



This is the print version of the [Skeptical Science](http://sks.to/pastco2) article '[CO2 was higher in the past](http://sks.to/pastco2)', which can be found at <http://sks.to/pastco2>.

# Do high levels of CO<sub>2</sub> in the past contradict the warming effect of CO<sub>2</sub>?

## What The Science Says:

Climate and CO<sub>2</sub> levels have always varied together. During past ice ages CO<sub>2</sub> levels were low, and during warm periods CO<sub>2</sub> was higher.

## Climate Myth: CO<sub>2</sub> was higher in the past

"The killer proof that CO<sub>2</sub> does not drive climate is to be found during the Ordovician- Silurian and the Jurassic-Cretaceous periods when CO<sub>2</sub> levels were greater than 4000 ppmv (parts per million by volume) and about 2000 ppmv respectively. If the IPCC theory is correct there should have been runaway greenhouse induced global warming during these periods but instead there was glaciation." ([The Lavoisier Group](#))

## At a glance

Before diving headlong into this myth, one key thing needs to be pointed out. The confidence expressed in the above statement. Phrases like 'killer proof' should be enough to ring alarm bells warning the statement is not the work of any credible scientist. Scientific writing is a relatively sober business.

That aside, this myth is about the nature of Earth's atmosphere and climate through deep time. We know quite a bit about that atmosphere now - but far from everything. Through geological studies, we know a lot more about how the planetary climate evolved over time. But far from everything. It's work in progress.

Evolution of climate over deep time was governed by several factors. Fluctuations in the carbon cycle were driven by changes in the balance between CO<sub>2</sub> sources and sinks. In those pre-human times, the key CO<sub>2</sub> source was volcanic and the key sink was, as now, weathering. Volcanism is still a significant CO<sub>2</sub> source - but about a hundredfold less than human emissions.

Weathering is a chemical reaction that involves the breakdown of the minerals making up the rocks of Earth's surface. Its key agent is carbon dioxide dissolved in rainwater, this being a weak acid. Since rainwater delivers the CO<sub>2</sub>, the intensity of weathering will partly depend upon rainfall. In turn, that depends on how wet - or dry - the climate happens to be in any given place at any given time.

That leads us into palaeogeography - the science of how the layout of the globe has changed through time. Slow changes in layout are driven by plate tectonics and continental drift. Geological evidence tells us that most of the continents on Earth were sometimes gathered together, to form 'supercontinents'. At other times, they were widely dispersed. Such changes in layout through deep time had implications for both the climate and intensity of weathering.

In general terms, the dry interior of a supercontinent reduces weathering, allowing CO<sub>2</sub> levels to rise because the sink cannot keep up with the source. A dispersed pattern is a lot better for weathering and the sink can outpace the source, allowing CO<sub>2</sub> levels to fall.

Over geological timescales, changes in Solar brightness matter, too. Solar brightness is considered to have increased steadily by about 10% per billion years of Earth's history. In the late Ordovician, 445 million years ago, there would therefore have been 4-5% less sunshine reaching the Earth. That's a big difference and enough to change what is known as the 'ice-threshold' - the point beyond which perennial ice-sheets can exist on Earth's surface.

There was certainly an ice-age in the late Ordovician. There are multiple lines of evidence that lend support to that statement. Dispersed continents favoured weathering and CO<sub>2</sub> drawdown. Because of the dimmer Sun, the ice-threshold was set at a much higher CO<sub>2</sub> level than in more recent times. Something else happened too. The late Ordovician ice-age was accompanied by the second-greatest mass-extinction in the fossil record. Neither the quote nor its parent document mention that. One wonders why.

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## Further details

Although our understanding of atmospheric composition through deep time is still a work in progress, we now know enough to state that climate and CO<sub>2</sub> levels have always varied together. During ice ages CO<sub>2</sub> levels were low, and during warm periods CO<sub>2</sub> was higher.

In the Eocene (56-34 million years ago) there were no polar ice caps, temperatures were about 10°C hotter than the 20th Century, and CO<sub>2</sub> was about 1,500ppm ([Westerhold et al. 2020](#), [Rae et al. 2021](#)). During the last Ice Age, CO<sub>2</sub> varied between about 180 and 300 ppm as ice sheets waxed and waned with orbital wobbles ([Rae et al. op.cit.](#)). CO<sub>2</sub> was also about that level during the late Paleozoic Ice Age, 340-290 million years ago ([Foster et al. 2017](#)).

Early attempts to estimate CO<sub>2</sub> for that long ago in Earth's past were broad-brush and very uncertain (e.g., [Royer 2006](#)), leading to the high CO<sub>2</sub> estimates referred to in the myth. New data and refined techniques have since clarified the picture considerably. The 2006 estimates, for example, averaged data across 10-million-year timesteps, the 2017 data in the figure below used 0.5-million-year timesteps, and newer compilations don't average across timesteps. At the same time, CO<sub>2</sub> and temperature uncertainties have reduced considerably so that climates from the geological past (e.g., Fig. 1) are now a useful reality check for climate models ([Tierney et al. 2020](#), IPCC 2021, see the intermediate version for more detail).

Data for the Ordovician are less certain, but they suggest that CO<sub>2</sub> was about 2,400ppm and falling before the end-Ordovician glaciation ([Pancost et al. 2013](#)). Glaciation at higher CO<sub>2</sub> levels than today was possible at that time for a variety of reasons including a less-bright Sun back then (see the intermediate version). The Jurassic and Cretaceous span 134 million years with several hothouse episodes and several cooler episodes, with CO<sub>2</sub> varying from about 600 ppm to about 1500 ppm accordingly ([Witkowski et al. 2018](#)), but there was no glaciation in that time. Earth's long-term climate (over millions of years) is governed by the balance between CO<sub>2</sub> emitted into the atmosphere by volcanoes and CO<sub>2</sub> removed from the atmosphere by [weathering of rocks](#). This has prevented runaway climates and kept Earth's climate generally habitable for about 4 billion years, but it can be outpaced by abrupt greenhouse gas releases (e.g. at the end-Permian mass extinction), or removals (e.g. "Snowball Earth" periods).

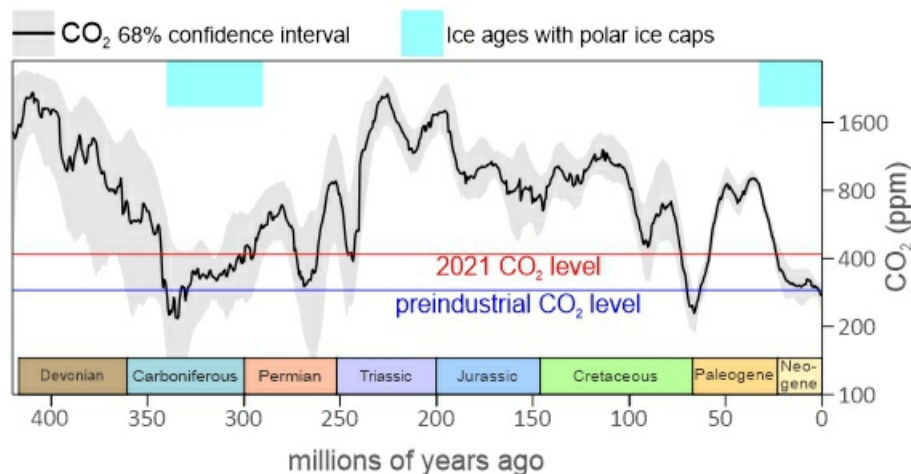


Figure 1. CO<sub>2</sub> levels for the last 420 million years, showing periods with ice ages. Note this curve is

smoothed and too low resolution to show spikes in CO<sub>2</sub>, eg at the end-Permian, end-Cretaceous, PETM, etc. Data from [Foster et al. \(2017\)](#). Late Paleozoic Ice Age per [Rolland et al. \(2019\)](#). Preindustrial CO<sub>2</sub> 278 ppm, [2021 CO<sub>2</sub> 420ppm](#) (CO2.Earth). Newer data zooming in on the last 66 million years can be found on the [intermediate tab](#).

Nevertheless, Earth's climate system has, for the most part, maintained a near-balance in terms of the overall habitability of the planet. This is despite periodic shocks of an internal (e.g. supervolcanic eruptions) or external (e.g. giant impacts) nature. That the key pre-human source of CO<sub>2</sub> was volcanic activity and that volcanic activity is largely driven by plate tectonics is likely to be the key to this stability. Plate tectonics is a constant, ongoing process and probably has been for much of Earth history. That CO<sub>2</sub> sources and sinks mostly do not stray too far apart - with the unique exception of human emissions - is very likely to be down to plate tectonics and its vital role in the Slow Carbon Cycle through geological time.



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