long Term Threat

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The carbon dioxide (CO<sub>2</sub>) in the atmosphere has a controlling influence on Earth's climate. The current level of this gas in the atmosphere exceeds all previous records over the past 800,000 years. The climate is currently being influenced by this excess CO<sub>2</sub> as demonstrated by increasing global average temperature and rising sea level.

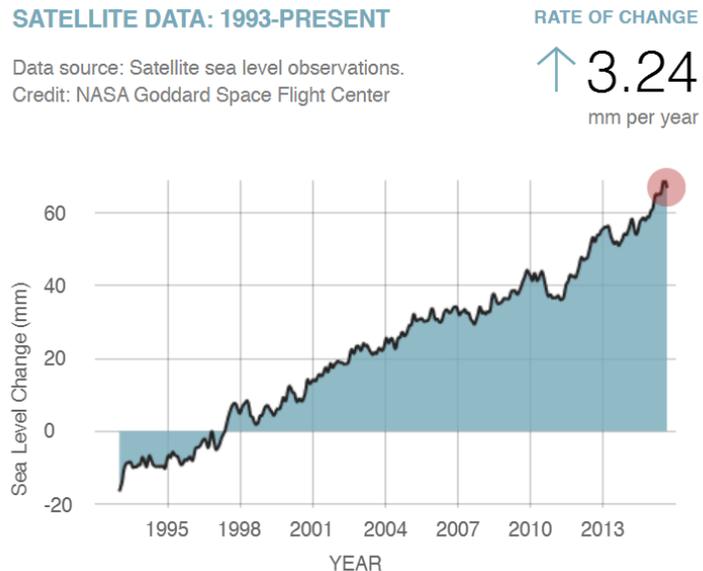


Figure 1. Sea Level Rise

Credit: NASA Goddard Space Flight Centre

Rising sea level is caused by land-based ice melting and sea water expanding and is less subject to short-term variations than global average temperature, Figure 1. There has been a steady increase in sea level due to increasing global heat. More significantly, however, it shows clearly that global warming has been going on since 1989 or earlier and it must be concluded that it will continue as long as a large excess of carbon dioxide remains in the atmosphere. If sea level continues to rise at the same rate it will be 8.5 metres above the present in about 2500 years (half of recorded history). This is especially significant as 8.5 metres was the maximum during the previous interglacial warm epoch, 120 thousand years ago (USGS). That peak was followed by the quaternary ice age, referred to as the Wisconsin glaciation in North America.

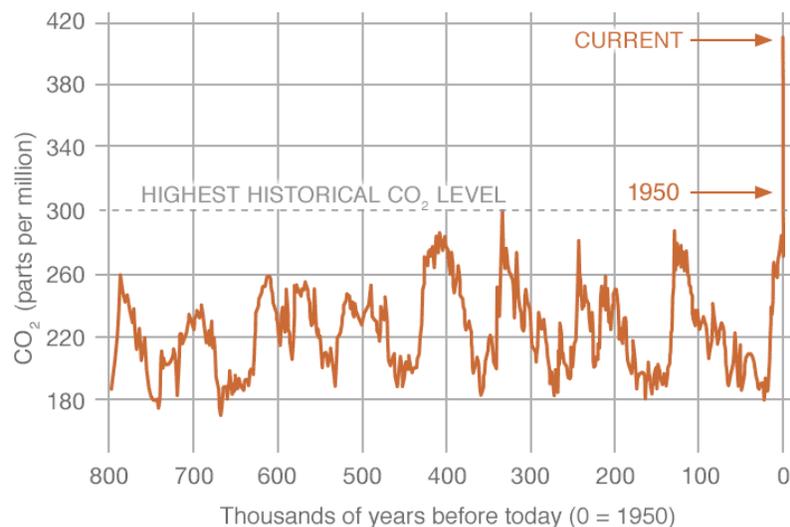
Attempts are being made to curb climate change by reducing emissions of Greenhouse Gas (GHG). Carbon tax and carbon offsets are used by some governments to achieve CO<sub>2</sub> reductions. While this is useful to limit the amount of gas being emitted, it does not reduce the CO<sub>2</sub> already in the atmosphere. Reducing GHG emissions to zero could work in the very long run but it would take several thousand years for the atmospheric CO<sub>2</sub> to fall to a level that is safe from the point of view of climate. Further, there is a severe economic cost to doing so; the

modern world thrives on abundant energy supplies. Thus, the current sources of energy based on fossil fuel would have to be phased out and replaced with renewable or nuclear energy supplies.

As climate change is being driven mainly by the high level of carbon dioxide in the atmosphere, the definitive way to curb it is to remove the excess of the gas. Several companies are working on this, so called carbon removal, but only on a small scale, including: Climeworks of Switzerland; Carbon Engineering of Canada; Deep Branch Biotechnology, of UK and others. Another suggestion for long term storage of captured CO<sub>2</sub> is pumping it into the ground in depleted oil and gas wells and other suitable geological locations. Growing a trillion trees, it is claimed, would reduce the level of CO<sub>2</sub> sufficiently but there is a risk of forest fires reversing the process as may have happened in prehistoric interglacial periods.

In view of the large amount of fossil fuel consumed in the past, similar large amounts of CO<sub>2</sub> must be removed to restore the energy balance of the Earth. One product that could be used in billion-ton quantities is organic soil. CO<sub>2</sub> could be captured and converted to an organic soil amendment using biotechnology. Further, if soil type nitrogen is incorporated into this material by means of the Maillard reaction, it would become a valuable product. Soils normally contain 1 to 10% organic matter, but many have been depleted due to intensive agriculture.

Figure 2.  
Long Term CO<sub>2</sub> Records.  
Credit: NOAA. Data source:  
Reconstruction from ice cores.



This dramatic diagram published by NOAA illustrates the degree to which the atmospheric carbon dioxide now exceeds all previously known levels, Figure 2. The level of CO<sub>2</sub> in the atmosphere remained below 300 parts per million for eight hundred thousand years. The current level, 417 ppm attained in 2021, is already having a major impact on the Earth's climate.

The immediate effect is that more of the infrared radiating from Earth to space is reflected back to the ground resulting in an accumulation of energy. This shows up as increasing global average temperature (IPCC) and rising sea level, Figure 1. The rise in temperature is more acute in Polar Regions and, if it continues, sea ice will disappear, and polar ice caps will

continue to melt. Not only will this accentuate the sea level problem, but it will lead to major changes in the Earth's weather systems including precipitation patterns and ocean currents.

More ominous, however, will be a long-term change in reflectivity of the Earth as areas covered by snow and ice diminish. With less of the solar radiation reflected, the additional radiation captured will gradually push the Earth to a higher orbit, further from the sun. As energy received is inversely proportional to the square of the distance, the planet will collect significantly less solar energy. The Earth will become progressively cooler, and the climate will gradually shift towards an ice age. These changes normally take place over thousands of years, but it may be accelerated by the high level of greenhouse gases currently in the atmosphere. Unfortunately, once set in motion, it would be very difficult if not impossible to reverse such a trend. For the biosphere, an ice age would be catastrophic.

Protecting the biosphere by reducing the amount of carbon dioxide in the atmosphere is imperative. It could be carried out over several hundred years, but much less than one thousand years would be more prudent. Although the cost would be extremely high, the cost of destroying the biosphere is incalculable. Reducing the level of carbon dioxide would have immediate benefits as it would stop and likely reverse the current global warming and associated climate effects, including extreme weather events.

On a more positive note, if it can be done successfully, and an ice age averted, there are immense and far-reaching implications. It would mean that the Earth could be maintained in the "Goldilocks" zone, not too hot and not too cold, indefinitely by regulating the level of carbon dioxide in the atmosphere. In other words, it would break the cycle of ice ages and interglacial warm spells that has been a feature of Earth's climate for a million years. Thus, developing technologies to control the amount of carbon dioxide in the atmosphere would have momentous long-term benefits.