This is the print version of the Skeptical Science article 'CO2 is just a trace gas', which can be found at http://sks.to/trace.

How substances in trace amounts can cause large effects

What The Science Says:
Small amounts of very active substances can cause large effects.

Climate Myth: CO2 is just a trace gas
"We have been grossly misled to think there is tens of thousands of times as much CO2 as there is! Why has such important information been withheld from the public? If the public were aware that man-made CO2 is so incredibly small there would be very little belief in a climate disaster ..." (Gregg Thompson)

At a glance

When the first edition of this rebuttal was posted in August 2011, atmospheric CO_2 was at around 390 parts per million (ppm). Now (August 2023) the number is 421 ppm - and rising.

To a non-chemist, 421 ppm might sound like a vanishingly small amount, simply because you're comparing a small number (421) with a very big one (1,000,000). It therefore comes as no surprise to find that this apparent contrast was seized upon by practitioners of misinformation. Claiming that things occuring in apparently tiny amounts must be harmless is such an easy talking-point to bandy about, since much of the intended audience is unlikely to deal with such numbers on an everyday basis. But it's also one great big red herring. Why?

Hundreds of parts per million may not *sound* like a lot, but in fact many substances have important properties when present at such levels. Here are a few examples:

- He wasn't driving drunk, he just had a *trace* of blood alcohol; 800 ppm (0.08%) is the limit in all 50 US states and limits are even lower in most other countries.
- Don't worry about your iron deficiency, iron is *only* 4.4 ppm of your body's atoms.
- That ibuprofen pill can't do you any good; it's *only* 3 ppm of your body weight (200 mg in 60 kg person).
- The Earth is *only* 3 ppm of the mass of the solar system.
- Your children can drink that water, it *only* contains a *trace* of arsenic (0.01 ppm is the WHO and US EPA limit).
- Ozone is *only* a *trace* gas: 0.1 ppm is the exposure limit established by the US National Institute for Occupational Safety and Health. The World Health Organization (WHO) recommends an ozone limit of 0.051 ppm.
- A few parts per million of ink can turn a bucket of water blue. The color is caused by the absorption of the yellow/red colors from sunlight, leaving the blue. Twice as much ink causes a much stronger color, even though the total amount is still *only* a *trace* relative to the water.
- *Only* 500 ppm of hydrogen sulphide (bad egg gas) in air is a hazardous level, as any health and safety fact-sheet will tell you. It will make you seriously unwell at that kind of concentration. In fact, at above 100 ppm, you can no longer smell the gas because its toxicity has switched off your sense of smell.

Just a trace-gas? Yeah, right.

It's not the concentration of a substance that necessarily matters. Instead, it's what any substance can do at a certain concentration and that property will of course vary from one substance to another. These are all useful things to recall when someone dismissively tells you that carbon dioxide is “only a trace gas”. It doesn't matter.

Please use this form to provide feedback about this new "At a glance" section. Read a more technical version below or dig deeper via the tabs above!

Further details

Although percentage or parts per million are convenient ways to talk about the relative amounts of gases in the atmosphere, they only tell us how much there is compared to everything else up there. Concentration doesn’t give an absolute amount.

For example, most people will have trouble breathing on top of Mount Everest. The atmosphere still contains 21% oxygen, just like at sea level. But the air is rarefied, meaning the relative proportions of all of its constituent gases are the same but the density of their molecules has reduced by around two thirds. With every breath you take you will only get around a third of the oxygen molecules that you would at sea-level. It's the number of oxygen molecules that matter because through their chemical properties and interactions with our bodies, they support respiration - and therefore life.

We are now emitting some 44 thousand million tonnes of carbon dioxide every year (source:IPCC AR6, WG 3 Technical Summary 2022). Fourty four thousand million tonnes is a hard number to visualise. One way to do so is to consider that it's more than seventy times heavier than the combined weight of the current global human population. Maybe that's even more mind-boggling! But nitrogen makes up 78% of the atmosphere - it's vastly more abundant than CO_2. Because of that, the concentration of CO_2 - despite such vast emissions figures - just nudges up by a few ppm a year.

In 1959 the measured CO_2 concentration was 316 ppm whereas at the time of writing (2023) it's 424 ppm. That represents an exponential increase of 108 ppm over 64 years - exponential because our annual emissions have now increased vastly, compared to the 1950s and 60s. That's despite the knowledge of the harm being done by them.

Pre-industrial levels of CO_2 were around 280 ppm, so the overall increase to date has amounted to some 144 ppm - a 50% increase. That CO_2 increase has in turn been sufficient to raise global temperatures by more than a degree celsius relative to pre-industrial times, so we have a bench-mark with which to look at future emissions. Furthermore, because CO_2 is a non-condensing greenhouse gas, once it's up there in the atmosphere it stays around for a long time, so much of that 144 ppm increase still has work to do - meaning that the warming already caused by it will continue for many years.

Often we talk about a doubling of CO_2 from pre-industrial levels (280 increasing to 560 ppm) and its effect upon temperature: Arrhenius did the first calculation on this over 100 years ago. He could not foretell a time when such a CO_2 overloading might occur due to human activity, since the emissions of the very early 1900s were very low compared to now. We now have that doubling firmly in our sights. In the decade of 2013-2023, CO_2 levels have risen by nearly 30 ppm. If our emissions flatlined at current rates, we would reach that doubling-point sometime in the 2060s - not that far off at all - and that's assuming there are no nasty surprises waiting for us in terms of feedbacks.

So we know the amount of CO_2 in the atmosphere has increased in this manner because we have constantly measured its concentration since the late 1950s. We know from current and historical data that the climate has already significantly warmed,. The link between increasing greenhouse gases and increasing temperature is even clearer now than it was in the 19th Century. CO_2 in our atmosphere is trapping energy that would otherwise escape to space. That's an intrinsic property of this particular substance.

If a trace gas can absorb and re-radiate IR at even low concentrations, what do you think will happen if we double that concentration? Twice as many CO_2 molecules, all busy doing precisely what they do and for long into the future. CO_2 may be a trace gas but because of that intrinsic property it has, that doesn't matter.

Cartoon summary

This Cranky Uncle cartoon depicts the "Red Herring" fallacy for which the climate myth "CO_2 is just a trace gas" is a prime example. It is used to deliberately divert attention to an irrelevant point to distract from a more important point. Please see the accompanying blog post for more information about the cartoon collection.

SkepticalScience.com

Skeptical Science explains the science of global warming and examines climate misinformation through the lens of peer-reviewed research. The website won the Australian Museum 2011 Eureka Prize for the Advancement of Climate Change Knowledge. Members of the Skeptical Science team have authored peer-reviewed papers, a college textbook on climate change and the book Climate Change Denial: Heads in the Sand. Skeptical Science content has been used in university courses, textbooks, government reports on climate change, television documentaries and numerous books.