# The Physics of the Carbon Cycle: About the Origin of CO2 in the Atmosphere

Eike Roth[1]

[1]independent researcher

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## Abstract

IPCC claims that Global Warming is caused more or less exclusively by anthropogenic emissions of CO2. Therefore, only a total stop of these emissions could avoid a disaster. In IPCC's reasoning, two concepts are central: The "constant airborne fraction", according to which about 50 % of all anthropogenic emissions remain in the atmosphere, whatever the emissions and whatever the concentration, and the "fixed carbon budget", which is the maximum amount humans may emit, when Global Warming should stay below a given limit, independent of the temporal distribution of the emissions. In this article, it is shown that three prerequisites must be fulfilled for these two central concepts to be viable: All natural sources of CO2 must have remained constant, the short-term partners of the atmosphere must store the same amount of CO2 as the atmosphere itself, and the atmosphere together with its short-term partners must be a closed system. And it is shown with high confidence that, according to the rules of physics, all three are not fulfilled. If this were confirmed, it would have a serious impact on the entire climate debate. A careful review seems to be needed urgently.

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# The Physics of the Carbon Cycle:
## About the Origin of $CO_2$ in the Atmosphere

Eike Roth

Klagenfurt, Austria, independent researcher

## Abstract

IPCC claims that Global Warming is caused more or less exclusively by anthropogenic emissions of $CO_2$. Therefore, only a total stop of these emissions could avoid a disaster. In IPCC's reasoning, two concepts are central: The "constant airborne fraction", according to which about 50 % of all anthropogenic emissions remain in the atmosphere, whatever the emissions and whatever the concentration, and the "fixed carbon budget", which is the maximum amount humans may emit, when Global Warming should stay below a given limit, independent of the temporal distribution of the emissions. In this article, it is shown that three prerequisites must be fulfilled for these two central concepts to be viable: All natural sources of $CO_2$ must have remained constant, the short-term partners of the atmosphere must store the same amount of $CO_2$ as the atmosphere itself, and the atmosphere together with its short-term partners must be a closed system. And it is shown that, according to the rules of physics, all three are not fulfilled with high confidence. If this were confirmed, it would have a serious impact on the entire climate debate. A careful review seems to be needed urgently.

**Key Words:** Global warming, carbon cycle, carbon budget, airborne fraction, $CO_2$ concentration, anthropogenic emissions.

**Key Points:**

- According to the rules of physics a "constant airborne fraction" and a "fixed carbon budget" cannot exist in an open system.
- Increased natural emissions are the main driver of the enhanced atmospheric $CO_2$-concentration.
- Climate is either driven by naturally released $CO_2$, or other factors dominate. Reducing anthropogenic emissions is no more necessary.

## Plain Language Summary

Global Warming is generally seen as one of our greatest challenges. Most scientists regard $CO_2$ as the main cause of warming, and our emissions as the single source of its growth in concentration. Consequently, these emissions must be terminated completely to avoid disaster. This view is widely accepted, notwithstanding some heated scientific debates, especially about the actual strength of $CO_2$'s impact on climate ("climate sensitivity"). But however that may be, there seems to be another weak point in the above argumentation, which is discussed hardly ever: Can an increase in $CO_2$ emissions by 5 % really increase the concentration by 50 % in the open system "atmosphere"? That is thoroughly scrutinized in this article. With the result: It is very unlikely! If confirmed, there are only two possibilities left: Either climate is determined by $CO_2$, then it is determined by naturally emitted $CO_2$, or other factors dominate, then $CO_2$ only plays a subordinate role, whatever its climate sensitivity. In both cases, nature is stronger than man regarding $CO_2$ too, and we do not need to reduce emissions, we can continue to benefit from cheap fossil energy and from improved agricultural production, driven by $CO_2$. A careful clarification is needed urgently.

## 1. Introduction

The current global warming is usually assessed to be the result of the anthropogenic emissions of $CO_2$. However, it is hard to understand why all the enormous decades-long research effort has not led to a sufficiently accurate and undisputed clarification of the correct value of the "climate sensitivity of $CO_2$" (that is the warming in case of doubling the concentration). Even in its latest report, AR6, IPCC gives the band width of uncertainty with 2.5 to 4 °C, almost a factor of 2 (IPCC, 2021)! Others claim higher or lower numbers, even way off. An end of the dispute is not in sight. This impossibility to adequately narrow the uncertainty could perhaps be due to scientists focusing too much on the interactions of $CO_2$

and climate, without sufficiently validating the starting point of their considerations, the assumption that the increase in $CO_2$ concentration is manmade. It might even be impossible to achieve unambiguous results when the base is erroneous. This article tries to scrutinize the reliability of the base.

## 2. The element carbon and its cycle

In its organic form, carbon is the basis of all life: *Without carbon, no life!* And in its chemical form $CO_2$, it again is the basis of all life: *Without $CO_2$, no photosynthesis*, no plants, no animals, no humans. Concentration doesn't even have to be zero, whenever it falls below about 150 ppm, photosynthesis would stop and all life, as we know it, would be terminated.

Initially, $CO_2$ was the main component of the atmosphere. But meanwhile, most of it has been transferred to rocks, reducing it to a trace gas with only 0.04 % concentration. However, this was not a straightforward process, rather large amounts of rocks with all their carbon content have been subdued into the earth mantle by plate tectonic processes, and a part of that carbon has been reemitted into the atmosphere as $CO_2$ by volcanoes, and then these processes repeated. This leads to the concept of a "*carbon cycle*".

Usually, scientists distinguish between the "*geological*" (or "slow", or " long-term") and the "*biological*" (or "fast", or "short-term") carbon cycle (e. g. Harrison, 2024). The "geological" cycle includes processes such as sedimentation, weathering of rocks, plate tectonics, etc., running on time scales of millions of years or longer. Therefore, this cycle is irrelevant regarding manmade climate changes. In contrast, the "biological" cycle comprises all exchange processes between atmosphere and biosphere, respectively ocean. These processes are generally performed on short time scales, from days to several thousand years. Therefore, this cycle does play a role in climate discussions.

However, for a better understanding, it seems appropriate to subdivide the "biological" cycle even further, depending on the speed of the processes (Roth, 2019, 2020, 2022, 2023). In this article, the term "*small cycle*" is used for all fast-running processes (high exchange rates, time scales up to several decades), and the term "*large cycle*" is used for all slower-running processes (lower exchange rates, longer time scales). The "small cycle" comprises all exchange processes between the atmosphere and the *near-surface ocean layer*, respectively the *short-lived terrestrial biomass*, which all run at high exchange rates. The near-surface ocean layer is roughly about 50 to 100 m thick, it is well mixed by wind and waves, it includes organic material in different forms, it is sunlit (photosynthesis!), and it exchanges carbon with the atmosphere on the one side and with the deep ocean on the other side. To the short-lived terrestrial biomass belong annual plants, leaves, needles, and the like. It takes out $CO_2$ from the atmosphere by photosynthesis and gives it back by respiration and rotting.

The "large cycle" then comprises all slower exchange processes of the atmosphere, respectively the "small cycle", with the *deep ocean* and with *long-lived terrestrial biomass* **(**long-lived woods, humus, peat, etc., including permafrost). "Small cycle" and "large cycle" together form the "biological cycle" (Fig. 1).

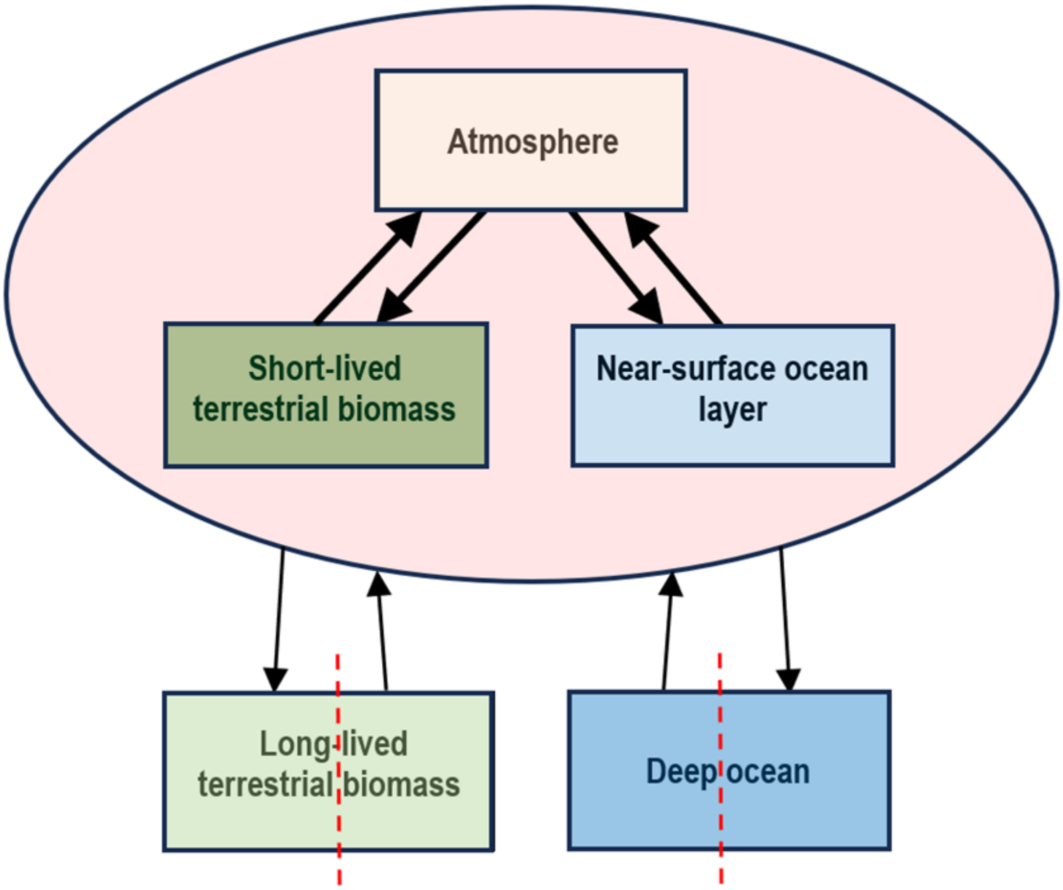


*Fig. 1: Carbon Cycle, schematic. The "small cycle" occurs inside the ellipse, the "large cycle" is all together. Arrows symbolize $CO_2$-exchanges, dashed red lines indicate decoupling of inflow and backflow in that reservoir.*

## 3. What happens when $CO_2$ is emitted?

The events following an emission of $CO_2$ into the atmosphere can be described to proceed in *3 steps* (Fig. 1):

- First, distribution of that $CO_2$ within the atmosphere: This is performed very effectively by wind and weather, and the same concentration is reached everywhere within a few months (not precisely the same concentration, local and short-term variations exist, but can be neglected for the discussions here).
- Second, further distribution within the "small cycle": This is performed by high exchange rates (about a quarter of the atmospheric inventory per year! IPCC, 2007, 2013, 2018, 2021), and an equilibrium is reached within a few years (same partial pressure all over the "small cycle").
- Third, transfer of carbon out of the "small cycle" into the deep ocean, respectively into long-lived terrestrial biomass: This is performed by considerably slower processes, and due to the large inventories (IPCC, 2007, 2013, 2018, 2021), equilibrium will be reached only after about thousand years (equilibrium within the "large cycle").

These three steps will be discussed in more detail further below.

## 4. "Carbon Budget", "Airborne Fraction", and "Climate Sensitivity"

IPCC claims that anthropogenic $CO_2$ emissions are the only cause of global climate change (IPCC, 2007, 2013, 2018, 2021). To avoid a catastrophe, we must completely stop all our emissions. IPCC assumes that there is a "maximum amount of cumulative net global anthropogenic $CO_2$ emissions that would result in limiting global warming to a given level", IPCC calls this the "*carbon budget*" (IPCC, 2021). This "carbon budget" we have almost used up, so time is pressing for countermeasures. According to its definition, the "carbon budget" is independent from the temporal distribution of our emissions.

IPCC deduces the existence of this fixed "carbon budget" from *two assumptions*:

1. The rise in atmospheric $CO_2$-concentration is (exclusively!) the consequence of the anthropogenic emissions, and that is because approximately 50 % of them remain in the atmosphere (quantitatively, not necessarily the individual molecules emitted), independent of the height of these emissions and independent of the concentration already reached; IPCC speaks of a constant "*airborne fraction*" (IPCC, 2007, 2013, 2018, 2021).

2. The concentration increases the temperature by a fixed amount for each doubling of the concentration. This amount is labelled the "*climate sensitivity of $CO_2$*" (IPCC, 2007, 2013, 2018, 2021).

Focus of the considerations here is a careful check whether a "fixed carbon budget" and a "constant airborne fraction" can exist in the real world. It will be shown that both concepts contradict physical rules with high confidence. If this is confirmed, anthropogenic emissions *cannot be* the main cause of the rising $CO_2$-concentraion, and therefore also not of the rising temperature, whatever the "climate sensitivity" of $CO_2$ is. Consequentially, this "climate sensitivity" is only of secondary importance here. It should only be repeated that its exact value is scientifically highly controversial; and for those interested, a few helpful publications are listed (Beemt, 2019; Curry, 2023; Koutsoyiannis, et al. 2023; Lewis, 2023; McKitrick & Christiy, 2020; Scafetta, 2022, 2024; Spencer, 2024; Spencer & Cristy, 2024; Vahrenholt & Lüning, 2020).

## 5. Prerequisites

Physics and logic require three prerequisites to be fulfilled, when the fixed "carbon budget" and the constant "airborne fraction" should exist:

1. All other sources of $CO_2$ *must have remained constant*. Otherwise, they would contribute to the growing concentration, perhaps they could even dominate it.

2. The short-term partners of the atmosphere must store the *same amount* of $CO_2$ as the atmosphere itself. Otherwise, it would not be possible that always 50 % of the anthropogenic emissions remain in the atmosphere.

3. The atmosphere together with its short-term partners (the "short cycle") *must be a closed system*. Otherwise, $CO_2$ would be taken out of this system, reducing the concentration, the more, the higher the concentration.

It will be shown that all three prerequisites are not fulfilled with a high level of confidence.

## 6. Prerequisite 1: Constant natural sources

Inside the atmosphere, $CO_2$ reacts as an inert gas: There is no $CO_2$ produced and none vanishes. All $CO_2$-molecules inside have been emitted from an external source, and all will leave again into a sink. This outflow starts when the first molecules accumulate, it is *the stronger the higher the concentration is*, and it lasts theoretically until the last molecule.

For clarification: This outflow is the *gross* outflow. It must be strictly distinguished from the *net* outflow, which is the difference to the simultaneous gross inflow. The net flow between two reservoirs always goes from higher to lower concentration, but this net flow is always the *superposition of two countercurrent gross flows*, back and forth. In equilibrium, the net flow always is zero, but the two countercurrent flows depend on the concentration in the respective emitting reservoir (exceptions: emissions from human activities or volcanos depend on external effects!).

The dependency of the gross outflow on concentration follows inevitably from the main processes involved, dissolution in water and photosynthesis: These are diffusion-processes, and diffusion depends on concentration! This has an immediate consequence: Whenever the emissions into the atmosphere remain constant, the concentration in it *adjusts itself to a fixed value*: that value, where *outflow equals inflow!* Hereafter, the concentration remains constant, despite of ongoing emissions! This alone *contradicts the existence of a fixed "carbon budget" and of a constant "airborne fraction" inevitably!* That's rather all that needs to be said.

But two further consequences of the (gross) outflow rising with the concentration should be mentioned:

1. When the total emissions into the atmosphere rise by x %, then the concentration in it can rise *at most by x %* too (in equilibrium, before even less)!
2. All sources contribute to the concentration according to their relative strength. *No one can contribute disproportionately!*

These two consequences always exist whenever the (gross) outflow from a reservoir increases with concentration, regardless of the exact shape of this dependency. But because the outflow from the atmosphere runs mainly via diffusion (dissolution in ocean water and photosynthesis in plants!), this shape *must be proportionality!* Well, not necessarily exact from zero concentration up to 100 %, but within the range of interest here, from about 300 to about 400 or 500 ppm, proportionality applies at least in good approximation! (Attention: this is the gross outflow, the net outflow is proportional to the difference in concentration!).

Another important feature is that this gross outflow from the atmosphere is completely independent of what happens subsequently to the molecules that have left the atmosphere (for example, whether they are circulated back into the atmosphere or not), and it is also completely independent of how much molecules are emitted into the atmosphere simultaneously (and from which source they are emitted)! Therefore, if we know how much the concentration has changed (we can measure it!), we can calculate, how much *the (gross) outflow must have changed* as a consequence. And if we know the gross outflow, we can calculate *which inflow must have taken place* to let the concentration develop as it did, independent of the cause of this inflow (Roth, 2019, 2020, 2022, 2023)!

Short supplement: As already said, the gross flowrate from the atmosphere into the ocean does not depend on what happens to the molecules afterwards. This also holds for possible chemical transformations of those $CO_2$ molecules in the ocean water. But the (gross) flowrate back into the atmosphere does depend on those transformations. This is, because the transformation-products, carbonate and bicarbonate, do not contribute to the $CO_2$ partial-pressure, which drives the flow back into the atmosphere. This is further enhanced due to the solution equilibrium between these transformation-products and $CO_2$ depending on concentration.

To summarize: Because the concentration in the atmosphere has risen by 50 %, the total gross outflow from the atmosphere *must have risen by 50 % too*, at least approximately! That seems to be what physics requires. And since the concentration has risen, the total inflow *must have risen even more!* That seems to be, what the mass balance requires. In other words: The total inflow into the atmosphere *must have risen by about 50 %!* The 5 % anthropogenic emissions are *far too small* in any case.

Interim result: This confirms the result already found: To explain the observations, other sources of $CO_2$ must have been enhanced substantially, prerequisite 1 *cannot be fulfilled!*

*Which sources* have been enhanced, is of secondary importance for the discussions here, but clearly it is very interesting. One contribution inevitably comes as an *answer* to the higher concentration in the atmosphere, whatever the cause: Because of the rather small size of the immediate reaction partners of the atmosphere, the near-surface ocean layer and the short-lived terrestrial biomass (Fig. 1), the concentration in them always *rises markedly* when they take up more $CO_2$. Consequently, they must deliver *more* $CO_2$ back to the atmosphere! Therefore, when the emissions into the atmosphere increase, the emissions back into the atmosphere from these two reservoirs increase too, with only a short time lag. (Note: This is the answer the *atmosphere* gets from its direct reaction partners, for the answer, the "*small cycle*" gets from its partners, see section 8).

This feedback to increased emissions into the atmosphere exists without doubt, but there must be other enhancements of emissions too: At least the *higher temperature***,** whatever the cause, must have increased the emissions from ocean and biomass! Reasoning: Higher temperatures emit more $CO_2$ from the ocean (temperature dependent solubility of gases in liquids!), and they also enhance the exchange rates between atmosphere and biomass, the latter boosted even more by the growing of biomass ("global greening", see e. g. Chen et al., 2024; Scinexx, 2016; Zhu et al., 2016). One can discuss the size of this temperature-driven enhancement, but not its existence. Higher temperatures always increase emissions!

One more remark: Regarding the natural fluxes, IPCC always emphasizes that they have remained constant. But in Fig. 5.12 of (IPCC, 2021), numbers are given that clearly contradict this: The emissions from land into atmosphere have risen from 111.1 to 136.7 PgC/y, and that from ocean into atmosphere have risen from 54.6 to 77.6 PgC/y. The increase of together 48.6 PgC/y outweighs the anthropogenic emissions of 11 PgC/y by more than a factor four! IPCC only does not discuss its own numbers.

Summarizing the fulfillment of prerequisite 1: Anthropogenic emissions are *much too small*, and increased temperatures *must have enhanced* emissions too! Further enhancement might come e. g. from relocations of ocean currents with different carbon content, or from volcanoes (on land or submarine), and there are some more possibilities. The rules of physics *require* substantially enhanced emissions, but they also *provide possibilities* for that to happen. There is no need to assume any unknown physical effect.

## 7. Prerequisite 2: Equal storage capacity

If the "small cycle" were a closed system with equal storage capacities in the atmosphere itself and in the rest of the cycle, all $CO_2$ taken up would distribute itself with *half of it* remaining in the atmosphere. That is exactly, what IPCC assumes regarding the anthropogenic emissions (IPCC, 2007, 2013, 2018, 2021)! But that only works in a closed system with equally large storage capacities!

Fig. 5.12 in (IPCC, 2021) gives numbers for carbon-inventories. Their interpretation is complex, because most of the $CO_2$ dissolved in ocean is converted into carbonate and bicarbonate, which do not contribute to the partial pressure. And regarding biomass, IPCC does not differentiate between short-lived and long-lived biomass. But the numbers given strongly suggest that there is considerably less $CO_2$ in the atmosphere than in the rest of the "small cycle". If correct, *less* than half of the anthropogenic releases remain in the atmosphere!

However, this "equal capacity" is only valid anyway if no other sources are enhanced. Otherwise, the atmosphere must be larger to retain 50 %. Obviously, that is even *less likely*. Hence, the fulfillment of prerequisite No. 2 is *seriously in doubt.*

But perhaps other observations can help: There is a radioactive variant of $CO_2$, $^{14}CO_2$ (8 neutrons in the C-nucleus, $T_{1/2}$ about 6000 years), with a very low natural atmospheric concentration. But following the atomic bomb tests, its concentration almost doubled (Fig. 2). And after the test stop agreement in 1963, this concentration decreased rapidly, essentially *down to its previous value* before the bomb tests. In this case, definitely *less than 50 %* of the $^{14}CO_2$ released anthropogenically remained in the atmosphere!

And in this regard "normal" $CO_2$ *cannot behave differently!* It must distribute itself in the "small cycle" according to the same pattern as $^{14}CO_2$, basically independent of the individual molecular weight. Even with "normal" $CO_2$, only *significantly less than 50 %* can remain in the atmosphere! This confirms that the observed increase of the concentration by 2.5 ppm/y most probably *is not* the result of half of the anthropogenic emissions remaining in the atmosphere (as IPCC assumes), but rather the result of *much stronger sources* combined with *substantially increased outflow* of $CO_2$ from the "small cycle" into the deep ocean, respectively into long-lived biomass.

In summary, even if there is no real proof, there is strong evidence that prerequisite 2 *is not fulfilled!*

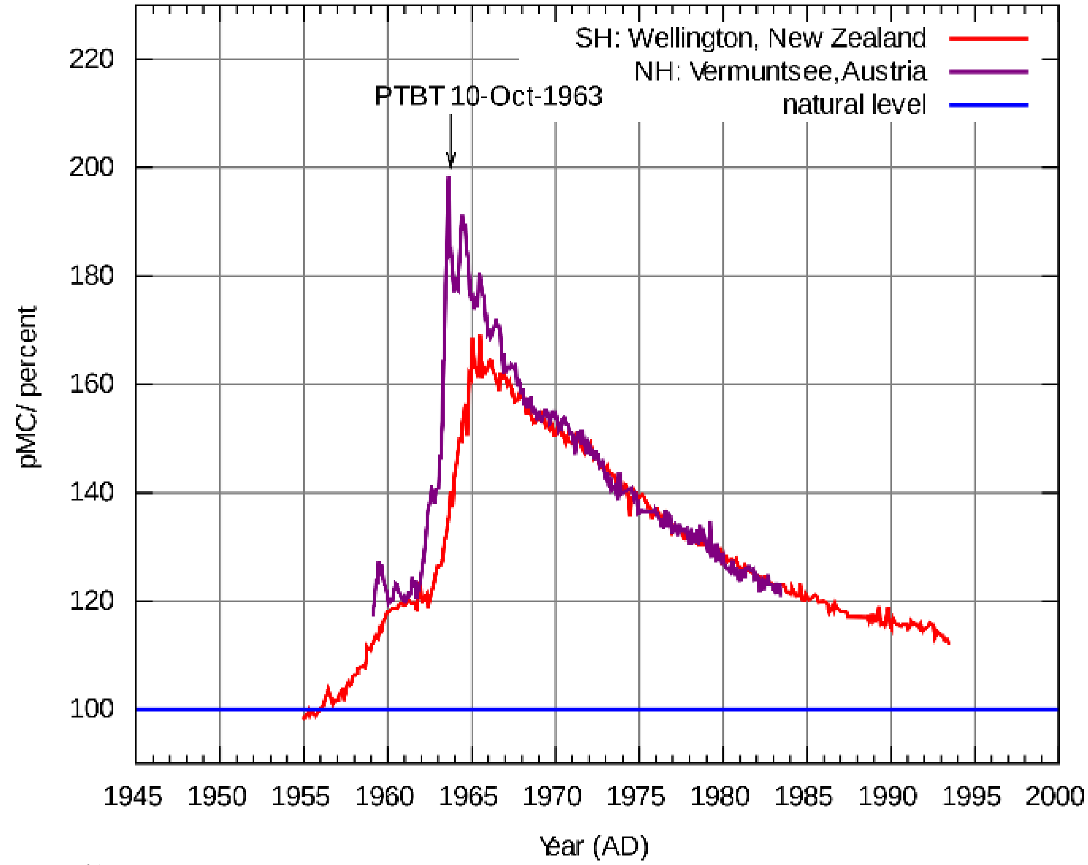


*Fig. 2: $^{14}CO_2$ concentration in the atmosphere: Pulse and decay after the atomic bomb tests (Hakanomono, 2015).*

## 8. Prerequisite 3: Closed system

In a closed system, all $CO_2$ emitted into it remains in it. Constant emissions enhance the concentration indefinitely. But in an open system, this is completely different: Because of the gross outflow rising with concentration, constant emissions enhance the concentration *only until outflow equals inflow*. Afterwards, the concentration *remains constant*, despite of ongoing emissions. Because the “small cycle” is an open system, prerequisite 3 *cannot be fulfilled.* Therefore, the fixed “carbon budget” and the constant “airborne fraction” *cannot exist!*

*Reasoning:* The only parameter really measured is $CO_2$-concentration. And to interpret these measurements, a special feature of the carbon-exchange with the deep ocean is of particular importance: Forward flow and return flow *can diverge substantially!* The downward flow into the deep ocean increases with the atmospheric concentration (more accurate: with the concentration in the near surface ocean layer), because the two effective processes, the biological pump (sinking of dead organisms with calcareous shells) and the physical pump (sinking of entire water packages with their whole contents), run proportional to concentration, at least approximately. But due to the sheer size of the deep ocean, and due to the slow currents in it, the return flow back from the deep ocean remains basically *unchanged* for about 1000 years! The answer of the deep ocean to an increasing atmospheric concentration simply takes that long. Therefore, when the concentration in the atmosphere changes, the exchange with the deep ocean is *imbalanced* for a significantly long period!

(IPCC, 2021) gives the downflow into the deep ocean with 275 PgC/y. Previously, it was about 100 PgC/y (IPCC, 2007, 2013, 2018). Nothing shows clearer than this surprising suddenly jump that we are *far away from knowing everything for sure* in the carbon cycle! But whatever the real value, it doubtless proves that the “small cycle” *is an open system!*

Similar it is regarding the long-lived terrestrial biomass: Here, too, the storage time is large and therefore, the exchange between atmosphere and long-lived biomass is *imbalanced* for a longer period. IPCC only gives combined numbers for the short-lived and the long-lived terrestrial biomass (IPCC, 2021), but a substantial part of the answer of the terrestrial biomass to rising atmospheric concentration is considerably delayed unambiguously, contributing to the openness of the system.

For clarification: It is the *size* of the direct reaction partners, that determines the time delay of an answer to increased emissions of $CO_2$: The atmosphere as such has small partners, resulting in a *quick* answer, within maximal a few years, the partners of the "small cycle" in total are much larger, resulting in a delay of about *1000 years*. During this time, the "small cycle" definitely *is an open system!*

## 9. Dependence on temporal distribution

As already said, the definitions of the fixed "carbon budget" and the constant "airborne fraction" require *independence of the temporal distribution* of the anthropogenic emissions in both cases. For example, emissions evenly distributed over 100 years must have the *same consequences* as an abrupt emission of the same total amount in a single pulse. And the consequences must be the same, independent of the time of this pulse, be it e. g. in year 1 or 100, or in any other year.

But if, for example, 50 % of that amount are emitted in year 1 and the other 50 % are emitted in year 100, and if that should have the *same consequences* as the larger single pulse in year 100, *no* $CO_2$ must be taken out of the atmosphere for 100 years despite of substantially increased concentration! That *contradicts* physics, which requires outflow to increase with concentration, and it also *contradicts* the fixed "airborne fraction" of 50 %, which, if correct, would mean that 50 % of any amount emitted are withdrawn within a few years! The two concepts, the "fixed carbon budget", and the "constant airborne fraction", *contradict each other!*

Appraisal: Both assumptions, the fixed "carbon budget" and the fixed "airborne fraction", are key components in IPCC's attribution of the rise in $CO_2$-concentration solely to human emissions (IPCC, 2007, 2013, 2018, 2021). Both seem to *contradict physics*, and they *cannot coexist*, because they are mutually exclusive! Probably, both are incorrect. Most likely, the rise in $CO_2$-concentration is a *mood of nature with only a small human contribution!*

## 10. Driving force of 120 ppm

Today, the concentration in the atmosphere is about 120 ppm higher than it was 150 years ago. And today the net outflow from the atmosphere into the ocean and into the terrestrial biomass is about 2.5 ppm/y. Sometimes, this is interpreted as the 120 ppm being the *driving force* to emit the 2.5 ppm/y from the atmosphere. On that basis, it is calculated: If we freeze our emissions at today's value, the concentration increases only up to a new equilibrium at about 500 ppm, and if we reduce our emissions to 50 %, the concentration remains constant immediately, and if we terminate our emissions, the concentration falls rapidly, exponentially with a time constant of about 55 years down to the old equilibrium 150 years ago (e. g. Vahrenholt & Lüning, 2020; Halperin, 2015; Spencer, 2019).

But that seems to be *wrong for two reasons:*

- First, the driving force for the actual net outflow is the *actual* difference in concentration between the atmosphere and its sinks, not the *mathematically calculated* difference between today's concentration and that 150 years ago. The atmosphere does not even have a memory for any past concentration, it only knows today's boundaries.
- And second, an imbalance with a driving force of 120 ppm appears to be *totally impossible* in a system with an exchange rate of about a quarter of the inventory per year and the gross outflow depending on concentration, at least for slow transients (and the real transients always have been below 1 % of the inventory per year!). Such a high imbalance would be eliminated completely within only a few years!

Today's net flow of 2.5 ppm/y from the atmosphere into the near surface ocean layer and into the terrestrial biomass is tantamount to the statement that these two reservoirs emit 2.5 ppm/y less than they get. What they get, we know, is driven proportionally by the total concentration in the atmosphere, and regarding their emissions, we do not know the driving force (temperatures, ocean currents, volcanoes, etc.), but we can calculate the (gross) flux by obeying the mass balance. These simple physical relationships show that a difference of 120 ppm does not exist in nature, and never can be the driving force for the 2.5 ppm/y.

## 11. What happens when we terminate our emissions?

Presumably not very much. On the basis of the considerations here, the development of the concentration has been determined by changes of natural emissions, and this will also hold for the future! Anthropogenic emissions are much too low to be a real player. If natural emissions will continue to rise, the concentration will rise too, and if nature reduces its emissions, the concentration will fall too, whatever we do. The influence humankind can exert is so small that it hardly matters.

## 12. Discussion

The main result of the considerations here is that both, the fixed “carbon budget” and the constant “airborne fraction”, *do not exist,* and as a consequence, the emissions from natural sources *must have been increased substantially* to rise the concentration as it is observed. Against this, two objections are raised in particular: The estimations made here for the size of the natural flows are *too unreliable*, and *a sink cannot be a source.*

The first one is difficult to comprehend, because the estimations are made strictly on the basis of physical rules, and they show that the natural flows have grown by a multiple of the anthropogenic emissions. Therefore, the preponderance of natural emissions would remain valid, even if an important failure should be found somewhere. This “remain valid” is supported by the fact that the two cycles, the one between atmosphere and ocean, and the other between atmosphere and biomass, are totally independent of each other (except for the atmosphere being part of both), and that they operate by essentially different physical processes. Each of the two cycles is strong enough on its own to maintain the central statement “nature dominates”, even if the argumentation presented here should break down in the other cycle. The preponderance of nature would be less, but it would still apply, rejecting IPCC’s view “only the anthropogenic emissions”. Therefore, there must be at least two independent failures to uphold IPCC’s view. Of cause, that is possible in principle, but it is even more unlikely. The central statement “nature is stronger than humankind” seems to be robust.

The second objection seems to be self-evident on the first view: A sink cannot be a source! The numbers are clear: At least for the last 60 or so years ocean and terrestrial biomass always *have been* a net sink. They always have taken up $CO_2$ net, in an amount equal to about half of the anthropogenic emissions. Therefore, it is often argued that the anthropogenic emissions *must be the only source* of the increased concentration because ocean and terrestrial biomass always have been a *net sink!*

But that is a premature judgment. It simply ignores the fact that the (gross) outflow always *increases* with rising concentration, whatever the cause. Let’s start with external emissions, that are emissions from the outside of the “small cycle” into the atmosphere (e. g. anthropogenic emissions by burning fossil fuel or by cement production, or emissions from volcanoes, etc.): In all such cases the concentration in the atmosphere rises, and as a consequence the (gross) outflow from the atmosphere rises too, but it stays a little bit behind the (gross) inflow. Consequently, ocean and terrestrial biomass act as a *net sink,* taking up part of the enhanced emissions. That applies for all external emissions.

Not much different in case of internal emissions, that are emissions out of ocean or terrestrial biomass by relocations between them and the atmosphere (caused for example by enhanced temperatures or by changed ocean currents, but also anthropogenic emissions by land use changes fall into this category): Here, too, the concentration in the atmosphere rises, and consequently the (gross) outflow from it rises too, and again this outflow stays a little bit behind the inflow. But in this case, ocean and terrestrial biomass lead the way, and they emit more than they take up. They now act as a *net source!* That applies for all internal emissions.

Another important point is that in both cases the quantity as net sink, respectively as net source, is the *momentary difference* between total input and total output to/from ocean and terrestrial biomass.

This is the separate consideration. But what is when both forms of enhanced emissions, external and internal, occur *simultaneously*? Then both increase the concentration in the atmosphere, and by that both increase the (gross) outflow from it. This doubly increased outflow now even can be larger than the emissions from ocean and terrestrial biomass alone without crediting the anthropogenic emissions. In that case, ocean and terrestrial biomass *switch to be a net sink* (with regard to the total emissions), in spite of *still being a net source* for their own (under exclusion of the anthropogenic emissions)! This switch always occurs, when the anthropogenic emissions are *strong enough* to enhance the concentration enough, so that the (gross) outflow now overtakes the emissions from ocean and terrestrial biomass alone. Then, ocean and terrestrial biomass act as *a sink and as a source at the same time!* That is no contradiction, they are a sink with regard to all sources combined, and they are a source simultaneously with regard to what they do alone, independent of the external emissions!

That fits well with the findings in (Ollila, 2016) that ocean and biomass had been a *net source* of $CO_2$ for 200 years, with only very small anthropogenic emissions during that time, but they switched to be a *net sink* around 1956, when the anthropogenic emissions became strong enough. For clarification: They became strong enough to enable that switch, however, that does not tell *which one* of the two emissions have contributed more to the observed rise in concentration. But this is an easy question: Since the emissions from natural sources have increased about *tenfold* compared to the anthropogenic emissions (about 50 % versus about 5 %), the answer is clear-cut (and there is even plenty of room left for inaccuracies, see above)!

## 13. Consequences and final remark

Once again: The main result of the considerations here is that both, the fixed "carbon budget" and the constant "airborne fraction", *do not exist,* and that consequently the emissions from natural sources *must have been enhanced substantially* to rise the concentration as it is observed! If confirmed, there are only *two possibilities left:* Either the climate is determined by $CO_2$, then it is *natural* $CO_2$ that determines, or other factors dominate, then $CO_2$ plays only a *subordinate role* at most! In both cases, there is *no need to reduce anthropogenic emissions,* at least not for climate protections sake. We could benefit from cheap energy from fossil fuels and from $CO_2$-improved plant growth without any remorse. And we would have to accept the climate, as it develops on its own, and if necessary, we would have to implement mitigating measures!

The results shown here clearly *contradict the mainstream view*. This is a good reason for caution, but the results seem to be backed by physics and by logic, and counterarguments do not seem to be sustainable. Therefore, a careful review is required urgently. This article aims to push the discussion.

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