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Climate: Man or Nature?

A Contribution to the Discussion

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Abstract

From a purely logical perspective, humans can only be the main cause of the ongoing warming if two preconditions are met: CO_2 must have a strong climate impact and the large amount of CO_2 in the atmosphere must primarily be anthropogenic. However, the fulfillment of both preconditions is scientifically controversial.

Controversy regarding the strength of the climate impact of CO_2 stems primarily from this being a quantitative question with many uncertain assumptions that everyone makes differently. This leads to results and consequences ranging from "harmlessly small" to "catastrophically large". A resolution of this dissent is not in sight.

Controversy regarding the primary origin of CO_2 is less about quantitative aspects but more about the fundamental assessment of the behavior of CO_2.

In this paper, an assessment of the behavior of CO_2 is made, based on elementary physical quantities and principles. Different viewpoints are taken into consideration, but results stay the same: The increase in atmospheric CO_2 is most likely predominantly due to increased emissions from natural sources with only a minor contribution from anthropogenic emissions. The popular thesis "It's all man-made" is challenged and a careful review is urgently required.

If the predominantly natural origin of the large amount of CO_2 is confirmed, then there are logically only two possibilities left: Either climate is primarily dependent on CO_2, then it is primarily dependent on natural CO_2. Or, other climate influences predominate, then CO_2 only plays a minor role, regardless of its origin. In both cases, nature is stronger than man and it makes no sense to reduce or even stop anthropogenic CO_2 emissions for climate protection reasons! We could concentrate on more urgent tasks. That is why the question of the origin of all the CO_2 is so important. The intention of this paper is to contribute to an in-depth discussion.

Keywords: Carbon cycle; global warming; CO_2-budget; CO_2 residence time; anthropogenic emissions.

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1. Introduction

Climate has always changed, and it will continue to do so. Nowadays, temperatures are rising again. This climate change differs from previous ones in that this time humankind could be the cause through its CO_2 releases. Whether this is the case is examined in this paper.

For this purpose, Fig. 1 shows the development of the CO_2 concentration in the atmosphere and the globally averaged air temperature close to the ground from 1880 to the present day. The scales are chosen so that the curves can be compared as easily as possible. Superficially, there seems to be a relatively good agreement, which might justify a cause/effect relationship (CO_2 determines the temperature - or vice versa?). In detail, however, there are also considerable deviations, which rather speak against such a relationship. The roughly similar course of the curves could also just be a coincidence (or the result of a completely different common cause). What applies? This paper attempts to clarify the issue.

But prior to that an important comment on the CO_2 concentration in Fig. 1 is necessary: This figure shows the "usual" CO_2 curve, as it can be found in almost all publications on the climate problem, with a continuous increase since 1880 (and before that, not shown here, a constant value of approx. 280 ppm for thousands of years). However, the course of this curve is largely undisputed only from 1958 onwards, when a new spectroscopic measurement method with considerably improved accuracy was introduced. Prior to that there is controversy: In this period, the curve shown in Fig. 1 is based exclusively on proxy data, particularly reconstructions from ice cores. Direct measurements using chemical methods, which show a completely different picture, are not considered. Among others, Beck (2022) analyzed almost 100000 individual measurements in detail and found strong fluctuations, with values in the 19th century and around 1940 similarly high as today. Engelbeen (2023) criticizes this evaluation as erroneous and cherry-picking, Harde (2023) confirms particularly the high values around 1940, and Fiedler (2023) shows that around the midst of the 19th century values around 400 ppm were the generally accepted state of knowledge. An end of the controversy is not in sight. This paper conservatively uses the "usual" curve as shown in Fig. 1. However, it should be explicitly pointed out that if the chemical measurements of that time were more accurate than the reconstructions from proxy data, the climate problem would differ strongly.

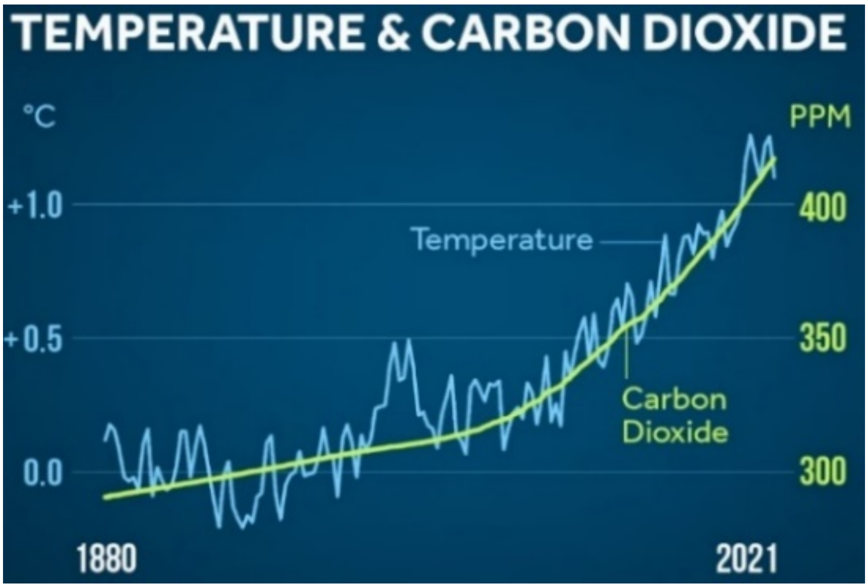

Fig. 1: CO_2 and temperature in the atmosphere from 1880 to 2021:Green: CO_2 concentration in parts per million (ppm), blue: Globally averaged air temperature near the ground in °C (anomalies to the initial value, more precisely to the average of the years 1881-1910). Source: Climate Central, Climate Matters, May 4, 2022, "Peak CO_2 & Heat Trapping Emissions".

Since the start of the Industrial Revolution, *three changes* have undeniably taken place:

- Humans have started to release *large amounts* of CO_2.
- The concentration of CO_2 in the atmosphere has *increased significantly*.
- The temperature has *increased* by a little more than 1 °C.

Thank God, some say, because in their opinion life has become much more comfortable as a result of warming, and because the global food supply has been improved substantially, not least due to the large amount of CO_2 in the atmosphere ("CO_2 fertilization", e. g. Scinexx 2016; Zhu et al. 2016).

Bad, say others, because they think they can already see more extreme weather events and they expect truly catastrophic climate changes in the future if we don't completely stop our CO_2 emissions as soon as possible ("net zero").

These different opinions are only mentioned here because they contribute to the overall picture of "scientifically open ", but they will not be discussed further. Rather, the central topic here is the *elementary question* of the entire climate discussion: What is the definitive cause of the warming that has already occurred and could possibly still be expected? **Is it mankind, or rather nature?**

Commonly, this is regarded to have been clarified at length: it is clearly mankind with its CO_2 releases, so they say. Of these releases, half would remain in the atmosphere long-term, increasing the concentration and, consequently, the temperature. However, this can only be true if two *essential preconditions* are met:

- First: CO_2 must have a *strong impact* on climate!
- Second: The large amount of CO_2 in the atmosphere must have been *released by humankind!*

Even if only one of these two preconditions is not met, humankind cannot be predominantly responsible for the climate! Are they met or not? Contrary to popular belief, this is *scientifically open* in both cases! If one takes a closer look, dissent exists and is plausible in many cases.

Regarding the climate impact of CO_2, there is a very large and constantly growing number of scientific papers that only attribute a minor role to CO_2 in climate events. Instead, other influences would be more significant. The sun is typically cited for this, but often also internal variabilities and other factors are quoted.

In the opinion of the author of this paper, however, nothing has been decided yet, *the science is clearly at odds!* Only to the general public is it presented differently: the science is said to be settled, even though *science never really settles*. And in the case of the climate impact of CO_2, it gets increasingly difficult to hide the existing dissent, because of the increasing number of opposing statements. But it doesn't matter, whether this dispute is held publicly or only within the sciences. Because the question of "climate impact" of CO_2 is a very complex question that can only be answered with complicated calculations and on the basis of uncertain assumptions (e.g. about the effects of water vapor and clouds), a timely end to the dispute is uncertain. Opinions don't tell much (everyone has their own!), only time will tell which one is more correct. Only the existing dissent is certain!

Regarding the large amount of CO_2 in the atmosphere, the essence of the debate differs: Doubts about the anthropogenic origin are raised only rarely and have therefore only been discussed very little up to now. Publicly, this dissent almost does not exist at all, but in science, it clearly does exist (e.g. Andrews 2023; Andrews 2023A; Berry 2019; Berry 2021; Berry 2023; Berry 2023A; Harde 2019; Harde et al. 2021; Mueller 2023; Pollard 2022; Roth 2023; Salby et al. 2021A; Salby et al. 2021B; Schrijver 2022; Stallinga 2023). And because "skeptics" very well quote physically plausible arguments (see below), and because the subject is factually not quite as complex and untransparent as that of the climate impact of CO_2, an agreement is perhaps easier to achieve here. Only time will tell. In any case, this paper aims to make a contribution to an in-depth discussion.

2. The Origin of the Large Amount of CO_2 in the Atmosphere

To make the scientific dispute more understandable, the main reasons for the doubts about the anthropogenic origin of the large amount of CO_2 in the atmosphere should be explained and discussed in more detail:

2.1 Basics

2.1.1. Inert gas

CO_2 within the atmosphere behaves like an inert gas. Except for minimal amounts, no CO_2 is produced or lost in the atmosphere. The concentration in it therefore only ever changes according to the (momentary) difference between release and removal (each calculated as the sum of all sources, or, accordingly, all sinks): If more CO_2 is released into the atmosphere than is removed from it, the concentration rises precisely by the difference, if less is released than removed, concentration sinks precisely by the difference.

2.1.2. Removal increases with concentration

The removal of CO_2 from the atmosphere (number of molecules per second) principally increases with increasing concentration in it (and decreases with decreasing concentration) and it is generally independent of whether and how much CO_2 is released into the atmosphere simultaneously. That's just required by physics. (Caution: Often there is no clear distinction between "removal", which is the absolute number of CO_2 molecules removed per second, and "net removal", which only gives the difference to the CO_2 molecules released at the same time; unless otherwise stated, the "removal" is generally meant here in this paper).

2.1.3. Stabilization

As a result of item 2.1.2, whenever the release occurs at a constant value, the concentration adjusts itself to *that* level, where removal *is the same* as release. Then, there is equilibrium. Fig. 2 illustrates this.

That concentration adjusts itself to the value at which outflow equals inflow is not only required by physics (as a consequence of the removal increasing with concentration!), but it is probably also a necessary requirement for all life on earth: otherwise, there would probably not be a stable atmosphere, because CO_2 concentration would run away after the slightest disturbance! The self-stabilization of the atmosphere (decoupling of concentration from emissions via adjusting outflow to inflow) can therefore be regarded as sufficiently proven.

2.1.4. Historical data

Before the beginning of the industrial revolution, such a situation prevailed. Input and output were approximately 80 ppm/y and concentration settled at 280 ppm/y (e.g. IPCC 2021; ppm = parts per million, 280 ppm are 0.028%).

Since then, anthropogenic releases have been added. These have grown from initially very low values up to about 5 ppm/y today (this is about 5% of natural releases; Fig. 4). In this period, concentration has increased to about 420 ppm (e.g. IPCC 2021).

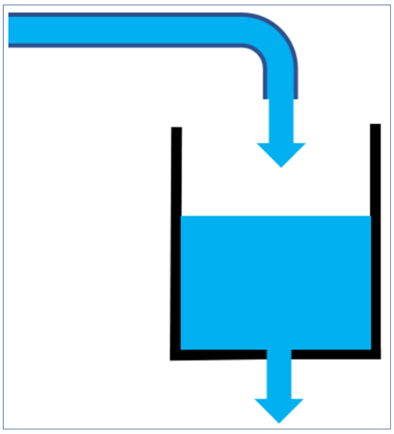

Fig. 2: For illustration: In a water tank with inflow from above and outflow through a hole in the bottom, the water level always adjusts itself to the one value, where outflow equals inflow. And the atmosphere behaves analogous: The CO_2-concentration adjusts itself to the one value, where outflow equals inflow.

2.1.5. Interim findings

Items 2.1.1 to 2.1.4 appear to be clearly correct and are probably not seriously questioned. However, it follows logically mandatory from item 2.1.3 that a reduction of anthropogenic releases to *zero is not necessary*. Not necessary, because, if anthropogenic releases are frozen at a fixed value (e. g. today's), concentration tends towards a stable value, that value, where outflow equals inflow. This is correct at least, when only anthropogenic releases are responsible for the increase in concentration, as the IPCC assumes. This state would be stationary and theoretically it could be maintained indefinitely without concentration (and potentially also temperature) continuing to rise, despite ongoing releases.

However, this poses serious consequences: IPCC claims that a "fixed CO_2 budget" exists, which is „the maximum amount of cumulative net global anthropogenic CO_2 emissions that would result in limiting global warming to a given level" (IPCC 2021, Glossary). The "fixed CO_2 budget" is often used as the basis for far-reaching assessments and decisions in the field of climate protection. But due to the described effect of self-stabilization of the atmosphere, **a "fixed CO_2 budget" cannot exist**, and all these assessments and decisions lack justification.

This result alone *sets the entire climate problem in a completely different light:* supposedly reliable findings suddenly hang in the air without any justification!

2.2 Core arguments

2.2.1. All molecules are the same

Because all CO_2 molecules *are the same* regardless of their origin, they must all *behave the same way*. And because removal of CO_2 from the atmosphere does not remain constant, but increases with increasing concentration (item 2.1.2), all sources contribute to the concentration according to their respective strength of releases. If the anthropogenic releases account for only about 5% of natural releases (item 2.1.4), then they can only have increased the concentration by about 5% (at equilibrium, less before; but see also section 2.4). *There can be no disproportionately higher contribution from any source!*

2.2.2. Increased releases from natural sources

In reality, concentration has increased by 50%, from 280 ppm in the past to 420 ppm today. In order to reach and maintain this value, the total releases into the atmosphere *must have increased by 50% too!* This means that releases from natural sources must have increased *almost 10 times* more than anthropogenic releases have been added! If natural releases were constant and anthropogenic releases increased the way they have, concentration wouldn't even have reached 300 ppm. For possible sources of increased natural releases, see section 2.4.

The same result of a significantly increased release from natural sources can also be obtained by a slightly different approach: The concentration in the atmosphere (the only value that is really *measured!*) can be used to calculate the level of removal (see below). From the change in the concentration, then it can be calculated which release must have taken place simultaneously, so that the concentration could have developed in exactly the way it did. In detail:

The rules of physics not only require that gross removal (not net removal!) of CO_2 from the atmosphere *depends on the concentration* in the atmosphere (item 2.1.2), but they also make it possible to *quantify the amount* of removal: Because removal takes place primarily via diffusion processes, in principle it must be *proportional* to the absolute concentration. In reality, however, this is probably only an approximation, because only "primarily" diffusion processes work (counterexample: CO_2 removal from the atmosphere through rain, but this could also be approximately proportional to the concentration), and because even in diffusion processes other influences may have some influence.

So, for example, in the case of biomass as a sink, the growth of plants not only depends on CO_2 concentration in the atmosphere (photosynthesis is executed via diffusion processes!), but also on the availability of water and nutrients. However, since plants grow well where they have enough water and nutrients (and therefore also remove a lot of CO_2 from the atmosphere there!), and since they also need less water when the CO_2 concentration is high (because their evaporation losses are smaller as a result of narrowed stomata), this dependency on availability of water and nutrients should not result in a major deviation from proportionality in the real world. Furthermore, proportionality to concentration probably also applies where other parameters already exert some influence, if these other parameters are kept constant. In addition, it must also be taken into account that the biomass has *significantly increased* (Scinexx 2016; Zhu et al. 2016), and therefore it also removes more CO_2 (and then inevitably it returns more CO_2 too). Regarding biomass, proportionality should therefore be at least a reasonable approximation.

The situation is similar with the second major sink, the ocean: In principle, the number of CO_2 molecules that go into solution per second is proportional to the concentration in the atmosphere (diffusion process!), but because of chemical transformations of the dissolved CO_2 this is valid only approximately in this case too: most of the CO_2 dissolved is converted into carbonate and bicarbonate, which do not contribute to the CO_2 partial pressure (the so-called "Revelle effect"). If the ratio between these chemical forms were constant, it would not have any further influence on the proportionality. But in reality, it is not constant, rather it changes slightly with concentration. Therefore, the proportionality between concentration and removal is only approximate for the ocean too. (To clarify: the Revelle effect has a very significant influence on the *amount* of carbon that is stored in the ocean water (in different chemical forms), but it only slightly influences the proportionality of the *CO_2 exchange rate* to the concentration, which is what matters here).

At least approximate proportionality therefore applies to *both* sinks, the removal by dissolution in ocean water and by photosynthesis in plants. But the question here is not proportionality per se, but rather whether the 5% anthropogenic releases alone are sufficient to increase the concentration by 50%, or whether considerable *additional sources* are required for this. And because both sinks are so strong, it is clearly sufficient for the latter if even only one of the two sinks is approximately proportional. However, since these two processes are physically completely different, and since they occur independently of one another (the only interconnection between the two is the atmosphere as a part of both processes), there must be a substantial error in *both* assessments for the releases from natural sources to have remained constant or increased only slightly, which is extremely unlikely. In any case, a deviation large enough to fully compensate for the above-mentioned factor of 10 is hardly imaginable. If no physical process can be defined that explains a significantly disproportionate effect of the anthropogenic releases under realistic conditions, significantly increased releases from natural sources are *logically mandatory* (see also section 2.4)!

2.2.3. Interim findings

Items 2.2.1 and 2.2.2 show very clearly the **necessity of significantly increased releases** from natural sources in order to explain the high concentration observed in the atmosphere. Therefore, almost certainly, *the climate problem is very different from how it is usually perceived!*

2.3 Supporting arguments

2.3.1. Continuously high increase

Another strong argument for significantly increased releases of CO_2 from natural sources (item 2.2.2) is the continuously high increase in the atmospheric concentration (Figs. 1 and 3). If the atmosphere were a closed reservoir with only anthropogenic releases as a connection to the outside, then these releases would remain in the atmosphere completely, and the concentration would correspondingly increase faster than observed (and it would also, contrary to item 2.1.5, continue to increase as long as there are anthropogenic releases!). However, since the concentration is growing slower than would be expected as a direct result of the anthropogenic releases, CO_2 must be removed from the atmosphere. Thus, the atmosphere is not a closed reservoir! And because removal is greater the higher the concentration is (items 2.1.2 and 2.2.2), concentration cannot continually increase faster than releases increase! The additional supply of CO_2 would simply *not be sufficient* for that.

In more detail: In the last 60 years, concentration in the atmosphere has grown ever more rapidly. From year to year, it has grown a good 2 % faster than in the previous year: the slope has increased from approx. 0.7 ppm/y in 1960 to approx. 2.5 ppm/y in 2020 (Fig. 3). In contrast, the anthropogenic releases have grown considerably slower over a similar period. Their growth increased only under 1 % annually: the slope has increased from approx. 0.048 ppm/y in 1950 to approx. 0.085 ppm/y in 2010, and in the last decade, they have grown even slower (Fig. 4, note the different scales)! Such *slowly growing* releases cannot explain the *much faster* growth of atmospheric concentration, as long as removal is concentration-dependent! The mass balance just wouldn't add up otherwise. And since no CO_2 is produced in the atmosphere (item 2.1.1), there must be *another source* emitting CO_2 into the atmosphere, which in turn is growing rapidly, even much faster than anthropogenic releases. Releases from natural sources must therefore not only *be larger* than anthropogenic releases (section 2.2), but they must also *grow faster* than them! The anthropogenic releases alone just *do not suffice*.

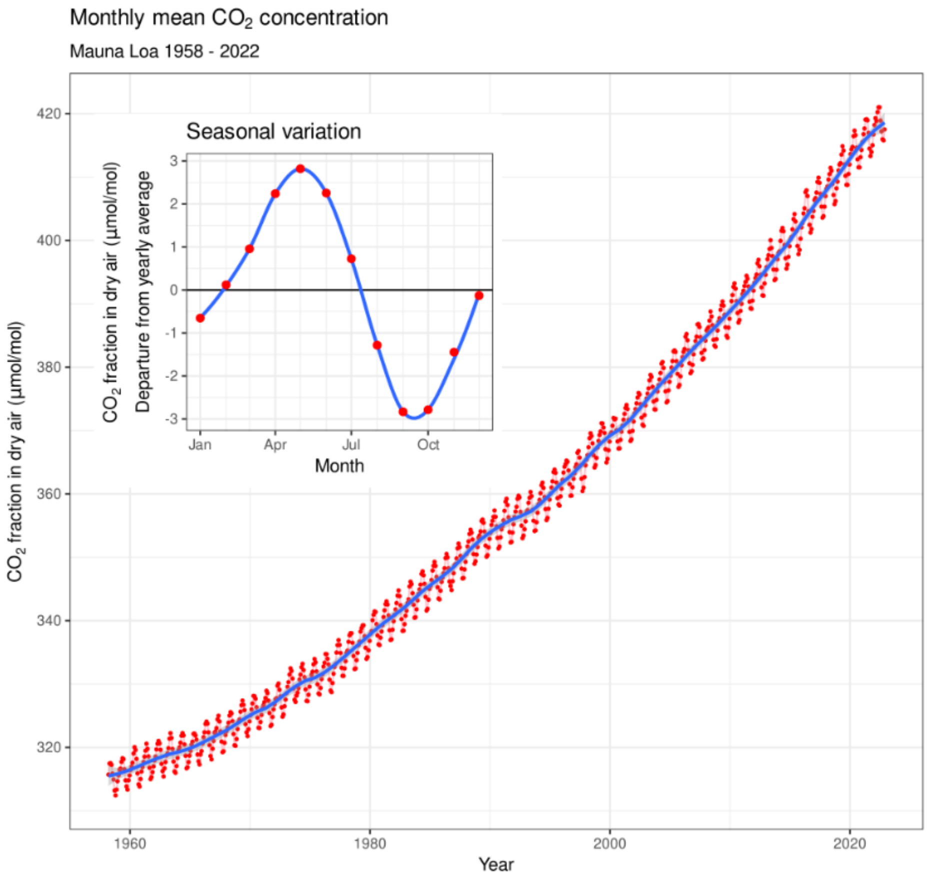

Fig. 3: Monthly CO_2 concentration, Mauna Loa, Hawaii, 1958-2022; Source: Wikipedia, Data: Dr. Pieter Tans, NOAA/ESRL (https://gml.noaa.gov/cogg/trends/) and Dr. Ralph Keeling, Scripps Institution of Oceanography (https://scrippsco2.uscd.edu). Accessed 2023-12-15 https://w.wiki/4ZWn.

This is often contradicted by arguing that the anthropogenic releases have been and are continuously *twice as large* as the CO_2 inventory in the atmosphere is growing, so they could very well be solely responsible for the increase. However, this argument overlooks the dependence of removal on concentration (item 2.1.2): Because removal increases with increasing concentration, *concentration cannot continuously rise faster* than releases rise, because the additional supply of CO_2 will not be sufficient. If concentration were to rise faster, **another source must contribute!**

2.3.2. Seasonal cycles

Another supporting observation are the seasonal cycles of concentration. These cycles are caused by seasonally fluctuating photosynthetic performance and decay of plants with significantly larger land areas in the northern hemisphere than in the southern hemisphere. Figure 3 shows the seasonal cycles superimposed on the long-term increase of concentration. The seasonal cycles show an amplitude of approximately 6 ppm. These cycles contradict the possibility that the increase in the concentration was caused by a limited capacity of the sinks, as the IPCC sees it

(IPCC assumes that the sinks can absorb only half the amount of anthropogenic releases). In reality, the sinks simply take CO_2, from wherever it had entered the atmosphere, and if they are offered more, then they take more! All sinks must *treat* each CO_2 molecule the same since all CO_2 molecules *are* the same, and therefore they *behave* the same! There can be no different treatment depending on the origin of the CO_2. Saturation of the sinks can be ruled out, because otherwise atmospheric concentration, which is increased every seasonal cycle, *could not be lowered again!* The overall greatly increased concentration is therefore probably not the result of small additional releases together with limited sinks (as IPCC sees it), but rather the result of greatly increased releases together with well-acting sinks!

Supplement: According to the IPCC, the sinks have been removing more and more CO_2 from the atmosphere over time: In addition to the previous (and according to the IPCC unchanged) 80 ppm/y (item 2.1.4) comes half of the anthropogenic releases. Today, this equals an additional removal of 2.5 ppm/y. Therefore, the IPCC attributes the sinks the potential to *easily take up that much*. Consequently, at least as long as anthropogenic releases still were below 2.5 ppm/y (until around 1970, Fig. 4), the concentration should only have increased *minimally* because the sinks were not yet saturated. However, even in those days' concentration increased *considerably* (Fig. 1), so the IPCC's view *cannot be correct.* The introduction of a much stronger source easily solves the problem.

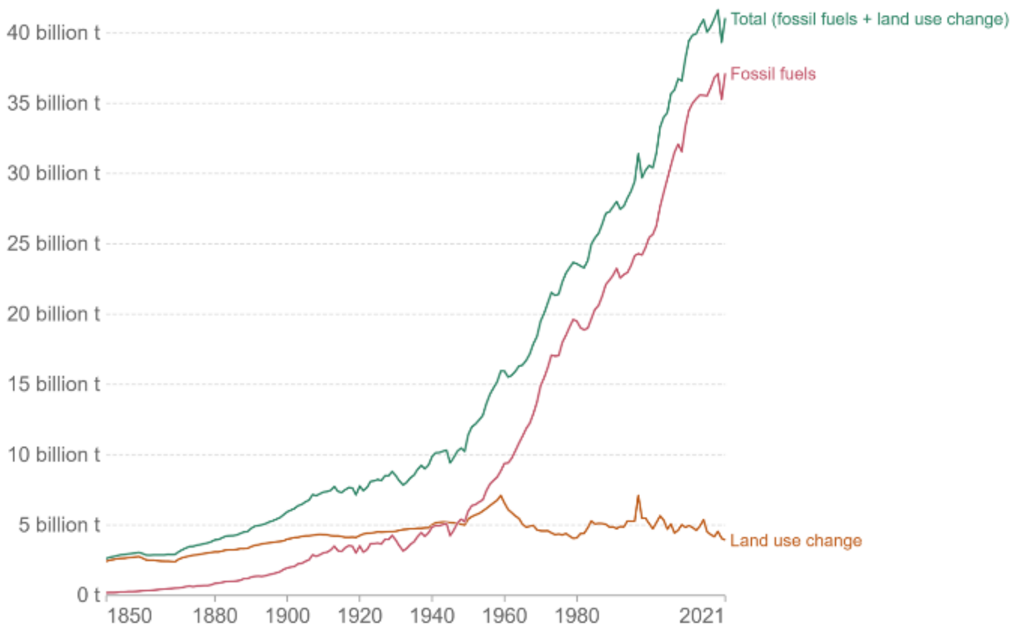

Fig. 4: Global anthropogenic CO_2 emissions 1850-2021 (conversion: 7.8 billion t CO_2 per year = 1 ppm CO_2 per year). Source: Hannah Ritchie, Max Roser and Pablo Rosado (2020) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-greenhouse-gas-emissions' [Online Resource].

Supplement to the allegedly constant "natural 80 ppm/y": IPCC apparently assumes that the pre-industrial equilibrium of fluxes has remained unchanged, and that it is only superimposed by the anthropogenic releases, which can be considered separately (and which, according to the IPCC, alone caused all the changes!). But that can't be correct, because the pre-industrial equilibrium came about just because *removal is dependent on concentration* (item 2.1.2). If the concentration changes, then the balance *necessarily shifts!* But not because of the anthropogenic releases, but because of the increased concentration! Rationale: If other releases had decreased to the same extent simultaneously, then anthropogenic releases would have only just compensated for that, without any overall effects arising! As long as the concentration is increased, there is *no return to the previous equilibrium*, not even if the anthropogenic releases were reduced to zero, because the boundary conditions have changed and simply would not allow such a return. And it is not only the enhanced concentration, but also the *general warming*, whatever the reason, that have *shifted the equilibrium explicitly*. And finally, the atmosphere has *no memory* for any previous equilibrium, it only knows the current boundary conditions. All of this proves that the idea of a constant natural equilibrium **cannot be true!**

2.3.3. The last 10 years and COVID

For about 10 years, the anthropogenic releases have been growing noticeably slower than before (Fig. 4), perhaps a consequence of global efforts to reduce CO_2. If these releases were to determine concentration, a slowdown should also be evident in the concentration curve. However, this is clearly *not the case*, see Fig. 3. Likewise: Due to the COVID lockdown, the anthropogenic CO_2 releases temporarily even fell sharply in 2020 (Fig. 4, by 17% at peak!). That should be noticeable as a clear dent in the concentration curve. However, this *is not the case*, see Fig. 3. This also *contradicts* the view that the anthropogenic releases dominate the concentration.

2.3.4. IPCC's numbers

A confirmation of significantly increased CO_2 releases from natural sources can also be found in IPCC's own numbers: According to Fig. 5.12 in IPCC (2021), releases from natural sources into the atmosphere have increased by (converted) approx. 23 ppm/y, *almost 5 times as much* as anthropogenic sources amount to! Sadly, IPCC ignores its own numbers in their text and explains the concentration increase solely by long-term retention of half of the anthropogenic releases (not the individual molecules, but the corresponding amount of CO_2). According to the IPCC, this separation of anthropogenic CO_2 into two halves always occurs (*constant "airborne fraction"!*), regardless of the level of the anthropogenic releases and regardless of the concentration that has already been reached (for the future, however, the IPCC fears that the airborne fraction will increase due to a possible overburdening of the sinks). However, the IPCC does not give a physical explanation for this behavior of CO_2, nor does the IPCC discuss the discrepancy to its own numbers. There is **great need for clarification!**

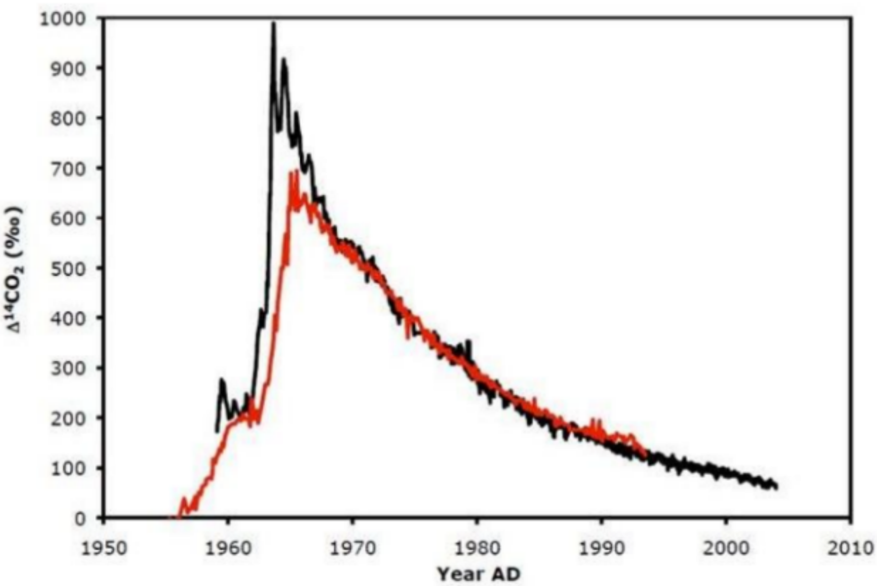

Fig. 5: The $^{14}CO_2$ concentration in the atmosphere: measurements at Vermuntsee (Black), Austria and at Jungfraujoch, Switzerland, at Baring Head, New Zealand (Red); Source: NASA. After the test ban agreement, the concentration fell very quickly and almost completely back to the starting level. The same must apply to any increased concentration if the increased release responsible for it is terminated again.

Supplementary remark: The numbers in Fig. 5.12 in AR 6 also confirm in principle the proportionality between concentration and removal from the atmosphere as it is claimed in this paper. This proves proportionality to be the correct interpretation of physics. IPCC does not elaborate this in AR 6 either.

2.3.5. $^{14}CO_2$

There has not been a sustained decline in CO_2 concentration for many millennia. Therefore, there are no corresponding observations. But there are such observations with a special form of CO_2: $^{14}CO_2$. Its specialty is radioactivity with a half-life of approximately 6000 years, which allows it to be distinguished from "normal CO_2". Chemically, both forms behave in the same way. $^{14}CO_2$ occurs in a very small percentage in the atmosphere naturally. It was produced anthropogenically by the above-ground atomic bomb tests in such quantities as to increase the concentration significantly (Fig. 5). After the test ban agreement in 1963, anthropogenic releases were largely stopped. Subsequently, the $^{14}CO_2$ concentration has *almost completely* returned to its natural starting level with a constant time constant of only approx. 15 years (Fig. 5).

Clearly, the long-term remainder of $^{14}CO_2$ in the atmosphere is not half of the anthropogenic releases! Rather, practically all of it has been removed by now. Chemically, “normal CO_2” cannot behave differently than $^{14}CO_2$. This means, that the high increase in concentration of 50 % (Figs. 1 and 3) **cannot be reached without substantial additional releases!**

The strikingly large fluctuations in the concentration of $^{14}CO_2$ in the first years after the test ban agreement, see Fig. 5, are due to subsequent seasonal delivery of $^{14}CO_2$ from the stratosphere, where it was predominantly produced, to the troposphere, where it was measured. Only after these subsequent deliveries are largely completed does "undisturbed" dilution occur, particularly by storage in the deep ocean. For more detail on the time response, see the discussions in section 2.4. Here, just the hint that the same dilution must apply to any pulse-elevated concentration in the atmosphere, regardless of its isotopic composition.

2.3.6. Interim findings

The argumentations in items 2.3.1 through 2.3.5 strongly support the central statement that the releases from natural sources **must have increased considerably** for the concentration to have been able to increase as much as was measured (and that these releases *still have to be strong* now, because otherwise the concentration would have dropped again for a long time). It remains to be investigated where this increase comes from or could come from. This is done in section 2.4.

A small note beforehand: In section 1 it was pointed out that, according to some researchers, the CO_2 concentration was already fluctuating strongly before human intervention and was similarly high in the middle of the 19th century and around 1940 as it is today. Even if this is confirmed, it only confirms the variability of natural sources and does not eliminate the need to consider how this variability can be explained. This is the purpose of section 2.4.

2.4 Possible sources

2.4.1. General considerations

The *global warming* has indisputably contributed to the increase of CO_2 in the atmosphere, whatever its source: As a result of the temperature-dependent solubility of gases in liquids, more CO_2 has inevitably been outgassed from the ocean, and biomass has also undoubtedly increased its CO_2 exchange with the atmosphere with increasing temperature. In addition, biomass has increased its mass considerably as a result of *fertilization* with CO_2 (Scinexx 2016; Zhu et al. 2016), which further increases CO_2 exchange with the atmosphere. By how much this has increased the total release is difficult to say, also because this depends not only on the average temperature, but also on its areal distribution, and also on many other influencing variables. But at least a *considerable contribution* from warming is probably undeniable.

Other candidates for the cause of increased atmospheric concentration are e. g. *relocations of ocean currents* with different carbon content and *volcanic outgassing*. Since these processes are only superficially scientifically known, quantifications are hardly possible here.

An interesting observation was put forward for discussion in Pollard (2022): *Freshwater ecosystems* could release up to *six times* as much CO_2 into the atmosphere as humans do by burning fossil fuels. This paper was retracted by the Chief Editor of Frontiers in Environmental Science and the Editor-in-Chief of Frontiers due to suspected methodological errors and limitations. The author did not agree to the retraction. It remains to be seen how the discussion will continue.

2.4.2. Feedbacks in the Carbon Cycle

Other possibilities for increased releases from natural sources are feedbacks, i.e. consequences of releasing additional CO_2 into the atmosphere on other carbon fluxes in the system. In climate science, a distinction is made between the "long-term" (or "geological") and the "short-term" (or "biological") carbon cycle. The "long-term" cycle also includes processes such as sedimentation and weathering of rocks and plate tectonic processes, which occur on time scales of millions of years and longer and therefore do not play a role in current climate discussions. In contrast, the "short-term" cycle describes exchange processes between the atmosphere and the biosphere or the ocean that occur on time scales of days to several millennia. These are relevant for climate discussions.

However, to discuss the development of the CO_2 concentration in the atmosphere in more detail, it is proposed in Roth (2021) to divide the "short-term" carbon cycle even further: into *fast-running processes* with time scales of days to decades, summarized in this paper as the *"small cycle"*, and into *longer-term processes*, called in this paper the *"large cycle"* (see Fig. 6). The rapid processes include all intensive CO_2-exchanges between the atmosphere and the near-surface ocean layer (about 50 to 100 m thick, well mixed by wind and waves, including all living organisms in it, sunlit (photosynthesis!), carbon exchange with the atmosphere on the one hand and with the deep ocean on the other hand), and all similarly intensive exchanges between the atmosphere and short-lived terrestrial biomass, such as annual plants, leaves, needles, etc. The "large cycle" then includes the slower exchanges with the deep ocean and with long-lived terrestrial biomass, such as long-lived woods, humus, peat, etc., and with permafrost.

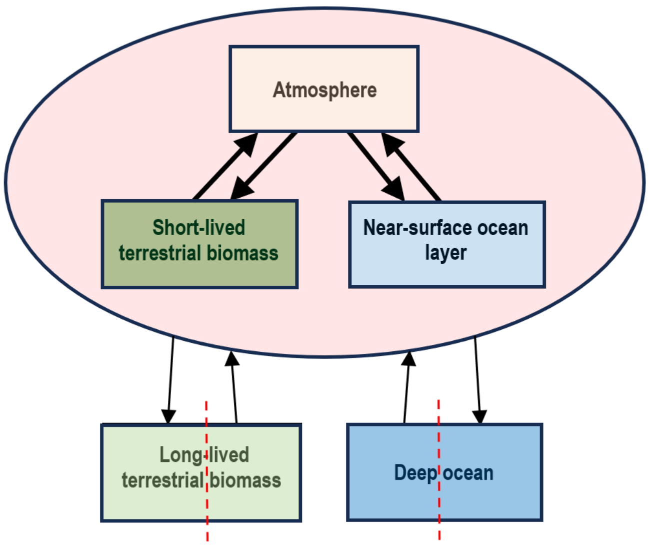

Fig. 6: Schematic diagram of the carbon cycle. In the first stage, all CO_2 released into the atmosphere is rapidly distributed evenly in the "small cycle" (summarized in the ellipse). Then, in the second stage, carbon is more slowly removed from this "small cycle" into the long-lived terrestrial biomass and into the deep ocean ("large cycle"). As a result of the long storage time in the last two reservoirs mentioned, absorption in them and return from them are decoupled for long periods of time (indicated by the dashed red lines).

When CO_2 is released into the atmosphere, it is very quickly (within a few months!) *evenly distributed* within the atmosphere by wind and weather. The atmosphere therefore practically always and everywhere shows the *same concentration* (the same CO_2 partial pressure). Only this well-mixed atmosphere reacts with its partners.

Note: This is generally true, but there are considerable local and temporal deviations in concentration, e. g. depending on the time of day, on wind- and weather-conditions, etc. This is not important for the considerations here, here only the so-called "background concentration" plays a role, which balances these local/temporal fluctuations, but it is very important for the interpretation of punctual measurements of the concentration, see the statement to corresponding discussions on the historical course of the CO_2 concentration in section 1.

CO_2 is removed from the (well-mixed) atmosphere in a *two-stage process*: First, equal distribution is established within the "small cycle". Second, this "small cycle" interacts, like a united larger reservoir, within the "large cycle" with the deep ocean and the long-lived terrestrial biomass (Fig. 6). Let us start with the first stage: the most important characteristic in it is the *intensive exchange* of CO_2 between the atmosphere and its partners: about a quarter of the CO_2 inventory of the atmosphere is exchanged annually (item 2.1.4), in first approximation in equal parts towards the terrestrial biomass and towards the near-surface ocean layer. This high exchange forces the near-surface ocean layer to match the CO_2 partial pressure of the atmosphere everywhere! And this partial pressure is the same everywhere on earth, see above. The temperature-dependent solubility of gases in liquids leads to areas of high concentration in cold water and areas of low concentration in warm water all at the same partial pressure! Roughly speaking, the cold ocean water near the poles *absorbs* CO_2 from the atmosphere and the warm ocean water near the equator *releases* CO_2 into the atmosphere.

Terrestrial biomass behaves similarly. However, because biomass strictly speaking has no CO_2 concentration, as it stores carbon exclusively in other chemical compounds, its behavior is very complicated. A sufficient approximation is that of a reservoir with a given CO_2 concentration, which, at equilibrium, must be the same as that in the atmosphere. During the growing season in spring and summer, much CO_2 is *taken* from the atmosphere, and in fall and winter, much CO_2 is *returned* by decaying leaves, needles, and grasses. In equilibrium, the two effects balance each other out over the year.

In order to better quantify the exchange processes within the "small cycle" and then also those between it and the deep ocean or the long-lived biomass, a *stepwise approach* is chosen: First, the processes within the "small cycle": When the assumption is made that the two reservoirs "short-lived terrestrial biomass" and "near-surface ocean layer" are much smaller than the atmosphere, even very small amounts of CO_2 taken from the atmosphere would increase the concentration in them considerably. Subsequently, the *same amount* of CO_2 received would be emitted back to the atmosphere after a short time! With increased concentration in the atmosphere, they would take out more, but they would also give back more, to the same extent and only minimally delayed. Such small reservoirs can be practically neglected. With them, the "small cycle" would simply behave as if it consisted of the atmosphere alone. Practically all additionally released CO_2 would remain in the atmosphere and increase the concentration in it accordingly (the interactions in the "large cycle" are not considered at first)!

If the two reservoirs "short-lived terrestrial biomass" and "near-surface ocean layer" were larger, they would play an independent role. If, for example, they had the *same size* as the atmosphere, then they would absorb *half as much* CO_2 as is released additionally into the atmosphere (whatever its origin), and the same amount would remain in the atmosphere. This is exactly the scenario IPCC assumes for anthropogenic releases. As a result of the high exchange rates this distribution would proceed very fast, equilibrium would be reached at the latest within a few years (the "small cycle" always moves *very close to equilibrium!*).

But equally sized reservoirs are rather unlikely under real earth conditions. The actual size of the reservoirs can only be given under arbitrary assumptions: Regarding the near-surface ocean layer, what is the best choice of its thickness? 50 m, 100 m, or 200 m? IPCC (2021) gives an inventory of 900 Gt C for this layer. However, because of chemical transformations in seawater, most of this carbon is in the form of carbonate and bicarbonate, which do not contribute to the CO_2 partial pressure (see also item 2.2.2). Therefore, the CO_2 content in this layer is much smaller than in the atmosphere, but the total carbon content in the layer is large.

Regarding the terrestrial biomass, there is a different problem: IPCC (2021) does not distinguish between short-lived and long-lived but gives values only for both combined: 1200 Gt C for “permafrost”, 450 Gt C for "vegetation" and 1700 Gt C for "soil" (essentially humus). These values, according to IPCC (2021), have not changed since 1750. What fraction of vegetation do long-lived woods make up? How much carbon do permafrost and soil exchange "rapidly" with the atmosphere? The author of this paper has found no data on this in the literature. For the atmosphere, IPCC (2021) gives 591 Gt C (before the beginning of industrialization, today it is 870 Gt C).

All together the "equal size" of reservoirs in the "small cycle" seems possible but would be *pure coincidence*. However, the exact value of these sizes is not important, as carbon is also removed from the “small cycle” into the deep ocean and into the long-lived terrestrial biomass (see below) in any case. Therefore, even with the same storage size in the "small cycle" a *completely different result* emerges altogether than assumed by IPCC.

The *second step* is the transfer of carbon from the "small cycle" into the deep ocean and into the long-lived terrestrial biomass. Even when taking the correct size of the reservoirs in the "small cycle", there is a *quantitative* problem: the amount of exchange between the "small cycle" (more precisely, the near-surface ocean layer) and the deep ocean is given *inconsistently* by IPCC: For many years, IPCC gave numbers close to 50 ppm/y (IPCC 2007, IPCC 2013, latest draft "Final Government Distribution" of IPCC 2021). However, in the final report IPCC (2021), Fig 5.12, numbers close to 130 ppm/y are given, which is *more than twice as much* as before (in each case converted with 2.13 PgC/y = 1 ppm CO_2 per year)! There is no reasonable explanation for this surprising jump (at least the author of this paper could not find one). However, the tremendous change makes it clear that *we still do not know everything for sure in the carbon cycle!* And concerning transport into the terrestrial biomass, IPCC (2021) does not distinguish between short-lived and long-lived biomass, but only gives a total of 52 ppm/y (before the industrial age, for today, IPCC gives 64 ppm/y). Presumably, the vast majority of this is attributable to the "small cycle", but data on this is lacking. But for the question, whether the anthropogenic releases alone are responsible for the large increase in the concentration, this is of minor importance, because they are *not large enough in any case*, as will be shown later. In item 2.4.4, however, the value will play a role once more.

Prior to that, however, a special feature of the carbon exchange between the "small cycle" and the "large cycle" should be explained: **removal and return diverge** (at least in relevant time scales)! The removal of carbon from the near-surface ocean layer into the deep ocean grows at least approximately proportionally with the concentration in the near-surface ocean layer (and thus in the entire "small cycle"), but the return of carbon from the deep ocean to the near-surface ocean layer takes place *practically unchanged* for some 500 to 1000 years due to the sheer size of the deep ocean and the slow currents in it. It simply *takes this long* for the deep ocean to respond to a change in the atmospheric concentration (and even then, most of the additional carbon released remains in the deep ocean because it is so huge).

According to items 2.1.2 and 2.2.2, the proportionality of removal to concentration applies generally. In the special case of removal by the deep ocean, this is fully confirmed by the two pathways of removal effective here, the "biological pump" and the "physical pump", and their mode of operation - sinking calcareous shells of dead biomass and sinking water packs with their contents, respectively.

Regarding the long-lived terrestrial biomass, detailed numbers are not available, as already stated. But here, too, the CO_2 absorbed is only released back into the atmosphere after a *considerable delay*.

However, a *growing withdrawal* from the "small cycle" and a return to it that is *constant for a long time* enforce that the concentration in the "small cycle" *can increase only very slowly*, unless a considerable *additional source* helps! Therefore, the small anthropogenic releases are *by far not sufficient* for a 50 % increase of concentration (as a reminder: that they cannot contribute disproportionately to the increase of the concentration has already been said in item 2.2.1). So, that the 50 % could come about at all, *a much larger additional source must have been added!*

This necessary additional source could be the deep ocean or the long-lived terrestrial biomass. But it cannot be caused by the anthropogenic releases, but only *by other causes* (e.g. rearrangement of ocean currents, whose cause we do not know yet, or enhanced temperatures, or volcanic outgassing into the ocean or into the atmosphere, or something else). We do not know this source, but it *must exist*, because the course of the concentration *cannot be explained otherwise!* Considering mass balance, the *size* of this additional release can be calculated retrospectively from the course of the curve of concentration.

2.4.3. Some more details to the difference between the atmosphere and the "small cycle"

Because of its importance, the crucial difference between the atmosphere and the "small cycle" should be discussed in more detail: Although in both cases the concentration could only increase by 50 % because the releases from natural sources have increased much more than the anthropogenic releases have added, the *possibilities* for this heavy increase in natural sources are *crucially different*:

In the case of the atmosphere, part of the increase in the strength of the natural sources is due to the small inventory in them. Because of this small inventory, the concentration in them increases rather quickly, and they then return a large fraction of the CO_2 stored back into the atmosphere relatively short term (not the individual molecules, but anyhow in quantity). It still is natural sources that must have become stronger, but in part they have become stronger *as a result of the anthropogenic releases!* (Supplement: Another part of the increased releases from natural sources definitely comes from the global warming, and other causes are also possible, e. g. increased volcanic outgassing, see item 2.4.1).

However, if one considers the "small cycle" in total instead of just the atmosphere as a single reservoir, then the relevant sinks here, the "deep ocean" and the "long-lived terrestrial biomass", are *very large*. Therefore, they respond to the enhanced carbon uptake into them (which is itself a consequence of the increased concentration in the atmosphere) only *after a delay of several 100 years!* However, the release from the natural sources *must already be increased now*, because, only with the anthropogenic releases alone, the concentration in the atmosphere (and thus in the "small cycle") could have increased only very little. This need for a strong source to significantly increase the concentration always exists when the outflow into the sinks (here into the deep ocean and into the long-lived terrestrial biomass) increases with the concentration. The situation is: The answer to the enhanced concentration in the atmosphere *has not yet been received*, but the increase of sources *must already have occurred*. Therefore, the increase in the strength of the natural sources must have come about almost entirely from some cause *other than the increased concentration* in the atmosphere!

To say it again quite clearly: In the case of the *atmosphere*, part of the increased release into it comes as a *response to the increased concentration* in it (and thus also as a response to the anthropogenic releases!), but in the case of the *"small cycle"* this is *not possible* in the relevant period of time! The reason for this is the *large size* of the deep ocean and the long-lived terrestrial biomass! It is ultimately this special feature of the interactions within the "large cycle" that makes a strong additional source truly *unavoidable*.

A somewhat different attempt to quantify: Let us again briefly consider the theoretical borderline case with infinitesimally small reservoirs of the short-lived terrestrial biomass and the near-surface ocean layer as in item 2.4.2: The "small cycle" then degenerates virtually entirely to the atmosphere alone, and without the deep ocean and the long-lived biomass, all anthropogenically released CO_2 would accumulate *exclusively* in the atmosphere, increasing the concentration further and further. However, with these long-term sinks operating, they *remove* almost all additionally released CO_2, with the consequence that the concentration in the atmosphere (and thus in the degenerated "small cycle") could increase only minimally without a *substantial* additional source. More precisely: This source must be increased to *fully close* the gap between the anthropogenic releases and proportionality to the concentration. Now, instead of the "degenerated small cycle", let's take its real size: Then the near-surface ocean layer and the short-lived terrestrial biomass *store a considerable part* of the anthropogenically released CO_2 within themself (instead of giving it back to the atmosphere) and, as a consequence, the concentration in the atmosphere can only grow *even less* than it does in the "degenerated small cycle", which requires an even stronger additional source! Therefore, it is again the imbalanced CO_2-exchange in the "large cycle" that makes a strong additional source truly *inevitable!*

2.4.4. To quantify the additional source

For the "small cycle" as a whole, of course, the same laws apply as for the atmosphere as a smaller reservoir. Therefore, all arguments put forward for the atmosphere are equally valid for the "small cycle". Especially, if the concentration in the "small cycle" has increased by 50 %, then the releases into it must also have increased by 50 %! This is where the *jump in IPCC's data* for CO_2 exchange with the deep ocean, described in item 2.4.2, comes into play: 50 % of the new value 130 ppm/y are 65 ppm/y. Subtracting from this the 5 ppm/y anthropogenic releases, shows that the releases from natural sources must have increased by about 60 ppm/y, about *12 times the anthropogenic releases!* But even with the old value of about 50 ppm/y, 50 % of it is 25 ppm/y, so in that case the releases from natural sources must have increased by 20 ppm/y. That is still about *4 times the anthropogenic releases!* The anthropogenic releases therefore play in any case only a *minor role*, with the new IPCC value still much more pronounced than with the old one. For clarification: Because there are no relevant numbers for the long-lived terrestrial biomass available, these calculations only consider the deep ocean. This is conservative, because the total releases must be increased by 50 % and not just those from the deep ocean.

2.4.5. Interim findings

It was shown in item 2.2.2 that the releases from natural sources *into the atmosphere* must be about **10 times greater** than the anthropogenic releases are. A (not well known) part of this increase is due to the increased releases from the short-lived terrestrial biomass and the near-surface ocean layer as a consequence of the relatively small size of these reservoirs (item 2.4.2). In item 2.4.4 it was shown that for the releases from natural sources *into the "small cycle"* only a lower limit of **4 times greater** than the anthropogenic releases can be specified, because of the great uncertainty in the exchange rates with the deep ocean and unknown exchange rates with the long-lived terrestrial biomass. But here, due to the large size of the reservoirs involved, *all enhancement* must come from another cause, independent of the anthropogenic releases. But whatever value applies, it is definitely a **multiple** of anthropogenic releases, these only play a minor role.

Assessment: If all arguments above in section 2 are true, then the climate can be influenced only to a minor extent by anthropogenic CO_2 releases! **The main cause of the observed climate change must be nature!**

2.5 Some more counterarguments

2.5.1. A sink cannot be a source

It is often said that ocean and biomass *could not* have contributed to the increase in the atmospheric concentration, because they have always been and still are a sink. It is further said that *a sink simply cannot be a source*. However, this argument overlooks the fact that ocean and biomass are always *source and sink simultaneously* (they cannot do otherwise!), and that every increased release into the atmosphere increases the concentration in it, and that every increased concentration in the atmosphere increases the removal from it by ocean and biomass.

A distinction should also be made, whether the increase in the concentration in the atmosphere is due to releases *from the outside* (from the outside into the "short-term" carbon cycle (item 2.4.2),

e. g. from fossil fuel burning or from volcanism), or *from the inside* (internal releases due to relocations within the "short-term" carbon cycle, e. g. as a result of warming, or of changes in ocean currents, or some other internal cause). External releases increase the amount of carbon in the "short-term" carbon cycle and are therefore *irreversible*. If the cause is terminated, there is *no return* to the previous equilibrium; rather, the system strives towards a *new* equilibrium. In contrast, releases from the inside leave the amount of carbon in the "short-term" carbon cycle unchanged and are therefore *reversible*. If the cause is terminated, the *previous* equilibrium is re-established.

Whether releases into the atmosphere come "from the inside" or "from the outside" also determines, whether ocean and biomass *act as a net source or as a net sink:* When releases come from the outside, a part of them remains in the atmosphere and the rest is transferred to the ocean and the biomass. Ocean and biomass therefore inevitably and always act as a *net sink* in the case of releases from the outside. If we look at the flows, releases from the ocean and from the biomass initially remain unchanged, but removals by them out of the atmosphere increase directly with the increasing concentration in the atmosphere. Higher removal and lower return signify a net sink! In contrast, releases from the inside are enhanced releases from the ocean and from the biomass through relocations between them and the atmosphere, and therefore the ocean and the biomass are inevitably and always a *net source* in the case of releases from the inside. If we look at the flows, releases from the ocean and from the biomass increase first, before removals by them increase with increasing concentration. Higher releases and lower removal signify a net source.

When the two processes *coexist*, two things matter: their relative strength and the atmospheric CO_2 exchange rate. It is exactly this coexistence, which we have in the real atmosphere: Releases from natural sources are predominantly internal releases, e. g. as a result of warming or of changes in ocean currents. They have been increased by approximately 50 %, which has also allowed the concentration in the atmosphere to increase by approximately 50 %. As a consequence, and somewhat delayed in time, removals by ocean and biomass have also increased. *Because of this lag,* the ocean and the biomass have always been a *net source*. This lag, and with it the strength as a persistent net source, are the smaller the higher the atmospheric CO_2 exchange rate is.

As a *second process*, anthropogenic releases have been added. These are essentially based on the burning of fossil fuels and are therefore largely releases from the outside. They are much smaller than the releases from natural sources, and they have increased the concentration just a tiny bit in addition, but still enough so that the removals by ocean and biomass *have now become larger* than the releases from them. Ocean and the biomass have thus become a *persistent net sink*, despite their increased releases!

Generally: Even if the ocean and biomass are a net source of CO_2 on their own, external releases make them a net sink if they increase the concentration to such an extent that the removal by the ocean and biomass now exceeds their release. Being a net sink and contributing to the concentration increase are therefore clearly **not mutually exclusive!**

2.5.2. Extremely unlikely

It is also sometimes said that it would be extremely unlikely for natural releases into the atmosphere and removals from the atmosphere both to *increase tremendously* over 150 years and to increase *exactly that much* as to accumulate net half of the amount of CO_2 released anthropogenically. However, firstly, releases and removals do not grow independently of each other (the latter rather follow the former relatively closely, being linked over the concentration) and secondly, any following relationship to the anthropogenic releases would be *just as unlikely!* It's similar to pebbles on a beach: It's extremely unlikely that you'll pick one up with exactly those properties as the one you're holding, but you've still picked one up. Any other pebble would be just as unlikely. This probability simply does not signify anything.

2.5.3. Time constant

Often (e. g. in Vahrenholt et al. 2020) climatologists calculate a time constant for the removal of "excess" CO_2 from the atmosphere using the difference between the present concentration and that at the pre-industrial equilibrium (420 - 280 = 140 ppm) as the driving force and the present net removal rate from the atmosphere (2.5 ppm/y) as the flow rate. This time constant is then approx. 50 years, considerably longer than the few years resulting from the considerations made in this paper (removal proportional to the absolute concentration). However, this linking of the 140 ppm and the 2.5 ppm/y is *pure mathematics*, without any physical basis, and therefore the time constant calculated in this way has *no value*. According to the laws of physics, the atmosphere has *no memory* of a previous equilibrium and the driving force for the net removal of CO_2 can only be the distance to the *new* equilibrium, as it is determined by the *current* boundary conditions (e. g. temperature). This distance to the actual equilibrium *can never be very large* in a homogeneous (well-mixed) medium, where removal increases with increasing concentration. In any case, 140 ppm surplus can definitely be ruled out due to the slow nature of the occurring changes (the annual anthropogenic releases are only about 1% of the atmospheric inventory even today!). The real time constant for reducing an increased CO_2 concentration is **only a few years** and not 50 years!

2.5.4. Decreasing oxygen concentration

It is also often cited as "proof" for the predominantly anthropogenic origin of the large amount of CO_2 in the atmosphere that the oxygen concentration in the atmosphere has decreased correspondingly to the increase in the CO_2 concentration (exactly to that extent, as is expected according to the amount of fossil fuels burned). However, this oxygen decrease only proves that the amount of fossil fuels burned is estimated correctly. It *signifies nothing* about whether or how much CO_2 has been released into the atmosphere from additional sources without oxygen consumption!

2.5.5. Saturation of sinks

IPCC believes that half of the anthropogenic releases have always remained in the atmosphere (constant "airborne fraction"). IPCC gives no physical explanation for this, but fears that the "airborne fraction" could increase considerably in the future due to saturation of the sinks (see item 2.3.4). Due to the rapid equilibration in the "small cycle", saturation is only possible of those sinks, which have a slow exchange rate. Namely, the long-lived terrestrial biomass and the deep ocean. There is no obvious reason why the long-lived terrestrial biomass should become saturated in the relevant range, and saturation of the deep ocean can definitely be ruled out due to its huge volume and to the high pressure and the low temperatures in it. Even if the "50 % model" were to apply at all, deterioration due to potential saturation **can be ruled out.**

2.5.6. Bern Carbon Cycle Model

It is also often argued that IPCC does not simply assume that 50% of the anthropogenic CO_2 releases remain in the atmosphere permanently (constant "airborne fraction", item 2.3.2), but uses the "Bern Carbon Cycle Model" for more precise calculations. This model, named after a group of researchers in Bern, assumes that "excess" CO_2 in the atmosphere is removed according to a formula as it is used for the *radioactive decay* of a mixture of unstable isotopes. This should account for the different *time responses of the various sinks* for CO_2 (e. g. UNFCCC 2002). With an appropriate choice of parameters in the model, the historical course of the CO_2 concentration can thus be calculated from the course of the anthropogenic releases, and with this, it is said, future courses can then also be calculated under assumed emission scenarios. However, this overlooks a *fundamental difference*: The individual unstable isotopes are different and decay according to *their* respective specific properties, whereas the CO_2 molecules are all the same and are removed from the atmosphere by different sinks according to the respective specific properties *of the sinks*. Thus, in radioactive decay, the *decaying substances* determine how fast they disappear, whilst in CO_2 removal, the *sinks* determine how fast the CO_2 disappears. In the case of radioactive decay, the strongest sinks (shortest half-life) are *the first to fade away*, afterwards only the smaller sinks work; in the case of CO_2-removal from the atmosphere, the strongest sinks remain *fully active* until the end. Therefore, the "Bern Carbon Cycle Model" **does not obey the physical conditions in the atmosphere!** For a more detailed critique, see e. g. Roth 2022.

2.5.7. Interim findings

All these counterarguments **do not hold**. Of course, there are many other counterarguments, but the author of this paper has not found any that would be better than those rejected here.

3. Appraisal of the Results

Every single argument presented here seems to strongly support the statement that the fast increase in the atmospheric CO_2 concentration is *primarily fed from natural sources*. All arguments together make this statement even *more stringent*. And all the counterarguments seem to be *baseless*. As long as no convincing counterargument is presented - at least in the opinion of the author of this paper - the rules of physics *exclude* a disproportionate contribution of anthropogenic releases to the concentration of CO_2 in the atmosphere! The lion's share of the increase that has occurred *must therefore come from natural sources*, which must have grown faster (much faster!) than the anthropogenic releases! As always, all of this is much more complicated in detail, but the result is basically the same as shown in this brief description here: **Nature is most likely stronger than humans** when it comes to CO_2 too! In any case, this view must be seriously discussed.

For information: Some more information is given in Roth (2022) (in German). So far, no viable counterarguments have been put forward, at least none have been revealed to the author of this paper. To put it gently, the question of the origin of all the CO_2 in the atmosphere is *scientifically open!* Just as is the question of the climate impact of CO_2, and just as some other questions about the climate. A more detailed discussion of most climate problems can be found in Roth (2019) (in German).

4. Conclusion

If all of this is principally correct, i.e. if the strong increase of CO_2 in the atmosphere is mainly due to *releases from natural sources* (and that is most likely true!), then there are, logically binding, *only two possibilities* left:

- Either *naturally released* CO_2 determines earth's climate, or
- Earth's climate *is not determined by CO_2 at all*, but other influencing factors predominate.

In both cases, **climate change is not man-made** (at least not predominantly)! Therefore, it *does not make any sense* to call for a reduction in the anthropogenic CO_2 emissions for reasons of climate protection. These emissions do not have a key influence ("if all of this is correct") on the CO_2 concentration and therefore they *cannot* have a key influence on the climate the more. Therefore, the question of wherefrom all the CO_2 in the atmosphere comes *directly affects the foundation of all climate considerations*. If this CO_2 comes mainly from natural sources, *humans cannot be responsible for the climate* (at least not through their CO_2 releases)! It is therefore *necessary above all to demand* that science discusses and clarifies the question of the *origin* of the large amount of CO_2 as quickly as possible without any bias. This question is at least as important as that of the climate impact of CO_2. Only when *both questions* have been clarified can decisions about climate protection measures be made responsibly! And the media and the public should at last acknowledge that the science of climate is still *divided* in many cases, including important issues. Not wanting to admit this or even intentionally wanting to keep it under cover does not solve a single problem, it only creates new ones.

5. Addendum: Actions

However, it is not only the *cause* of climate change that is scientifically open, the *actions* we should take on the basis of the assumption "man-made" are controversial too: Usually, it is demanded to completely transfer our whole energy supply to "renewable energies" as quickly as possible, primarily to wind and sun. But there are *two fundamental questions* scientifically open: Are these actions really *necessary* or not, and are they *useful and cost-effective* or not? Regarding the first, see above, there is *no necessity*. Regarding the latter, there is still no carefully carried out comparison of costs and benefits of these actions. Some experts say that the costs that *certainly* arise when implementing the demanded climate protection actions very probably exceed the costs that otherwise *debatably* might result from climate change, others contradict fiercely. There is no agreement in sight.

But irrespective of these two open questions, the above-mentioned demand clearly *violates the principles of "technological openness" and "modest use of the landscape".*

Regarding the first, because there may very well be *better solutions* (many people consider nuclear energy to be one!), and regarding the second, because wind and sun will probably *never* be the backbone of our energy supply! As long as there are no suitable (and affordable!) storage systems to compensate for their erratic energy availability, it simply *doesn't add up* in terms of numbers! For this reason alone, *other solutions must be found*.

But the need for other solutions probably applies even if the storage problem could be solved one day (which in the opinion of the author of this paper is not foreseeable). This is, because the solar radiation reaching the earth is simply *concentrated far too little!* So little that its large-scale use (in whatever way, e. g. directly using the radiation, or converted into the kinetic energy of the wind, or converted into biomass via photosynthesis) *inevitably* involves large-scale land use! With more and more people on earth, however, "area" is becoming more and more of a precious commodity (*we only have one planet!*). We need this precious commodity for everything, from our food supply, to our homes, to shops, to schools, etc., up to ensuring an appropriate living environment for people and nature. To satisfy our energy needs, we should *use it as efficiently as possible!* Wind and solar parks instead of forests, fields and natural landscapes are not a desirable alternative (even if one does not initially consider the possible environmental impacts of the large-scale use of wind and sun, the extent of these environmental impacts is disputed). Mankind *can do better*; it must not blindly follow what people feel to be “good” without analyzing impartially whether or not it is actually “good”. With climate, that *seems to be the case* at the moment!

And one last argument: As long as trading in *CO_2 certificates* applies in the EU (it has only just been expanded!), special additional requirements, such as the expansion of renewable energies in Germany up to x% in year y, are basically *without any effect* on the climate: if they are successful at all, they not only reduce CO_2, but also the consumption of certificates. The certificates that are not consumed in this way are traded, and *exactly the same amount* of CO_2 that was initially saved is then released elsewhere! That's what the buyer bought the certificates for. *The climate doesn't care!* Politicians *must decide* whether they want to achieve the CO_2 reduction (if it is necessary at all) through specially defined measures *or* through general certificate trading. Pursuing both strategies side by side makes little sense because they *work against each other* and thus only *increase costs unnecessarily!*

6. Summary

Logically binding, the observed climate change can only be caused by anthropogenic releases of CO_2, if CO_2 has a *strong impact* on climate *and* if most of the CO_2 in the atmosphere has been brought there *by humans!* Both are *scientifically controversial*, even if this is usually presented differently in public. While the climate impact is primarily a *quantitative* question that can only be answered with highly sophisticated calculations based on unsecured physical assumptions, the origin of the large amount of CO_2 can also be checked very well by means of *fundamental physical considerations.* That is the central theme of this paper here.

Essential starting points are the equality of all CO_2 molecules, the dependence of the (total) number of CO_2 molecules removed from a storage facility per second on the concentration in that storage facility, and the consideration of the fate of CO_2 released into the atmosphere in several stages (thorough mixing in atmosphere, approximate equal distribution within the three reservoirs atmosphere, short-lived terrestrial biomass and near-surface ocean layer, exchange with the deep ocean and long-lived terrestrial biomass). It turns out that under the real conditions on earth in relevant time periods **no source can contribute disproportionately** to the concentration in the atmosphere. For the concentration to have increased by 50% at all, the 5% anthropogenic releases are *much too small*, the releases from natural sources **must have increased substantially** in addition!

Therefore, on the real earth, *two processes* go on simultaneously: Firstly, nature increases its CO_2 releases into the atmosphere quite substantially. This increases the concentration and with it the removals by ocean and biomass also increase, but delayed, so that ocean and biomass insofar act as a *net source*. Secondly, anthropogenic releases. These are much smaller, but they increase the concentration sufficiently for the removals by ocean and biomass to *become stronger* than the releases from them. Ocean and biomass thus become a *net sink*, despite greatly increased releases from them.

This result is supported by considerations regarding the steepness of the increase in the concentration compared to the growth of the anthropogenic releases, regarding the comparability of these two curves in the COVID period and generally over the last decade, regarding the seasonal cycles of the CO_2 concentration, regarding the saturation or not of the sinks, and regarding the course the concentration of $^{14}CO_2$ in the atmosphere, as well as by showing the invalidity of the usual counter-arguments. The result is always the same: Physics requires that the **releases from natural sources must have increased significantly** in order to be able to explain the observations.

Exactly the *same result* is shown by some of IPCC's numbers as well: Even according to these numbers, the releases from natural sources *have increased much more* than the anthropogenic releases! IPCC just ignores its own numbers in its further text and says something clearly different in words.

A final clarification of the question of the *origin* of the large amount of CO_2 should therefore have the *highest priority* in all climate discussions! This contribution to the discussion here aims to give a boosted impetus to this.

Complementary to the investigation of the origin of the large amount of CO_2, this paper also shows that and why the climate *counteractions*, which are demanded on the basis of the assumption "man-made", *cannot bring the desired result*.

More or less as a by-product of the considerations here, it becomes evident that the assumption put forward by the IPCC that there is a *"fixed CO_2 budget"* for the anthropogenic releases in order to comply with a certain warming limit, which must not be exceeded**, cannot be justified physically.** For all decisions and demands based on such a "fixed CO_2 budget", there is no objective justification. *The climate problem must therefore be reconsidered also for this reason!*

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