Bringing numerical reality into climate discussions.

Bud Bromley: October 19, 2022 ClimateCite Corp

The increase in net human CO_2 emissions from 2019 to 2020 cannot exceed 0.000258% of net global atmospheric CO_2 concentration. Net human CO_2 emissions equals total human CO_2 emission minus absorption of those human CO_2 emissions. 0.000258% is the net annual increase in CO_2 concentration for 2019 to 2020 due to all CO_2 sources and CO_2 sinks, natural and human, according to the report of the NOAA-Scripps laboratory on Mauna Loa on Hawaii Island (MLO).

The data from MLO is commonly accepted as a "gold standard" to which other studies are compared. This paper challenges that concept for its CO_2 data and implications MLO puts forth regarding those data. But the challenge is not a fault in the diligence of the laboratories' work in analytical chemistry and scientific measurement, although there is one systemic problem in some of these data. But the important and far larger problem concerns what the data represents and the information that is implied and omitted, not with its accuracy, precision and other standard lab quality issues.

While NOAA, etc. writes statements such as "From 2000 through 2018, CO2 emissions to the atmosphere from burning of fossil fuels rose from 6.7 PgC yr^{-1} to 10.2 PgC yr^{-1} (1 petagram of carbon is 10^{15} gC, or 1 billion metric tons C, or 3.67 billion metric tons CO_2). Global fossil fuel emissions have increased steadily year upon year, with the exception of 2009 following the global economic recession and 2014-2016 when emissions held nearly constant (Figure 1)." https://gml.noaa.gov/ccgg/carbontracker/index.php#north_america They neglect to inform the reader that all of the CO_2 added to the air is absorbed by the environment, and that the apparent annual CO_2 increase is the residual difference between two large natural fluxes, total CO_2 emission flux and total CO_2 absorption flux. The apparent annual increase (i.e., the Keeling slope) cannot be caused by humans, as illustrated in this paper. Near the bottom of the same page linked above, NOAA informs the reader of uncertainties in their estimate of CO_2 emission flux, including that it contains guesswork (1). This may be the most useful information on that website.

According to MLO measurements, in the year 2019 to 2020, 2.58 ppm was the year-over-year increase, a 0.000258% increase in net global atmospheric CO_2 concentration. (At the time of writing this paper, MLO has not given final approval to 2021 CO_2 data.) This diligently-measured 2.58 ppm concentration is less than half of the two combined, natural, continuous CO_2 fluxes, as will be illustrated.

How much CO_2 is 2.58 ppm?

Most importantly, these CO_2 calculations must not be made by volume, e.g., ppmv, grams per liter, etc., in global carbon balance calculations, etc., nor should these calculations be based on estimates of the mass, volume or weight of the atmosphere, as will be illustrated here. The uncertainty in these data is too large for practical use. The size of the uncertainty in the estimates of these amounts relative to the amount of CO_2 renders such calculations counterproductive. For example, in the real atmosphere, the variance in the measurement of CO_2 due to the natural variance in humidity is so large that the CO_2 data from natural air samples is practically useless; thus MLO necessarily dries air samples; water is frozen out of air samples before gases are measured. Other organizations treat ppm and ppmv synonymously.

The unit of the measurement by MLO is micromoles of CO_2 per mole of dry air, which is a unit of molar mass, not a unit of volume. The molar mass of CO_2 is about 44 grams per mole of CO_2. That is, the carbon atom in CO_2 is about 12 grams per mole, and the two oxygen atoms are each about 16 grams per mole; 12+16+16 = 44 grams per mole, i.e., the molar mass of the CO_2 molecule.

The molar mass of dry air is about 29 grams per mole. (I will leave that calculation for the curious reader or another post.)

Measured by MLO, the increase in CO_2 due to all CO_2 sources and sinks for 2019-2020 was 2.58 micromoles CO_2 per mole of dry air, which is 2.58×10^{-6} moles of CO_2 per mole of dry air. That is, 44 grams/mole of CO_2 X 2.58×10^{-6} moles equals 1.13×10^{-4} grams of CO_2 per mole of dry air. Then 1.13×10^{-4} grams of CO_2 divided by 29 grams per mole of dry air equals 3.9×10^{-6} grams of CO_2 per gram of dry air, which is the increase in CO_2 for the year 2019 to 2020, due to all sources and sinks. 3.9×10^{-6} grams of CO_2 per gram of dry air per year is the slope of the Keeling curve for 2019-2020 expressed in grams of CO_2 per year.

Imagine how small that amount is! Less than 4 millionths of a gram increase in a gram of air!

NOAA informs us (link above) that "From 2000 through 2018, CO_2 emissions to the atmosphere from burning of fossil fuels … rose to 3.67 billion metric tons CO_2". We will assume that is true only for the purposes of this illustration. That is 3.67×10^9 metric tons. A metric ton is 1000 kilograms and a kilogram is 1000 grams. Thus we have 3.67×10^{15} grams of fossil fuel CO_2 emission per year, on average, reported by NOAA. This is an estimated annual average of 3.67 quadrillion grams of CO2 emissions emitted into air due to combustion of fossil fuels for the period 2000 through 2018 (except 2009). Sound scary? But wait, there is more. How much of that CO_2 was absorbed? Why is that absorption buried, ignored and dismissed?

3.9×10^{-6} grams of CO_2 per gram of dry air is the net residual difference after subtracting two natural, continuous, opposing, CO_2 fluxes. (A flux is the mass of material passing in one vector direction through an area of surface, and/or thickness of surface, per unit of time. For example grams of CO_2 emitted into air per square meter of ocean surface layer 1 nanometer thick per hour.) One of these fluxes is the emission of CO_2 into the air by all sources, natural and human, a portion of this flux NOAA says is

3.67 X 10^{15} grams of CO_2 emitted per year due to fossil fuel combustion. There are other sources of CO_2 in addition to fossil fuels. The emission flux is heavily emphasized, while usually the equally large absorption flux is barely mentioned. Whatever the amount of the total CO_2 emission flux, we know that it is offset by an opposing, natural, continuous CO_2 absorption flux which is diffusing CO_2 into sinks in the environment, i.e., ocean, soil, plants, etc. Almost never mentioned are the natural processes that keep these two fluxes in balance and science involved.

How do we know there are two large, opposing fluxes and their relative sizes? NOAA informs us (link above) informs us that on average we have 3.67 X 10^{15} grams of fossil fuel CO_2 emission per year, but the net residual difference measured by MLO between these two large CO_2 fluxes for the year 2019-2020 was 3.9 X 10^{-6} grams of CO_2 per gram of dry air. The MLO-measured 3.9 X 10^{-6} grams of CO_2, i.e., the Keeling curve slope, is less than a rounding error in the reported 3.67 X 10^{15} grams of fossil fuel CO_2 emissions. The annual fossil fuel CO_2 emissions are about nine orders of magnitude, about a billion times, larger than the net global annual increase reported by MLO! Where does all of this CO_2 go? This is the question that is largely ignored, while focusing instead of emissions.

The annual increase in <u>net</u> atmospheric CO_2 concentration for 2019-2200 due to all sources and sinks is a residual difference less than 4 millionths of a gram of CO_2 per gram of dry air, and this amount is continuously diluted into two giant fluxes of CO_2, and both fluxes exceed 3.67 X 10^{15} grams of CO_2 per year. Now the problems with the estimations of volume and mass of the atmosphere will be illustrated.

According to scientists Kevin E. Trenberth and Christian J. Guillemot (1994) in *The total mass of the atmosphere*:
https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/94JD02043

"Thus the mean mass of water vapor is 1.25×10^{16} kg ***and the dry air mass is 5.132×10^{18} kg,*** *corresponding to a mean surface pressure of 982.4 mbar. Overall uncertainties are ~0.1 mbar or 0.5×10^{15} kg in total mass and about double those values for atmospheric moisture content."*

According to this estimate reported by Trenberth and Guillemot, the atmosphere contains about 5.132 X 10^{18} kilograms of dry air, which is 5.132 X 10^{21} grams of dry air. Then the product of 3.9 X 10^{-6} grams of CO_2 (the annual increase per gram of dry air) multiplied by 5.132 X 10^{21} grams of dry air in the total atmosphere results in an approximate increase in the atmosphere of 2.0 X 10^{16} grams of CO_2 for 2019-2020 due to all sources and sinks, natural and human.

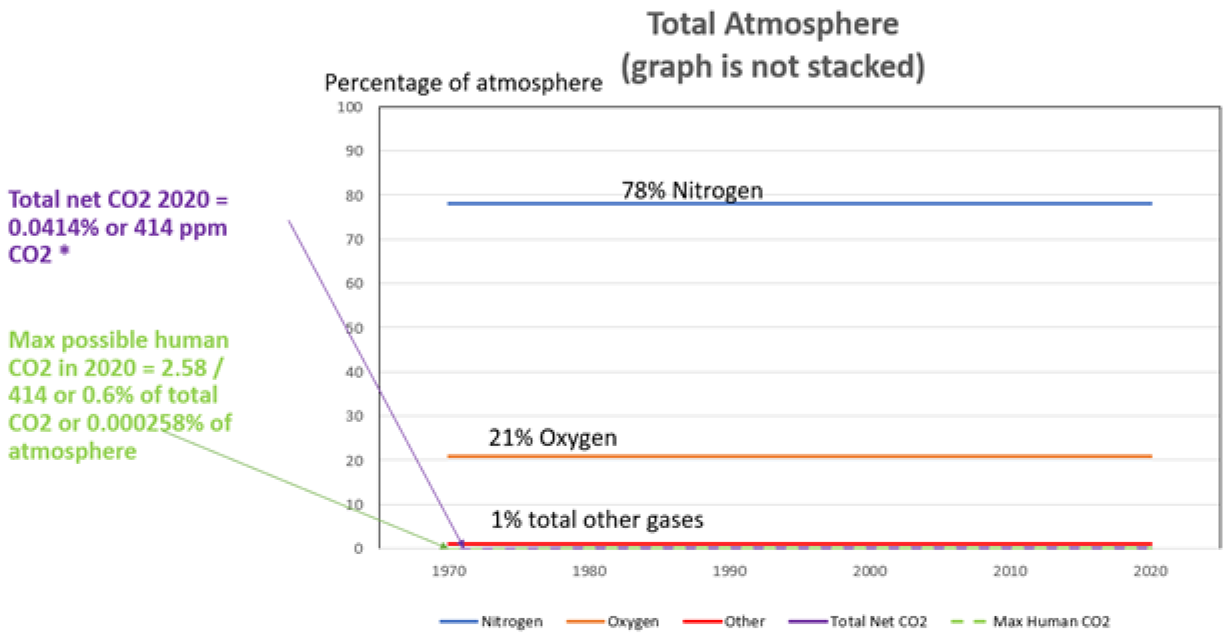
Then, using the estimate from the Trenberth and Guillemot reference, with this 2019-2020 CO_2 increase, we have 2.0 X 10^{16} grams of CO_2 added to the atmosphere, which is diluted immediately and continuously into 2 natural, continuous, vector directional fluxes of CO_2. The net annual difference between the two fluxes is 2.0 X 10^{16} grams of CO_2 per year for 2019-2020, which is the slope of the Keeling curve expressed in grams of CO_2 per year for 2019-2020. Notice that the net annual difference between the two fluxes is larger than the estimated average annual fossil fuel CO_2 emissions. Therefore it is not plausible that fossil fuel emissions are causing the slope of the Keeling curve.

The increase of 2.0 X 10^{16} grams of CO_2 per year are diluted continuously into 5.132 X 10^{21} grams of dry air, which results in a dilution of 2.57 X 10^5 to 1. In other words, the net increase in CO_2 mass in the atmosphere in 2019-2020 due to all sources and sinks is only one CO_2 molecule increase per 257,000 molecules of dry air; the CO_2 increase for 2019-2020 due to humans must be a number less than 1 because in this comparison 1 includes all CO_2 from all sources and sinks, natural and human.

Meanwhile the uncertainty in the Trenberth-and-Guillemot-estimated atmospheric mass is ***0.5×10^{15} kg or 0.5 X 10^{18} grams.*** Uncertainty here is a statistical estimation of confidence in the reproducibility of the estimates of mass of the atmosphere. High uncertainty implies that the estimated mass is unlikely to be found in a normal distribution of the data, it will be an outlier. We have 2.07 X 10^{16} grams of CO_2 divided into the Trenberth and Guillemot-estimated 5.132 X 10^{21} grams of dry air. But, the uncertainty of the dry air estimated mass is 5 X 10^{17}. **The uncertainty in the estimate of the mass of the atmosphere is 24 times larger than annual increase in net CO_2 due to all causes. This is like trying to measure a second with a clock that measures days.**

The annual increase in net CO_2 emissions for 2019-2020 is less than a rounding error in the dilution of that CO_2 in the atmosphere, and then only if the estimate of atmospheric mass was reasonably certain, which it is not.

The diligently-measured-and-reported increases in net concentration of atmospheric CO_2, i.e., the Keeling curve, must be questioned, despite its "gold standard" status, and global publicity in the press, government, and academia. The 1.13 X 10^{-4} grams of CO_2 per mole of dry air annual CO_2 concentration increase (or ~2.58 ppm slope) is hiding 2 large, natural, continuous CO_2 fluxes, and then these 3 CO_2 fluxes are diluted into amounts of the other atmospheric gases which combined are more than 257,000 times larger than the net CO_2 increase. No measurable or significant warming or climate forcing can result from such insignificant increases in net CO_2 concentration; the other gases hold far more energy. And then the uncertainty is so large that we do not know if this "gold standard" net CO_2 trend is real, a measurement anomaly, or a systematic error. Yet IPCC, WEF, world governments, world bankers, NGO's, academics, McKinsey & Company, the Pope, etc., are expecting people to spend $9 TRILLION per year to reduce a claimed human-fossil fuel driven CO_2 slope that is not proven to exist.



*Source Credit: NOAA-Scripps Global Monitoring Laboratory. Pieter Tans. www.esrl.noaa.gov/gmd/ccgg/trends/

(1) “Flux uncertainties: It is important to note that at this time the uncertainty estimates for CarbonTracker sources and sinks are themselves quite uncertain. They have been derived from the mathematics of the ensemble data assimilation system, which requires several educated guesses for initial uncertainty estimates. The paper describing CarbonTracker (Peters et al. (2007), Proc. Nat. Acad. Sci. vol. 104, p. 18925-18930) presents different uncertainty estimates based on the sensitivity of the results to 14 alternative yet plausible ways to construct the CarbonTracker system. For example, the 14 realizations produce a range of the net annual average terrestrial emissions in North America of -0.40 to -1.01 PgC yr-1 (negative emissions indicate a sink). The procedure is described in the Supporting Information Appendix to that paper, which is freely downloadable from the PNAS web site. Furthermore, the estimates do not take into account several additional factors noted below. The calculation is set up for sources and sinks to slowly revert, in the absence of observational data, to first guesses of net ecosystem exchange, which are close to zero on an annual basis. This set-up may result in a bias. Also due to the sparseness of measurements, we have had to assume coherence of ecosystem processes over large distances, giving existing observations perhaps an undue amount of weight. The process model for terrestrial photosynthesis and respiration was very basic, and will likely be greatly improved in future releases of CarbonTracker. Easily the largest single annual average source of CO2 is emissions from fossil fuel burning, which are currently not estimated by CarbonTracker. We use estimates from emissions inventories (economic accounting) and subtract the CO2 mole fraction signatures of those fluxes from observations. As a result, the biosphere and ocean fluxes estimated by CarbonTracker inherit error from the

assumed fossil fuel emissions. While these emissions inventories may have a small relative error on global scales (perhaps 5 or 10%), any such bias translates into a larger relative error in the annual average ecosystem sources and sinks, since those fluxes have smaller magnitudes. We expect to add a process model of fossil fuel combustion in future releases of CarbonTracker. Finally, additional measurement sites are expected to lead to the greatest improvements, especially to more robust and specific source/sink results at smaller spatial scales."
https://gml.noaa.gov/ccgg/carbontracker/index.php#north_america