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The relationship between atmospheric temperature and carbon dioxide concentration

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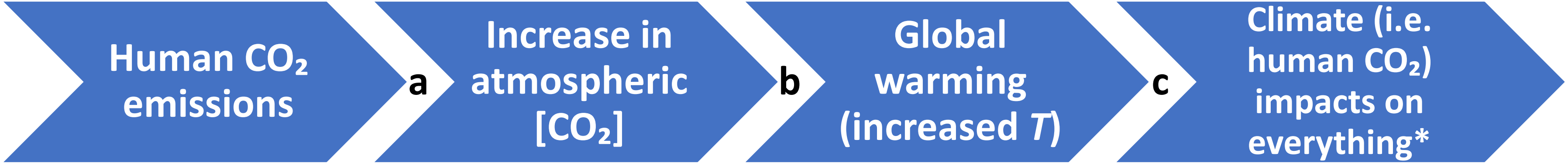
The mainstream climate narrative: The formation of a wrong causal chain



*from hydrology to kidney stones

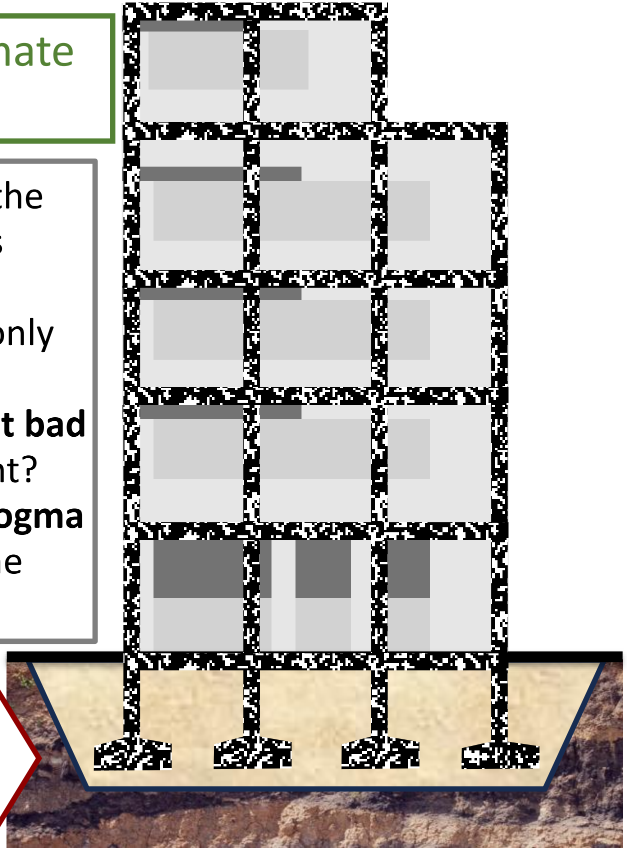
- This causal link, “a”, “b”, “c”, is the **core of so-called “climate science”**.
- In my view it is **naïve and simplistic**, reflecting kindergarten-level science.
- It is promoted by IPCC and the political and economic interests.
- It is also supported by mainstream “sceptics”.

My difference with “sceptics”: Inspecting the climate edifice

“Sceptics” usually argue with the climate establishment about the penthouse.

Why do (mainstream) “sceptics” accept the debating space (the penthouse) that was defined by the climate establishment?

1. Is the underlying science correct and only **details need to be discussed**?
2. Should sceptics prove that they are **not bad guys**, distanced from the establishment?
3. Should sceptics, **confess faith in the dogma “Humans are responsible”** and become climissioners to save the planet?



I have been working on inspecting the (shaky) foundation, i.e., the relationship between temperature and CO_2.

Investigation of the assumed link "a": Is the increase in atmospheric CO_2 caused by human emissions?

- IPCC and climate zealots reply: **Yes**
- (Mainstream) "sceptics" also reply: **Yes**
- I reply: **No**

Understanding and modelling the CO_2 dynamics

My studies are based on data, fully **excluding** anything originating from **climate models**.

The models I developed are **simple, transparent** and reproducible in a spreadsheet.

The data are **measurements** of $[CO_2]$, $\delta^{13}C$, $\Delta^{14}C$, and anthropogenic emissions.

Open Access Article

Net Isotopic Signature of Atmospheric CO_2 Sources and Sinks: No Change since the Little Ice Age

by Demetris Koutsoyiannis

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Abstract

Recent studies have provided evidence, based on analyses of instrumental measurements of the last seven decades, for a unidirectional, potentially causal link between temperature as the cause and carbon dioxide concentration ($[CO_2]$) as the effect. In the most recent study, this finding was supported by analysing the carbon cycle and showing that the natural $[CO_2]$ changes due to temperature rise are far larger (by a factor > 3) than human emissions, while the latter are no larger than 4% of the total. Here, we provide additional support for these findings by examining the signatures of the stable carbon isotopes, 12 and 13. Examining isotopic data in four important observation sites, we show that the standard metric $\delta^{13}C$ is consistent with an input isotopic signature that is stable over the entire period of observations (>40 years), i.e., not affected by increases in human CO_2 emissions. In addition, proxy data covering the period after 1500 AD also show stable behaviour. These findings confirm the major role of the biosphere in the carbon cycle and a non-discernible signature of humans.

Open Access Article

Refined Reservoir Routing (RRR) and Its Application to Atmospheric Carbon Dioxide Balance

by Demetris Koutsoyiannis

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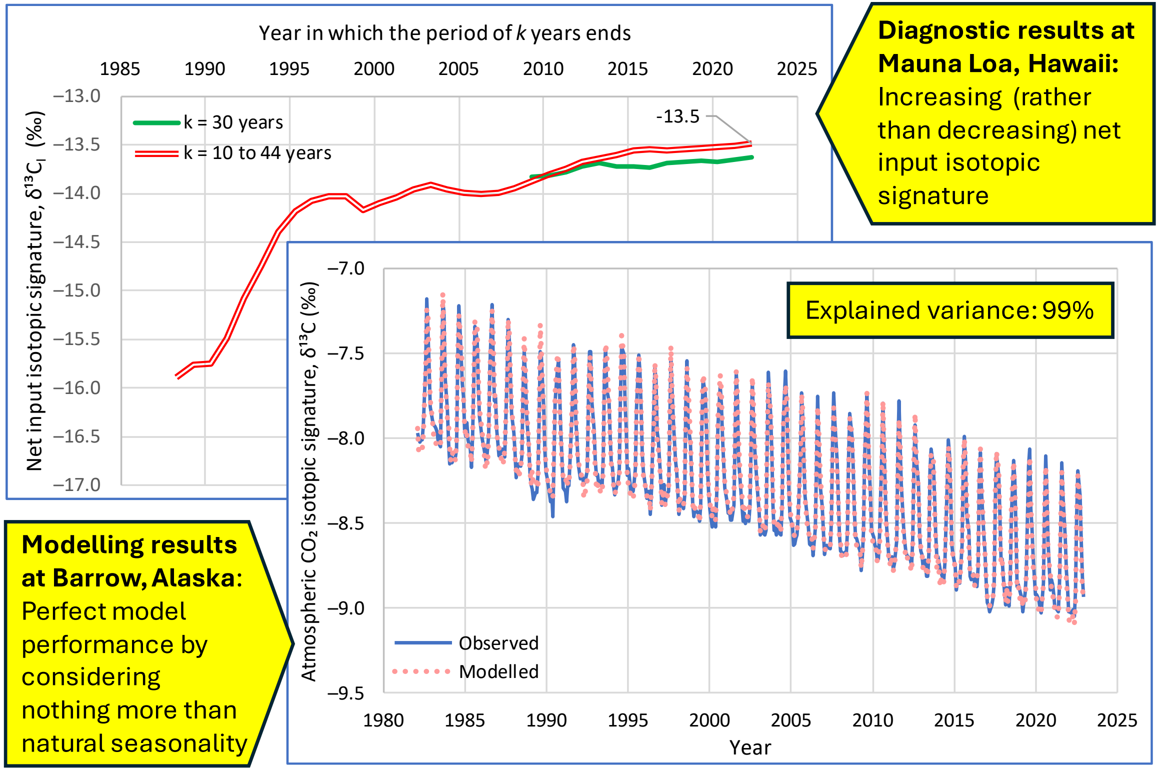
Abstract

Reservoir routing has been a routine procedure in hydrology, hydraulics and water management. It is typically based on the mass balance (continuity equation) and a conceptual equation relating storage and outflow. If the latter is linear, then there exists an analytical solution of the resulting differential equation, which can directly be utilized to find the outflow from known inflow and to obtain macroscopic characteristics of the process, such as response and residence times, and their distribution functions. Here we refine the reservoir routing framework and extend it to find approximate solutions for nonlinear cases. The proposed framework can also be useful for climatic tasks, such as describing the mass balance of atmospheric carbon dioxide and determining characteristic residence times, which have been an issue of controversy. Application of the theoretical framework results in excellent agreement with real-world data. In this manner, we easily quantify the atmospheric carbon exchanges and obtain reliable and intuitive results, without the need to resort to complex climate models. The mean residence time of atmospheric carbon dioxide turns out to be about four years, and the response time is smaller than that, thus opposing the much longer mainstream estimates.

What do carbon isotopic data ^{13}C reveal? (Koutsoyiannis, 2024a)

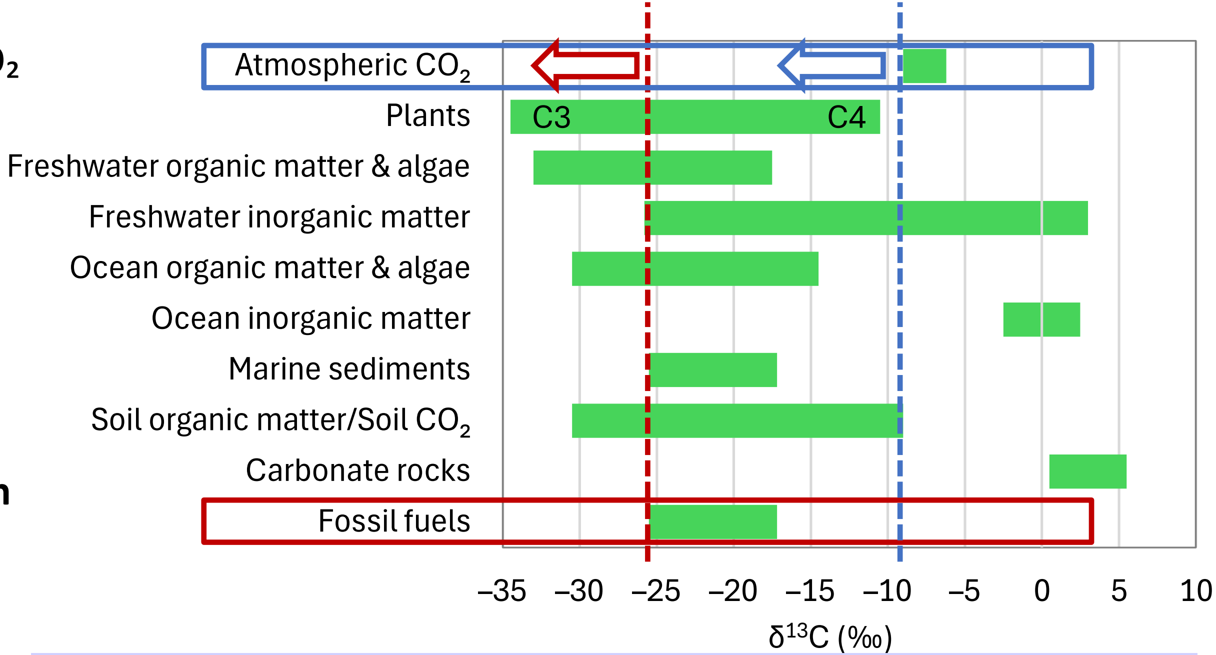
- The atmospheric $\delta^{13}C$ has been decreasing (see lower graph).
- However, the **net input signal** of the atmospheric $\delta^{13}C_I$ is not decreasing—in some cases, it is increasing (see upper graph).
- A constant $\delta^{13}C_I$ of about –13‰ (or less) at an overannual time scale is representative across the entire globe for the entire period of measurements.
- The same value holds for proxy data **after the Little Ice Age**.
- These support the conclusion that **natural causes drove the [CO_2] increase**.
- A **human-caused** signature (Suess effect, after Suess, 1955) is **non-discernible**.



Graph source: Koutsoyiannis (2024a; graphical abstract).

Why the Suess effect does not have a logical basis

- Fossil fuels have a small $\delta^{13}C$ signature, down to –26‰ and hence their input $\delta^{13}C_I$ is low.
- However, **C3 plants** (e.g., evergreen trees, deciduous trees and weedy plants) have **much lower** $\delta^{13}C$ values than fossil fuels, down to – 34‰, and thus their input $\delta^{13}C_I$ is even lower.
- Lower values than in fossil fuels, also appear in other CO_2 sources.
- When the **C3 plants** (and many other organisms) **respire**, they emit to the atmosphere low $\delta^{13}C_I$, decreasing the atmospheric $\delta^{13}C$ content.
- It is therefore **absurd** to suggest that it is **the emission from burning fossil fuels (4% of the total) that causes the atmospheric $\delta^{13}C$ value to fall**.



Graph source: Koutsoyiannis (2024d) after grouping similar categories from Trumbore and Druffel (1995).

Definitions and Glossary in Koutsoyiannis (2024c): Trying to bring rigour to climate by employing stochastics

Impulse response function **(*IRF*, $g_h(h)$)**: A system's output at a time distance (lag) h from the time in which the system is perturbed by an input that is an (instantaneous) impulse of unit mass (a Dirac delta function). It is also expressed in dimensionless form, $g(\eta) = g_h(\eta W_0) W_0$. An interesting property (proposition 1) is that the IRF is identical to the probability density function of the residence time for the case that the input is an impulse function.

Reservoir, linear: A reservoir in which the outflow is proportional to storage. Any other type of storage–outflow relationship defines a *nonlinear reservoir*.

Reservoir, sublinear: A reservoir in which the outflow is proportional to storage raised to a power $b < 1$.

Reservoir, superlinear: A reservoir in which the outflow is proportional to storage raised to a power $b > 1$.

Residence time **($\underline{W}$)**: The time duration that a particle (molecule) spends in the reservoir from its entry to its exit. Excepting the (unrealistic) case of a perfectly regular (laminar) flow, the residence time is different for different molecules and is therefore represented as a stochastic variable (hence the underscore in the notation).

Residence time, characteristic **(W_0)**: The time that is defined as the ratio $W_0 := S_0/Q_0$, where S_0 and Q_0 represent the initial conditions of storage and outflow, respectively, at time $t = 0$. In general, W_0 depends on the initial conditions. In a linear reservoir it is equal to the mean residence time, μ_W.

Residence time, mean **(μ_W)**: The mean of the stochastic variable $\underline{W}$, which represents the residence time. It may also be expressed in dimensionless form, $\mu_w = \mu_W / W_0$. In a linear reservoir, the mean residence time is equal to the characteristic residence time $\mu_W = W_0$, and the dimensionless mean residence time is $\mu_w = 1$. In a sublinear or superlinear reservoir, a simple approximation of the mean residence time is given by Equation (41).

Residence time, median **($W_{1/2}$)**: The median of the stochastic variable $\underline{W}$, which represents the residence time. It may also be expressed in dimensionless form, $w_{1/2} = W_{1/2}/W_0$. In a linear reservoir, the median residence time is smaller than the mean residence time by the factor ln 2 = 0.69. In a sublinear or superlinear reservoir, a simple approximation of the median residence time is given by Equation (41).

Response time, mean: The mean of the IRF, in dimensional form (μ_h) or dimensionless form ($\mu_\eta = \mu_h / W_0$). In a linear reservoir, the mean response time is equal to the mean residence time and to the characteristic residence time, $\mu_h = \mu_W = W_0$, and the dimensionless ones are $\mu_\eta = \mu_w = 1$. In a sublinear reservoir, the mean response time is generally smaller than the mean residence time. In a sublinear or superlinear reservoir, the mean response time is determined from the exact Equation (44).

Response time, median: The median of the IRF, in dimensional form ($h_{1/2}$) or dimensionless form ($\eta_{1/2} = h_{1/2}/W_0$). In a linear reservoir, the median response time is smaller than the mean response time by the factor ln 2 = 0.69. In a sublinear reservoir, the median response time is generally smaller than the median residence time. In a sublinear or superlinear reservoir, the median response time is determined from the exact Equation (44).

A contrast with the "intentionally vague"* IPCC terminology

- IPCC (2021) uses the terms *lifetime*, *turnover time*, *global atmospheric lifetime*, *response time*, *adjustment time*, *half-life* or *decay constant*, none of which is clear enough to allow quantification and even to allow distinguishing which one is referred to each time.
- In particular, when referring to CO_2 (and in contrast to other substances), IPCC is as vague as possible, e.g.:
  - [*T*]*he concept of a single, characteristic atmospheric lifetime is not applicable to* CO_2 (IPCC, 2013, p. 473).
  - *No single lifetime can be given* [for CO_2]. *The impulse response function for* CO_2 *from Joos et al. (2013) has been used* (IPCC, 2013, p. 737).
  - *Lifetime* [for well-mixed greenhouse gases] *is reported in years: # indicates multiple lifetimes for* CO_2 (IPCC, 2021, p. 302; see also p. 1017).
- IPCC insists on the weird idea that the behaviour of the CO_2 depends on its origin and that CO_2 emitted by anthropogenic fossil fuel combustion has higher residence time than naturally emitted:
  - *Simulations with climate – carbon cycle models show multi-millennial lifetime of the anthropogenic* CO_2 *in the atmosphere* (IPCC, 2013, p. 435).

* "Intentionally vague" has been quoted from MIT's *Climate Portal Writing Team Featuring Guest Expert Ed Boyle, How Do We Know How Long Carbon Dioxide Remains in the Atmosphere?*, 2023. https://climate.mit.edu/ask-mit/how-do-we-know-how-long-carbon-dioxide-remains-atmosphereEstimates. The full phrase is: "*Estimates for how long carbon dioxide* (CO_2) *lasts in the atmosphere* […] *are often intentionally vague, ranging anywhere from hundreds to thousands of years.*"

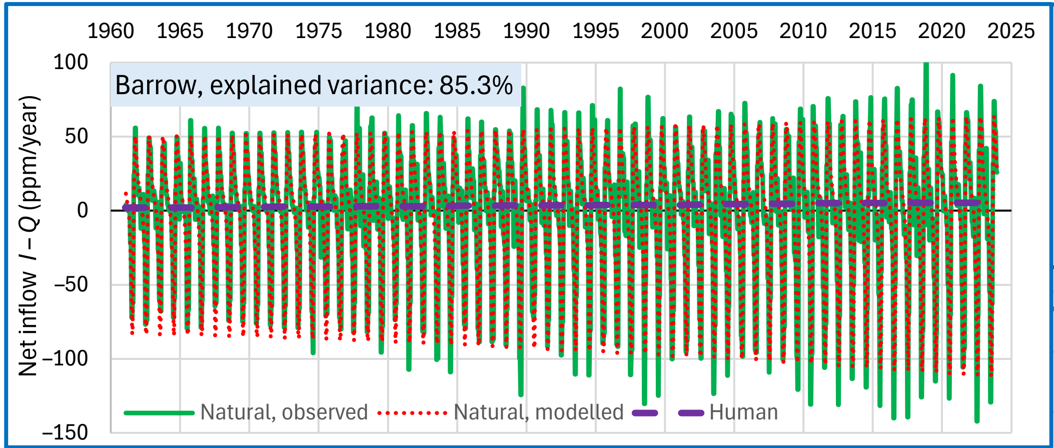
Full account of the atmospheric CO_2 dynamics

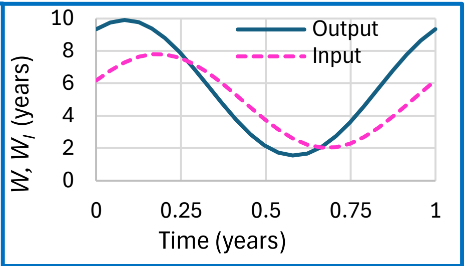
Evidently (and contrary to popular beliefs), the CO_2 mean residence time (*W*) in the atmosphere is:

a) independent of the origin (human or not);

b) about 4 years on overannual basis (there is no multi-millennial lifetime);

c) seasonally varying with lowest value < 2 years.

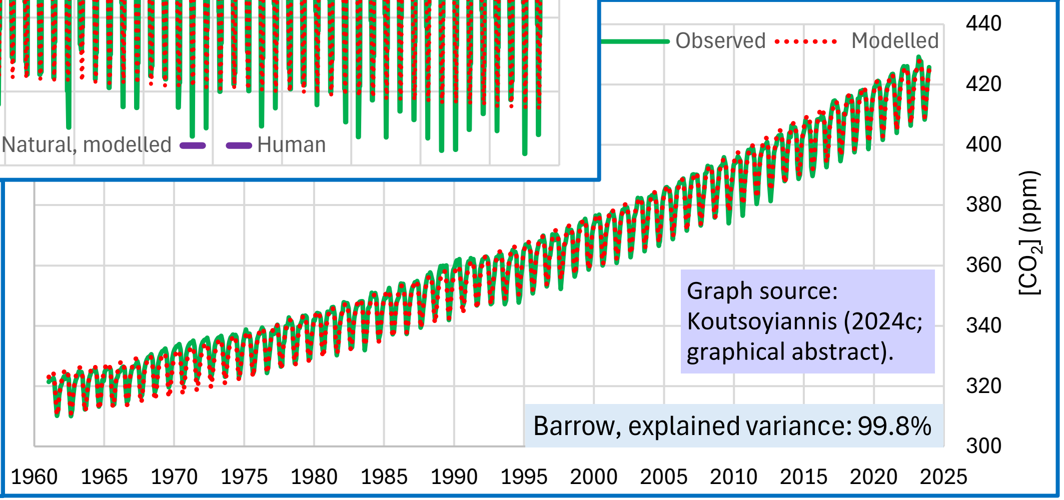




Mean residence time (*W*)*:* 3.9 years (seasonal variation: 1.6 – 9.9 years).

Net inflow seasonal variation range: 130 ppm/year in 1960s; 240 ppm/year now (**biosphere expansion**—compare with human emissions of max 5 ppm/year).

Model performance: excellent.



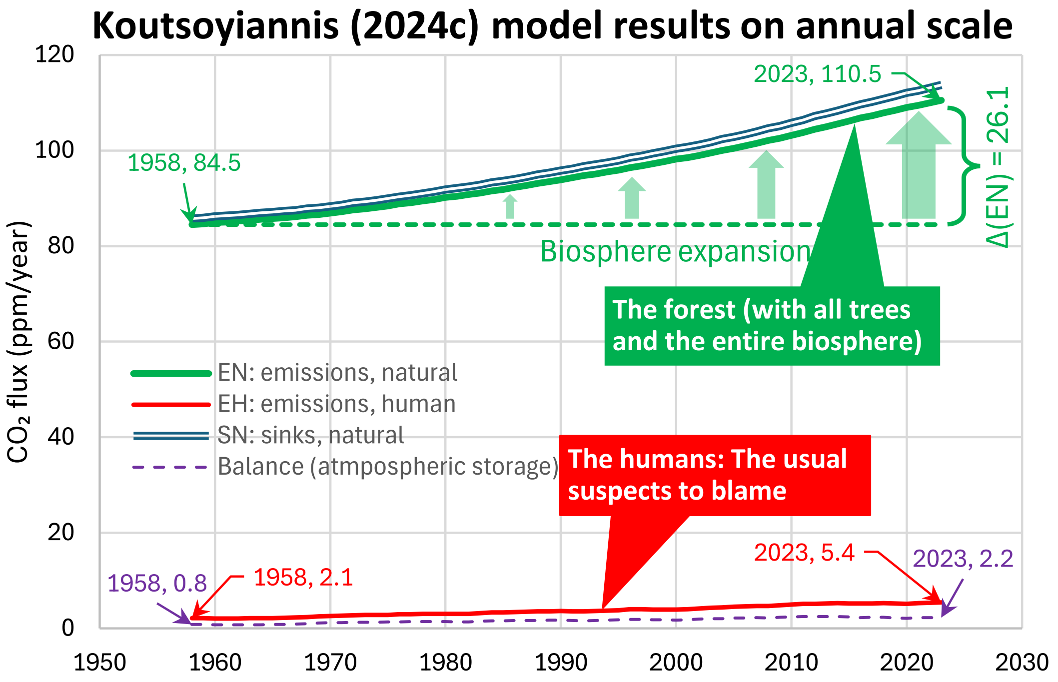
The biosphere expansion and related questions (& Answers)

1. Has the biosphere expansion (the upsurge Δ(EN) = 26.1 ppm CO_2/year) been caused by human emissions (2.1 to 5.4 ppm CO_2/year)?

   Answers: Mine No; IPCC's Yes*

2. Atmospheric CO_2 is less than half of human emissions. Does this demonstrate that natural processes have not added CO_2 to the atmosphere?
3. Nature (land and oceans) is a net sink. Is it proof that the CO_2 rise is caused by humans?
4. Does the Koutsoyiannis (2024c) model violate mass balance?

   Answers for 2-4: Mine No; „Sceptics"" Yes

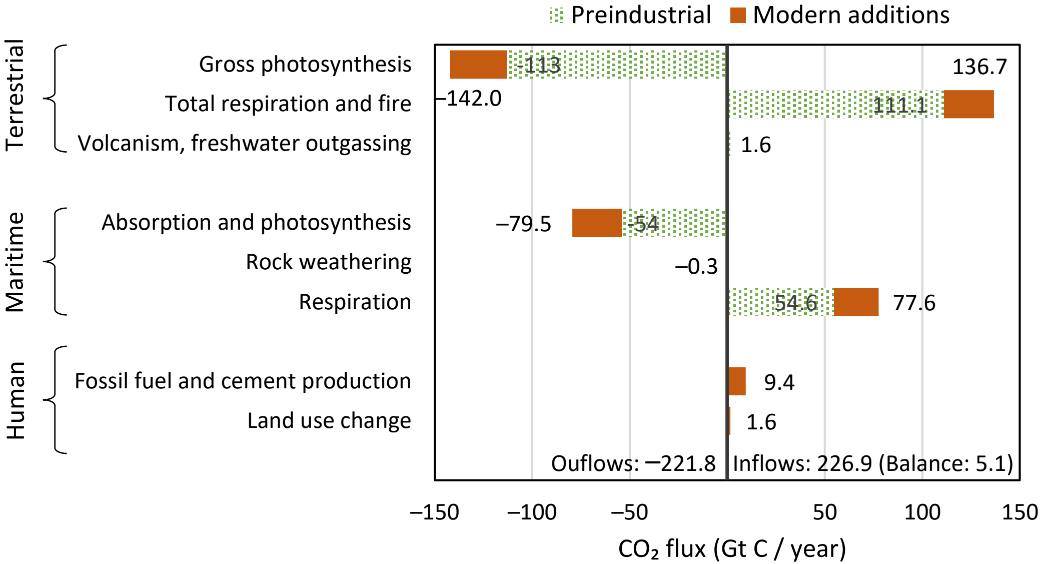


The graph was prepared from the Koutsoyiannis (2024c) model results, after aggregation to the annual scale.

* This is inferred from the following quotation: "*Emissions from natural sources, such as the ocean and the land biosphere, are usually assumed to be constant, or to evolve in response to changes in anthropogenic forcings or to projected climate change.*" (IPCC, 2021, p. 54)

My results are consistent with the IPCC (AR6) carbon balance

1. Humans are responsible for only 4% of carbon emissions (based on IPCC data).
2. The vast majority of changes in the atmosphere since 1750 (red bars in the graph) are due to natural processes, respiration and photosynthesis.
3. The increases in both CO_2 emissions and sinks are due to the temperature increase, which expands the biosphere and makes it more productive.
4. The terrestrial biosphere processes are much more powerful than the maritime ones in terms of CO_2 production and absorption.



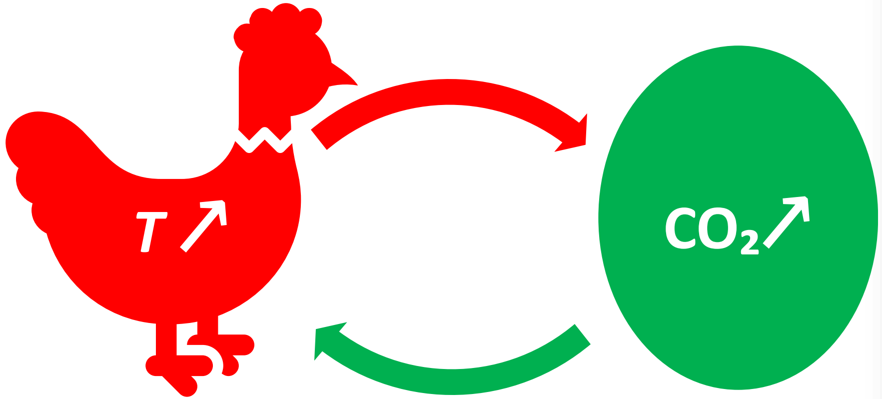
The estimates are “official” from IPCC (2021; Fig. 5.12). The presentation in the figure above is “unofficial”, adapted from Koutsoyiannis (2024c). In the recent publication by Lai et al. (2024) the estimates of gross photosynthesis and respiration are even higher, 157 and 149 Gt C/year (instead of 142.0 and 136.7 Gt C/year), respectively.

5. The CO_2 emissions by the ocean biosphere alone are much larger than human emissions.
6. The modern (post-1750) CO_2 additions to pre-industrial quantities (red bars in the right half of the graph) exceed the human emissions by a factor of ~4.5.

Investigation of the assumed causal link “b”: Does the increase in atmospheric CO_2 cause temperature increase?

- IPCC and climate zealots reply: **Yes**
- (Mainstream) “sceptics” also reply: **Yes**
- I reply: **No**

Causal relationship between CO_2 & temperature: “ὄρνις ἢ ᾠὸν;” (“hen or egg?”)



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Atmospheric Temperature and CO_2: Hen-Or-Egg Causality?

by Demetris Koutsoyiannis [1,*] and Zbigniew W. Kundzewicz [2]

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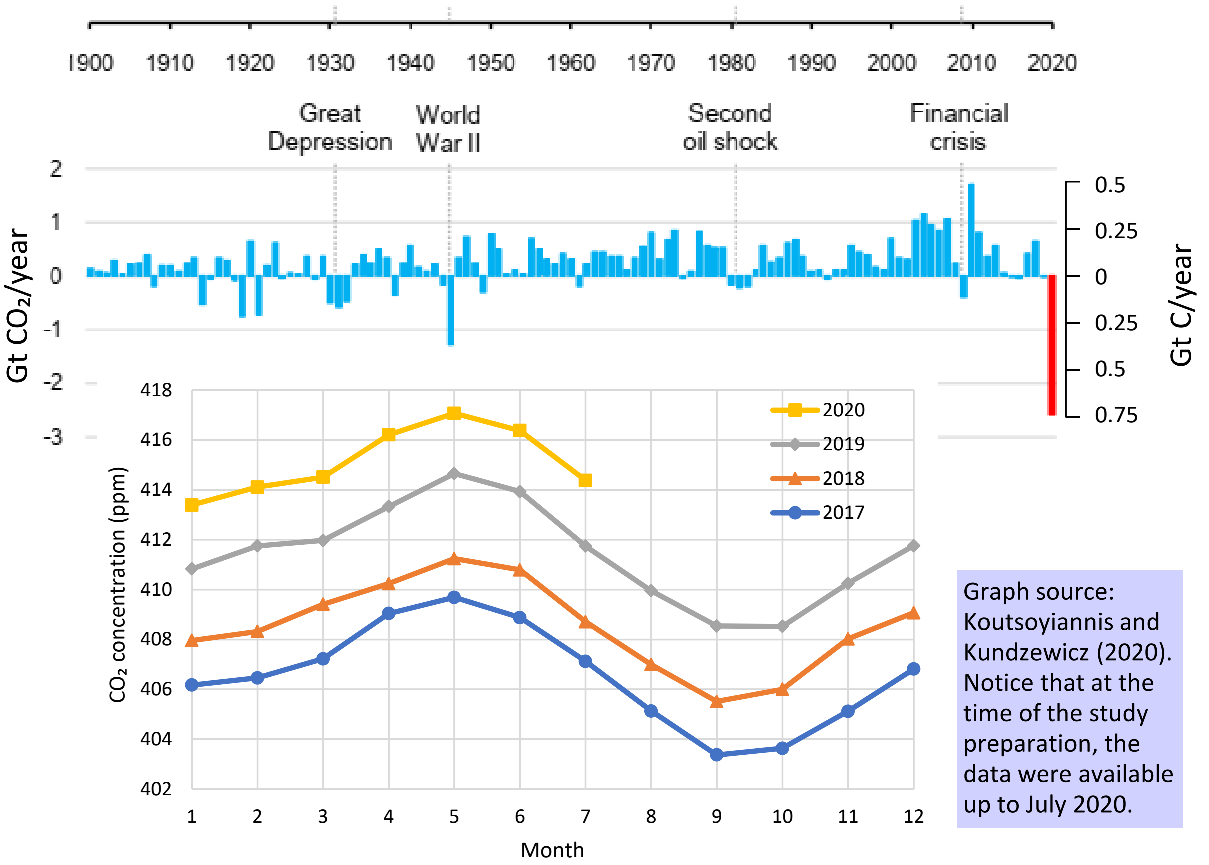
Abstract

It is common knowledge that increasing CO_2 concentration plays a major role in enhancement of the greenhouse effect and contributes to global warming. The purpose of this study is to complement the conventional and established theory, that increased CO_2 concentration due to human emissions causes an increase in temperature, by considering the reverse causality. Since increased temperature causes an increase in CO_2 concentration, the relationship of atmospheric CO_2 and temperature may qualify as belonging to the category of “hen-or-egg” problems, where it is not always clear which of two interrelated events is the cause and which the effect. We examine the relationship of global temperature and atmospheric carbon dioxide concentration in monthly time steps, covering the time interval 1980–2019 during which reliable instrumental measurements are available. While both causality directions exist, the results of our study support the hypothesis that the dominant direction is $T \rightarrow CO_2$. Changes in CO_2 follow changes in T by about six months on a monthly scale, or about one year on an annual scale. We attempt to interpret this mechanism by involving biochemical reactions as at higher temperatures, soil respiration and, hence, CO_2 emissions, are increasing.

Keywords: temperature; global warming; greenhouse gases; atmospheric CO_2 concentration

The beginning: The COVID unfortunate experiment



Graph source: Koutsoyiannis and Kundzewicz (2020). Notice that at the time of the study preparation, the data were available up to July 2020.

- COVID-imposed lockdowns caused the largest reduction in human CO_2 emissions in history.
- The global CO_2 emissions were over 5% lower in the first quarter of 2020 than in that of 2019 (IEA, 2020).
- However, the increasing pattern of atmospheric CO_2 concentration, as measured in Mauna Loa, did not change.

Development and application of a new causality framework

We have not applied an existing method but developed a new one with some importance as:

a) Causality is a central concept in **science**, **philosophy** and **life**, with very high **economic** importance.

b) Recently causal inference has become an **arena of enormous interest**.

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Revisiting causality using stochastics: 1. Theory

Demetris Koutsoyiannis, Christian Onof, Antonis Christofides and Zbigniew W. Kundzewicz

Published: 25 May 2022 https://doi.org/10.1098/rspa.2021.0835

Review history

Abstract

Causality is a central concept in science, in philosophy and in life. However, reviewing various approaches to it over the entire knowledge tree, from philosophy to science and to scientific and technological applications, we locate several problems, which prevent these approaches from defining sufficient conditions for the existence of causal links. We thus choose to determine necessary conditions that are operationally useful in identifying or falsifying causality claims. Our proposed approach is based on stochastics, in which events are replaced by processes. Starting from the idea of stochastic causal systems, we extend it to the more general concept of hen-or-egg causality, which includes as special cases the classic causal, and the potentially causal and anti-causal systems. Theoretical considerations allow the development of an effective algorithm, applicable to large-scale open systems, which are neither controllable nor repeatable. The derivation and details of the algorithm are described in this paper, while in a companion paper we illustrate and showcase the proposed framework with a number of case studies, some of which are controlled synthetic examples and others real-world ones arising from interesting scientific problems.

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Research articles

Revisiting causality using stochastics: 2. Applications

Demetris Koutsoyiannis, Christian Onof, Antonis Christofidis and Zbigniew W. Kundzewicz

Published: 25 May 2022 https://doi.org/10.1098/rspa.2021.0836

Review history

Abstract

In a companion paper, we develop the theoretical background of a stochastic approach to causality with the objective of formulating necessary conditions that are operationally useful in identifying or falsifying causality claims. Starting from the idea of stochastic causal systems, the approach extends it to the more general concept of hen-or-egg causality, which includes as special cases the classic causal, and the potentially causal and anti-causal systems. The framework developed is applicable to large-scale open systems, which are neither controllable nor repeatable. In this paper, we illustrate and showcase the proposed framework in a number of case studies. Some of them are controlled synthetic examples and are conducted as a proof of applicability of the theoretical concept, to test the methodology with *a priori* known system properties. Others are real-world studies on interesting scientific problems in geophysics, and in particular hydrology and climatology.

Milestones in causality—Philosophical reflections

Aristotle (384 – 322 BC):

> *that which when present is the cause of something, when absent we sometimes consider to be the cause of the contrary*.

Plutarch (AD 46 –119; Greek Middle Platonist philosopher):

> The first to pose the ***hen-or-egg*** type of causality as a philosophical problem—and **replace events with processes**:
>
> “*Πότερον ἡ ὄρνις πρότερον ἢ τὸ ᾠὸν ἐγένετο*” (Ηθικά, Συμποσιακὰ Β, Πρόβλημα Γ).

David Hume (1711– 1776; Scottish Enlightenment philosopher):

> the concept of a cause is merely a way we use to **describe regularities**.

Immanuel Kant (1724–1804, German Enlightenment philosopher):

(a) causality is understood in terms of rule-governedness;

(b) **the temporal causal order is irreversible**.

Theoretical probabilistic approaches to causality

Patrick Suppes (1922 –2014; American philosopher—Stanford Univ.):

Definition: *An event* $B_{t'}$ [occurring at time t'] *is a* prima facie *cause of the event* A_t [occurring at time t] *if and only if* (i) $t' < t$, (ii) $P(B_{t'}) > 0$, (iii) $P(A_t | B_{t'}) > P(A_t)$.

Suppes (1970)

Note: The definition is not very useful as, provably **it identifies causality with dependence**: In fact, it says that any two events that are neither synchronous nor independent establish a (*prima facie*) causal relationship.

David Cox (1924 –2022; British statistician—Oxford):

To the above three conditions of the definition, he added a fourth: (iv) *there is no event* $C_{t''}$ *at time* $t'' < t' < t$ *such that* $P(A_t | B_{t'} C_{t''}) = P(A_t | \overline{B}_{t'} C_{t''})$. Cox (1992)

Note: While this addition is certainly a theoretical advance, it is impractical: One **cannot enumerate all events that happened before time** t' and calculate their related conditional probabilities.

Applied probabilistic approaches to causality

Clive Granger (1934 – 2009; British-American econometrician—Univ. Nottingham and Univ. California, San Diego; Nobel in Economics, 2003):

Mostly known for the so-called "**Granger causality test**", based on the linear regression equation $\underline{y}_\tau = \sum_{j=1}^{\eta} a_j \underline{y}_{\tau-j} + \sum_{j=1}^{\eta} b_j \underline{x}_{\tau-j} + \underline{\varepsilon}_\tau$. If the coefficients b_j are nonzero, the interpretation is that the process $\underline{x}_\tau$ causes $\underline{y}_\tau$.

Granger (1969)

Notes: The framework may be problematic, both formally and logically:

- Formally **testing hypotheses in geophysics can be inaccurate (by orders of magnitude)** due to time dependence.
- The test is for **prediction**, which is fundamentally **different** from **causality**.

Judea Pearl (born 1936; Israeli-American computer scientist and philosopher):

He proposed a framework for causality combining probability with **graph theory**.

Pearl (2009); Pearl et al. (2016)

Notes: The framework is problematic, both formally and logically:

- In using conditional probability, **the chain rule is used inappropriately**.
- It is based on the **assumption that we already have a causal graph**—a way of identifying causes.

Our approach to causality

- Our review of approaches to causality over the entire knowledge tree, from philosophy to science and to technological and socio-political application, highlighted the **major unsolved problems**.
- Our method posited a modest objective: To determine **necessary conditions** that are operationally useful in identifying or falsifying causality claims; sufficient conditions are not sought.
- The necessary conditions are useful in two respects:
  - In a **deductive setting**, to falsify a hypothesized causality relationship by showing that it violates the necessary condition.
  - In an **inductive setting**, to add evidence in favour of the plausibility of a causality hypothesis.
- Our method replaces events with **stochastic processes**. It is fully based on stochastics—a superset of probability and statistics, with time playing an essential role.
- The method is based on a reconsideration of the concept of the **impulse response function** (IRF).
- **Real-world data**, namely time series of observations, constitute the only basis of the method.
- Model results and so-called ***in silico experimentation*** **are categorically excluded**. On the contrary, our method provides a test bed to identify whether or not the latter are consistent with reality.
- The general setting of the method is for the ***Hen-Or-Egg*** case, i.e., bidirectional causality, while the unidirectional cases of a ***causal system*** (causality direction according to the hypothesis) or an ***anticausal system*** (causality direction opposite to the hypothesis) are derived as special cases.

Mathematical representation

- Any two stochastic processes $\underline{x}(t)$ and $\underline{y}(t)$ can be related by

$$\underline{y}(t) = \int_{-\infty}^{\infty} g(h)\underline{x}(t-h)\mathrm{d}h + \underline{v}(t)$$

where $g(h)$ is the **Impulse Response Function** (IRF) and $\underline{v}(t)$ is another process uncorrelated to $\underline{x}(t)$.

- There exist infinitely many pairs $(g(h), \underline{v}(t))$ of which we find the least squares solution (LSS): the one minimizing $\mathrm{var}[\underline{v}(t)]$, or maximizing the explained variance $e \coloneqq 1 - \mathrm{var}[\underline{v}(t)]/\mathrm{var}[\underline{y}(t)]$.
- Assuming that the LSS $g(h)$ has been determined, the system $(\underline{x}(t), \underline{y}(t))$ is:

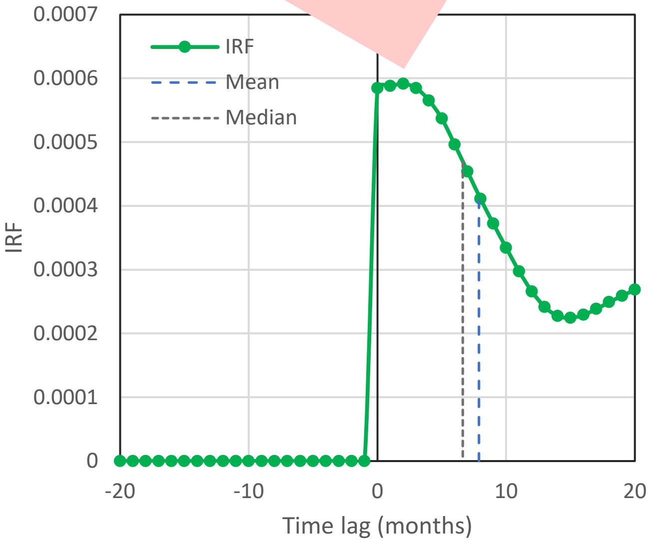
  1. **potentially hen-or-egg (HOE) causal** if $g(h) \neq 0$ for some $h > 0$ and some $h < 0$, while the explained variance is non negligible;
  2. **potentially causal** if $g(h) = 0$ for any $h < 0$, while the explained variance is non negligible;
  3. **potentially anticausal** if $g(h) = 0$ for any $h > 0$, while the explained variance is non negligible (this means that the system $(\underline{y}(t), \underline{x}(t))$ is potentially causal);
  4. **noncausal** if the explained variance is negligible.

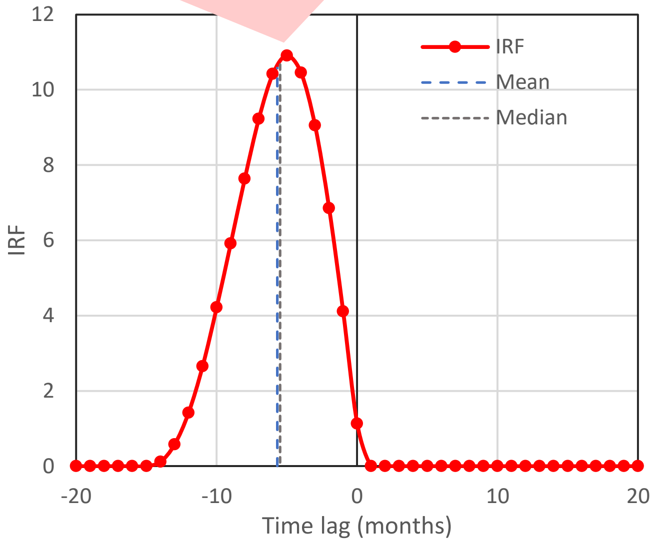
- The framework of causality identification is constructed for case 1, with the other three cases resulting as special cases.

Application to the temperature and [CO_2] relationship

Treating the system (*T*,[CO_2]) as potentially HOE causal, we conclude that it is potentially causal (mono-directional) with explained variance 31%

Treating the system ([CO_2], *T*) as potentially HOE causal, we conclude that it is potentially anticausal (counter-directional) with explained variance 23%





Graph source: Koutsoyiannis et al. (2022b).

Conclusion: The common perception that increasing [CO_2] causes increased *T* **can be excluded** as it violates the necessary condition for this causality direction.

In contrast, the **causality direction *T* → [CO_2] is plausible**.

Further development and application of the framework

The *Sci* (2023) paper extended the approach to **multiple scales** and the application to a longer period covered by instrumental data.

The *MBE* (2024) paper refined the methodology and also used **proxy data covering the entire Phanerozoic**.

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On Hens, Eggs, Temperatures and CO_2: Causal Links in Earth's Atmosphere

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Abstract

The scientific and wider interest in the relationship between atmospheric temperature (*T*) and concentration of carbon dioxide ([CO_2]) has been enormous. According to the commonly assumed causality link, increased [CO_2] causes a rise in *T*. However, recent developments cast doubts on this assumption by showing that this relationship is of the *hen-or-egg* type, or even unidirectional but opposite in direction to the commonly assumed one. These developments include an advanced theoretical framework for testing causality based on the stochastic evaluation of a potentially causal link between two processes via the notion of the impulse response function. Using, on the one hand, this framework and further expanding it and, on the other hand, the longest available modern time series of globally averaged *T* and [CO_2], we shed light on the potential causality between these two processes. All evidence resulting from the analyses suggests a unidirectional, potentially causal link with *T* as the cause and [CO_2] as the effect. That link is not represented in climate models, whose outputs are also examined using the same framework, resulting in a link opposite the one found when the real measurements are used.

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Research article | Special Issues

Stochastic assessment of temperature–CO_2 causal relationship in climate from the Phanerozoic through modern times

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Special Issue: A Commemorative Issue in Honour of Patricia Román Román: Stochastic modeling and forecasting in dynamic systems

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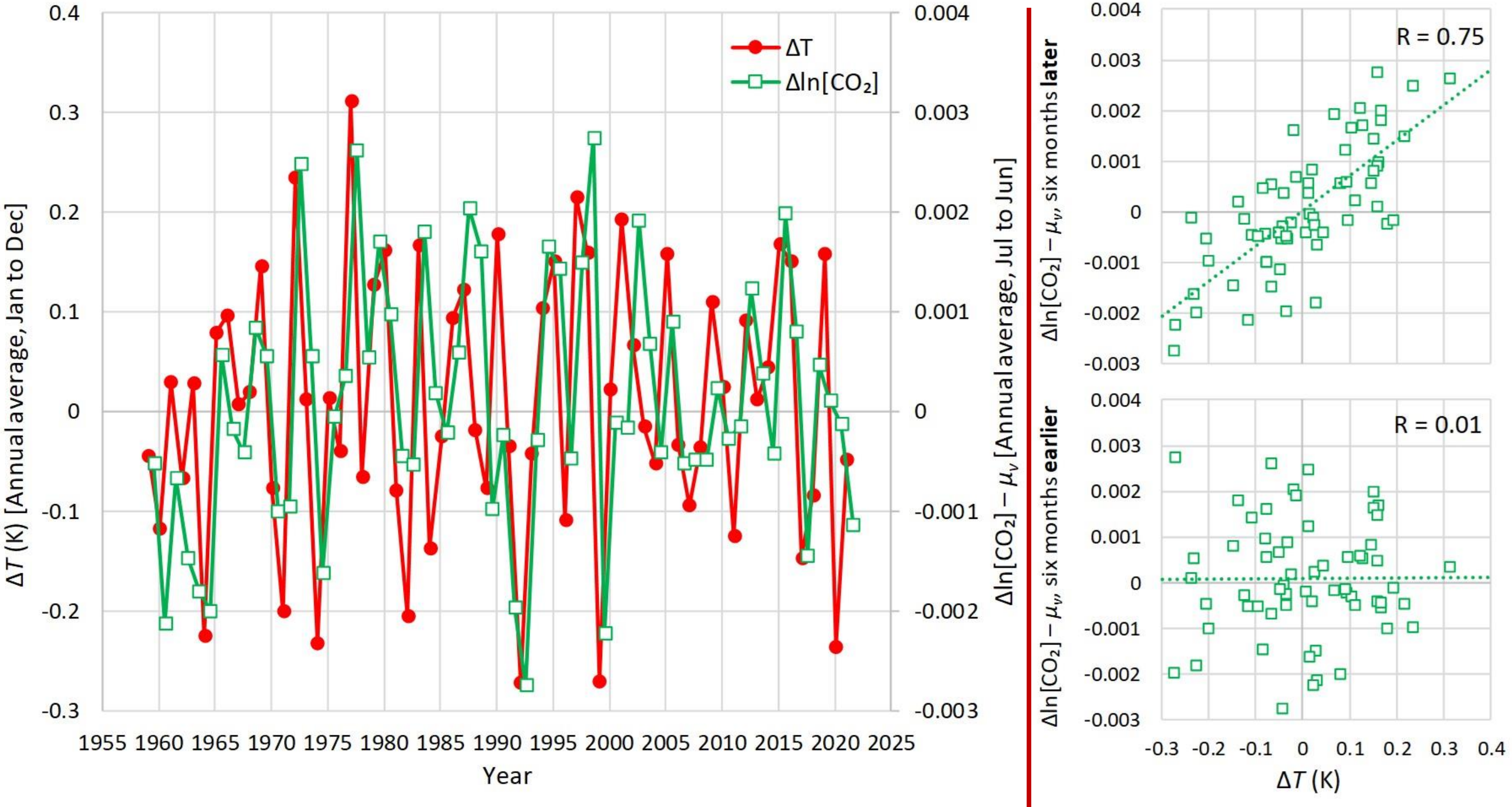
As a result of recent research, a new stochastic methodology of assessing causality was developed. Its application to instrumental measurements of temperature (*T*) and atmospheric carbon dioxide concentration ([CO_2]) over the last seven decades provided evidence for a unidirectional, potentially causal link between *T* as the cause and [CO_2] as the effect. Here, I refine and extend this methodology and apply it to both paleoclimatic proxy data and instrumental data of *T* and [CO_2]. Several proxy series, extending over the Phanerozoic or parts of it, gradually improving in accuracy and temporal resolution up to the modern period of accurate records, are compiled, paired, and analyzed. The extensive analyses made converge to the single inference that change in temperature leads, and that in carbon dioxide concentration lags. This conclusion is valid for both proxy and instrumental data in all time scales and time spans. The time scales examined begin from annual and decadal for the modern period (instrumental data) and the last two millennia (proxy data), and reach one million years for the most sparse time series for the Phanerozoic. The type of causality appears to be unidirectional, $T \rightarrow [CO_2]$, as in earlier studies. The time lags found depend on the time span and time scale and are of the same order of magnitude as the latter. These results contradict the conventional wisdom, according to which the temperature rise is caused by [CO_2] increase.

Quiz: what is (potentially) the cause and what is the effect?

The values plotted are annual averages of differenced time series for differencing time step of 1 year.

Each point represents the time average for a duration of one-year ending at the time of its abscissa.

The two time series are lagged by six months.

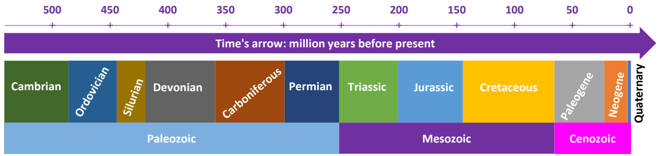
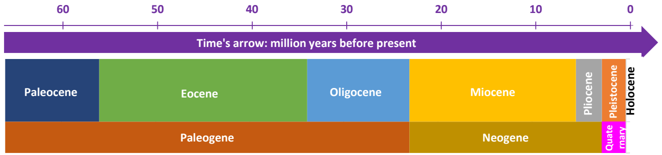
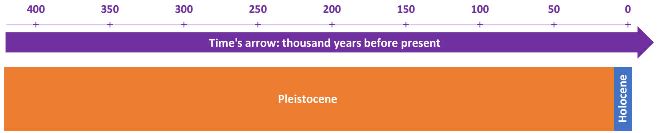
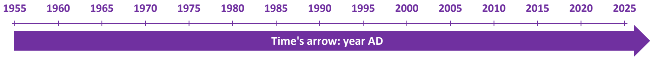


Source: Koutsoyiannis et al. (2023, graphical abstract).

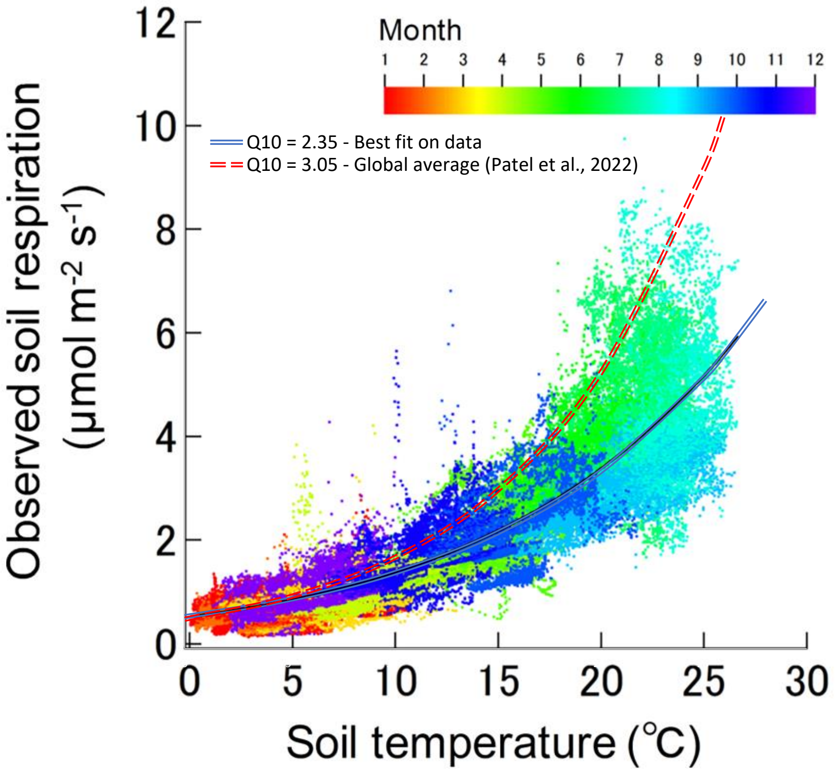
What does it take to tell cause from effect?

“The extensive analyses made converge to the single inference that change in temperature leads, and that in carbon dioxide concentration lags. This conclusion is valid for both proxy and instrumental data in all time scales and time spans.”

Source: Koutsoyiannis (2024b, abstract and graphical abstract).

<table>
<tr><th colspan="4">Summary of time lags (in years) of the $T \rightarrow [CO_2]$ potentially causal relationship
(positive in all cases, meaning that $[CO_2]$ lags behind T change)</th></tr>
<tr><th>Period</th><th></th><th>Analyzed timescale</th><th>Time lags, $h_{1/2}, \mu_h$</th></tr>
<tr><td>Phanerozoic</td><td>
</td><td>10^6</td><td>2.3×10^6, 6.4×10^6</td></tr>
<tr><td>Cenozoic</td><td>
</td><td>10^5</td><td>7.6×10^5, 9.1×10^5</td></tr>
<tr><td rowspan="2">Late Quaternary</td><td rowspan="2">
</td><td>500</td><td>1200, 3300</td></tr>
<tr><td>1000</td><td>1200, 4500</td></tr>
<tr><td rowspan="2">Common Era</td><td rowspan="2">
</td><td>1</td><td>25, 33</td></tr>
<tr><td>10</td><td>26, 33</td></tr>
<tr><td rowspan="2">Modern (instrumental)</td><td rowspan="2">
</td><td>1</td><td>0.6, 0.7</td></tr>
<tr><td>10</td><td>3.2, 3.3</td></tr>
</table>

A note for those who find it hard to believe that a rise in temperature will increase the natural CO_2 emissions



Living organisms love warm conditions and **increase their respiration with temperature exponentially**:

$$R(T) = R(T_0) Q_{10}^{(T-T_0)/10}$$

(Q_{10}: dimensionless parameter).

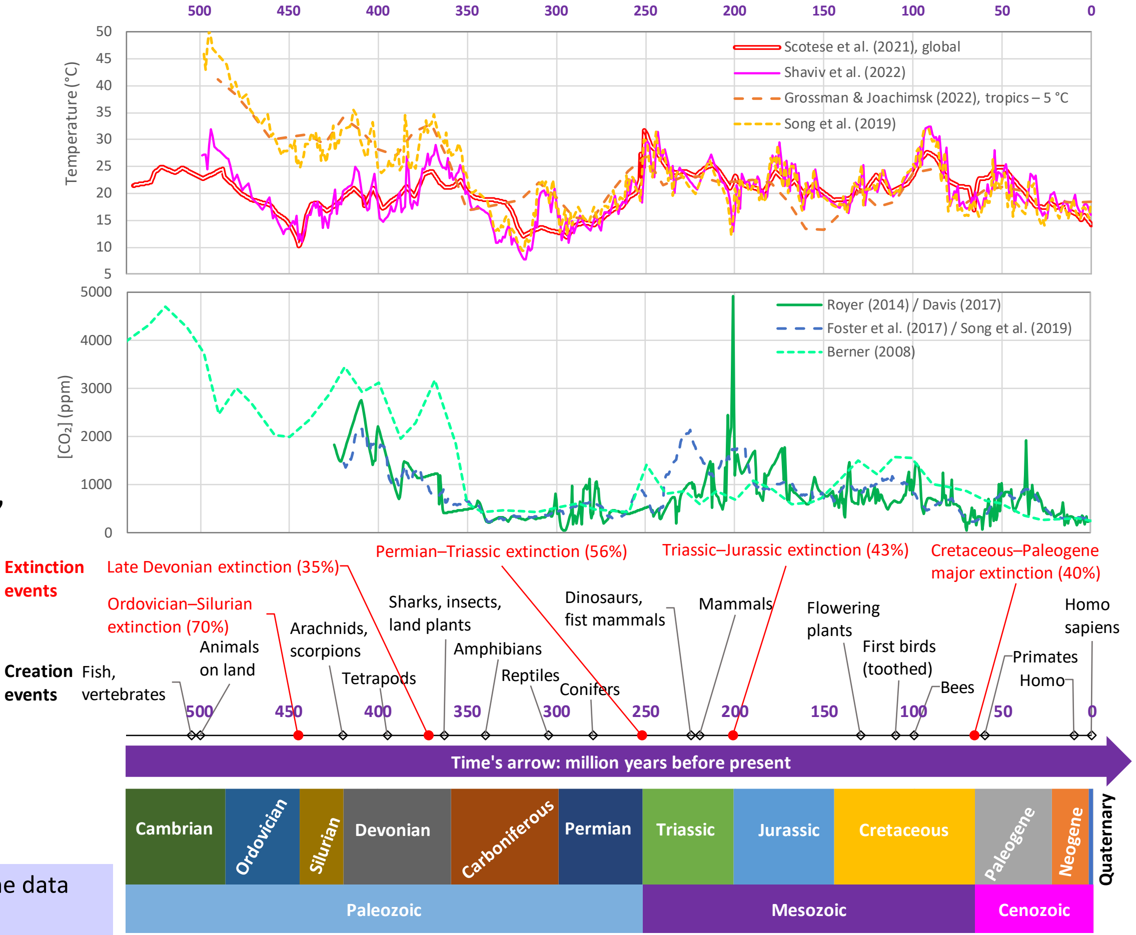
Graph with soil respiration and temperature data during 2005-10 in a temperate evergreen coniferous forest area in Japan, adapted from Makita et al. (2018).

Global average Q_{10} value from Patel et al. (2022).

Photo from Moore et al. (2021)

A note on paleoclimatic data

- Temperature range could have been as high as 40 °C.
- [CO_2] range appears to be **higher than an order of magnitude**.
- In general [CO_2] changes followed those of temperature, but there were periods of antithesis or decoupling.
- **The role of the evolving biosphere must have been dominant.**



Source: Koutsoyiannis (2024b), in which the origin of the data series can be found.

Investigation of assumed causal link “c”: Are there climate impacts, or ultimately, do human CO_2 emissions affect everything?

- IPCC and climate zealots reply: **Yes**
- (Mainstream) “sceptics” reply: **No**
- I reply: **No**

The relative importance of CO_2 as a greenhouse gas

The relative importance of CO_2 as a greenhouse gas is **inferred by comparison with H_2O**.

The paper on the left is based **only on ground data**.

The paper on the right is based on **satellite data (CERES)** and model **simulations of infrared radiation (MODTRAN)**.

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Hydrological Sciences Journal >
Volume 69, 2024 - Issue 2

Research Article

Revisiting the greenhouse effect – a hydrological perspective

Demetris Koutsoyiannis & Christos Vournas

Pages 151-164 | Received 01 Sep 2023, Accepted 09 Nov 2023, Published online: 22 Dec 2023

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ABSTRACT

Quantification of the greenhouse effect is a routine procedure in the framework of hydrological calculations of evaporation. According to the standard practice, this is made considering the water vapour in the atmosphere, without any reference to the concentration of carbon dioxide (CO_2), which, however, in the last century has increased from 300 to about 420 ppm. As the formulae used for the greenhouse effect quantification were introduced 50–90 years ago, we examine whether these are still representative or not, based on eight sets of observations, distributed across a century. We conclude that the observed increase of the atmospheric CO_2 concentration has not altered, in a discernible manner, the greenhouse effect, which remains dominated by the quantity of water vapour in the atmosphere, and that the original formulae used in hydrological practice remain valid. Hence, there is no need for adaptation of the original formulae due to increased CO_2 concentration.

SCIENCE OF CLIMATE CHANGE | EDITORIAL BOARD | SUBMISSION GUIDELINES

Demetris Koutsoyiannis: Relative importance of carbon dioxide and water in the greenhouse effect: Does the tail wag the dog?

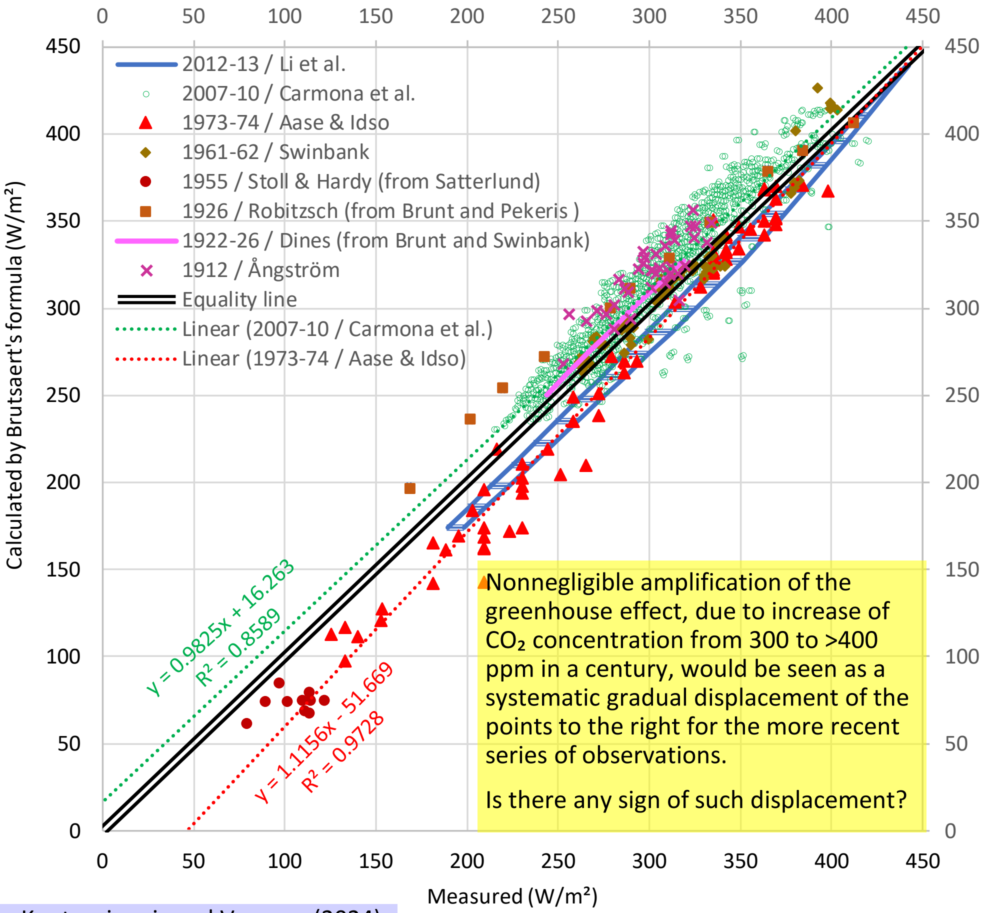
JAN / 5 NOVEMBER, 2024 / ARTICLES, NEWS, PAPERS, RECENT PAPERS

Using a detailed atmospheric radiative transfer model, we derive macroscopic relationships of downwelling and outgoing longwave radiation which enable determining the partial derivatives thereof with respect to the explanatory variables that represent the greenhouse gases. We validate these macroscopic relationships using empirical formulae based on downwelling radiation data, commonly used in hydrology, and satellite data for the outgoing radiation. We use the relationships and their partial derivatives to infer the relative importance of carbon dioxide and water vapour in the greenhouse effect. The results show that the contribution of the former is 4% – 5%, while water and clouds dominate with a contribution of 87% – 95%. The minor effect of carbon dioxide is confirmed by the small, non-discernible effect of the recent escalation of atmospheric CO_2 concentration from 300 to 420 ppm. This effect is quantified at 0.5% for both downwelling and outgoing radiation. Water and clouds also perform other important functions in climate, such as regulating heat storage and albedo, as well as cooling the Earth's surface through latent heat transfer, contributing 50%. By confirming the major role of water on climate, these results suggest that hydrology should have a more prominent and more active role in climate research.

Read more here. You find supplementary data here

What does a century of ground data say?

- While "climate science" babbles on about CO_2 as the determinant greenhouse gas, **hydrology has routinely quantified the greenhouse effect for 70 years.**
- This is necessary in **evaporation calculations** and the related formulae are based on data of atmospheric moisture.
- The paper is based on a **century-long collection of data on downwelling longwave radiation** at the surface.
- The analysis of this data set shows that there is **no discernible effect on the greenhouse intensity**, despite the increase of atmospheric [CO_2] from 300 to >400 ppm in a century.



Source: Koutsoyiannis and Vournas (2024).

The innovation of the *SCC* (2024) paper: Macroscopic relationships

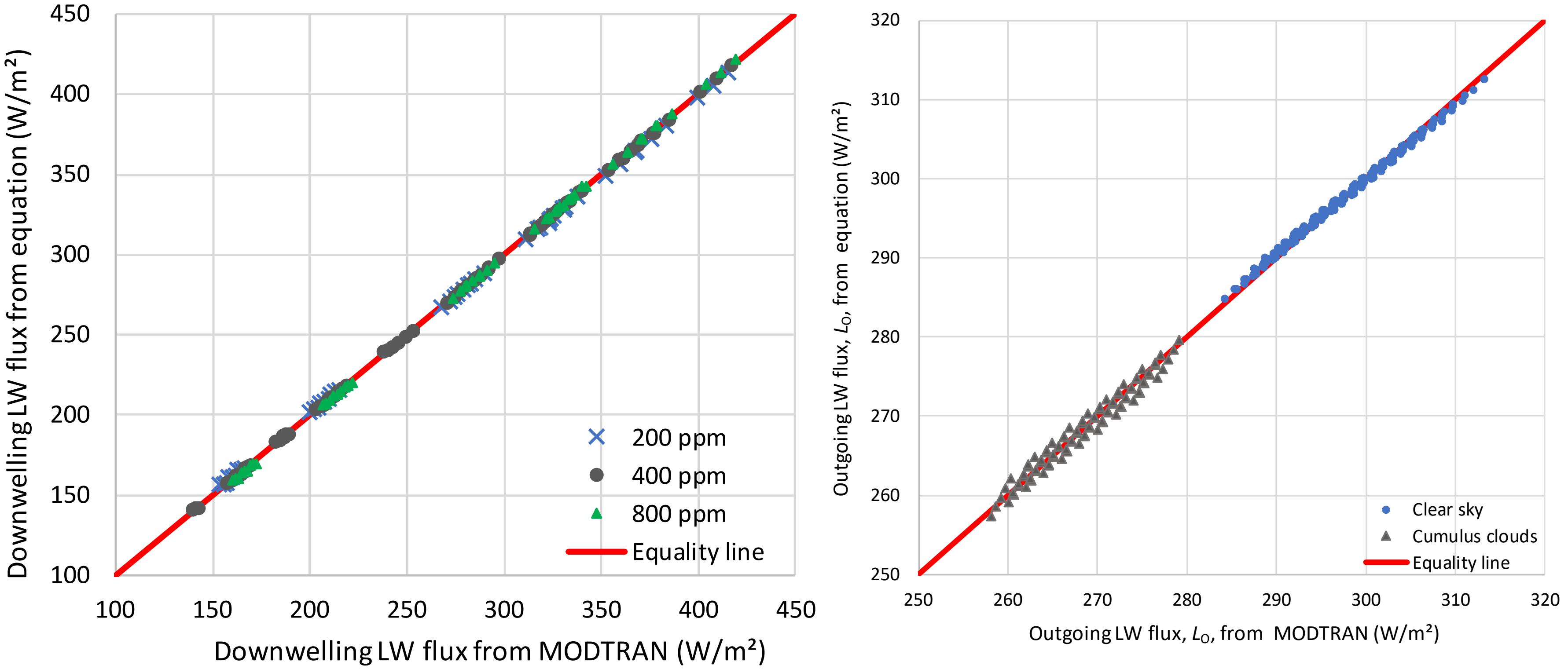
- **Basic relationship constructed from MODTRAN results and CERES data**:

$$L_{\mathrm{D,O}} = L^* \left(1 + \left(\frac{T}{T^*}\right)^{\eta_T} \pm \left(\frac{e_\mathrm{a}}{e_\mathrm{a}^*}\right)^{\eta_e}\right)\left(1 \pm a_{\mathrm{CO_2}} \ln \frac{[\mathrm{CO_2}]}{[\mathrm{CO_2}]_0}\right)(1 \pm a_C C)$$

  - $L_{\mathrm{D,O}}$: downwelling (D) and outgoing (O) longwave radiation flux;
  - T: temperature near the ground level;
  - e_a: water vapour pressure near the ground level;
  - $[\mathrm{CO_2}]$: atmospheric $\mathrm{CO_2}$ concentration with $[\mathrm{CO_2}]_0$ = 400 ppm.
  - C: cloud area fraction;
  - L^*, T^*, e_a^* dimensional parameters, with units [*L*], [*T*], and [e_a], respectively;
  - η_T, η_e, $a_{\mathrm{CO_2}}$, a_C: dimensionless parameters.
- The parameter values are optimized based on clear-sky MODTRAN results, except a_C, which has estimated from CERES satellite data.
- **Application to find the relative importance of each of the factors** $F_i \in \{T, e_\mathrm{a}, [\mathrm{CO_2}], C\}$:

$$\mathrm{d}(\ln L) = \frac{\mathrm{d}L}{L} = \sum_i \frac{\partial L}{\partial F_i}\frac{F_i}{L}\frac{\mathrm{d}F_i}{F_i} = \sum_i L_{F_i}^{\#}\frac{\mathrm{d}F_i}{F_i} = \sum_i L_{F_i}^{\#}\,\mathrm{d}\ln F_i\,, \qquad L_{F_i}^{\#} := \frac{\partial \ln L}{\partial \ln F_i} = \frac{\partial L}{\partial F_i}\frac{F_i}{L}$$

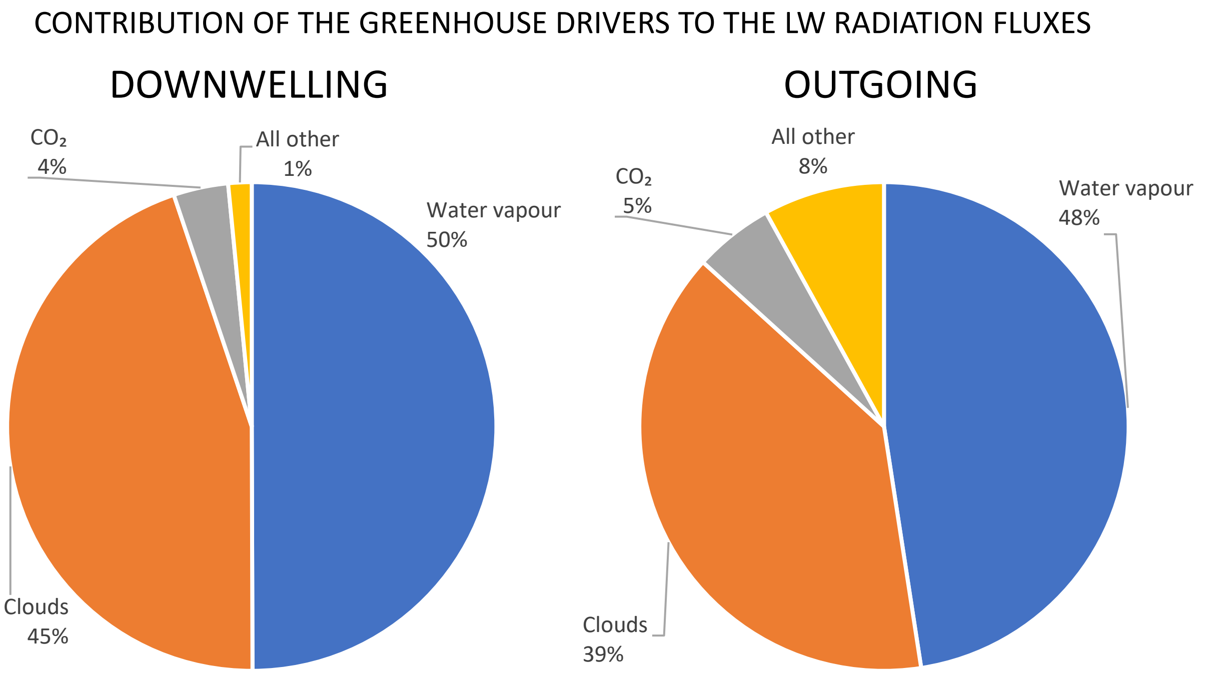
Comparison of macroscopic relationship with MODTRAN results: Perfect agreement



Source of graphs: Koutsoyiannis (2024e).

Quantification of relevant importance of greenhouse drivers

- The study was based on the standard theory and an established model of radiation in the atmosphere (MODTRAN), as well as on satellite radiation data.
- The chart on the left explains the findings of the *HSJ* paper: **there could be no discernible effect of the [CO_2]** increase in a century on the **downwelling** LW radiation.
- The chart on the right suggests that **the same** should have been the case (macroscopically) with the **outgoing LW** radiation (if data existed).



Source of graph: Koutsoyiannis (2024e).

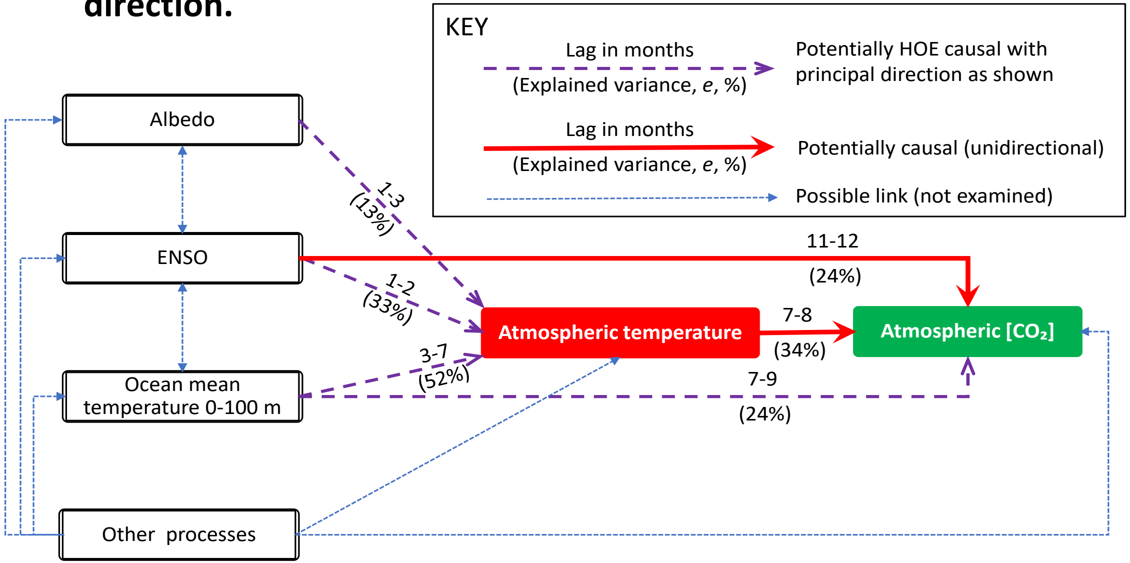
If the cause is not [CO_2], what might have caused the recent increase in atmospheric temperature?

Additional questions instead of an answer:

1. Should we expect the temperature to be stable?
2. Do complex dynamical systems **need external agents** to change their state?*
3. **What caused a cause**?
4. Have the huge changes in global temperature during the Phanerozoic (possibly up to 40°C) been explained?

Koutsoyiannis et al. (2023) examined some possible mechanisms of change, **internal to the climatic system**, as shown in the graph.

Schematic of possible causal links in the climatic system, with noted types of potential causality, unidirectional or HOE, and its direction.



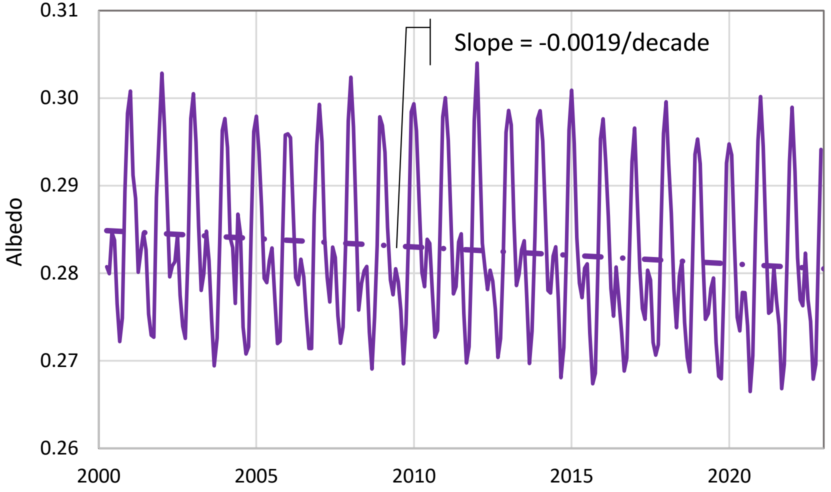
*For an answer to Question 2 see Koutsoyiannis (2006, 2010, 2013).

Source of graph: Koutsoyiannis et al. (2023).

The albedo change and the relevance of water/hydrology

TOA albedo time series (continuous line) from NASA's CERES data set, along with linear trend (dashed line).

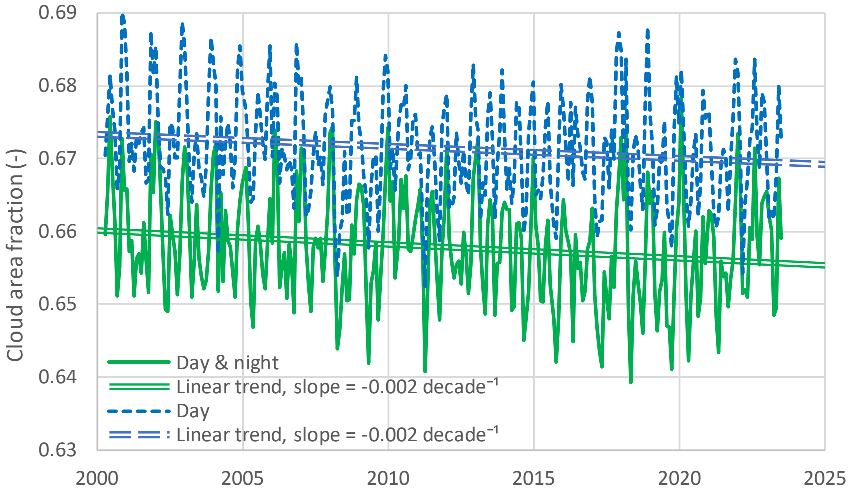
For the entire period, the decline of the albedo is about 0.004, which translates to 1.4 W/m^2, **greater than the average imbalance** (net absorbed energy) of the Earth, which, if calculated from the ocean heat content data, is about 0.4 W/m^2 (Koutsoyiannis, 2021).



Source of graph: Koutsoyiannis et al. (2023).

Total cloud area fraction (single lines) from NASA's CERES data set, along with linear trends (double lines).

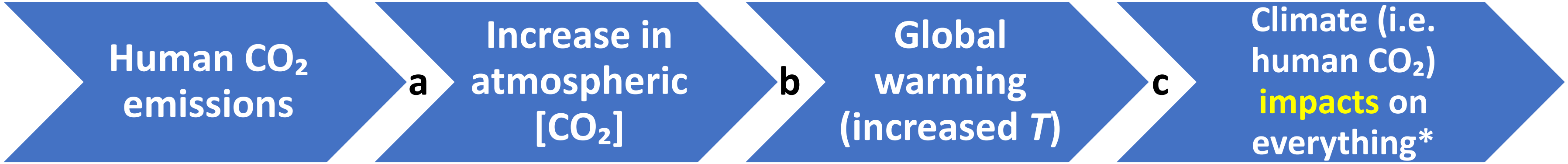
The decline in cloud area fraction is consistent with the observed decline of the albedo. This does not enable predictability. Rather, it raises additional questions, e.g., what caused the decline in clouds? Yet it **highlights the importance of H_2O and the insignificance of CO_2.**



Source of graph: Koutsoyiannis and Vournas (2024).

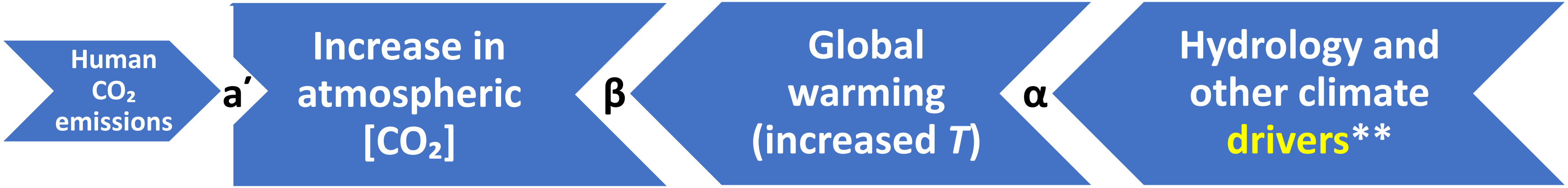
The inversion of causal chain

Mainstream but implausible causal chain (for the kindergarten):



*from hydrology to kidney stones

Proposed causal chain (for adults):



**kidney stones excluded

Causal links “a′” and “β” are estimated to contribute to the [CO_2] increase at percentages of 17% and 83%, respectively (Koutsoyiannis (2024f).

Final remarks

- The foundation of the modern climate edifice is afflicted by erroneous assumptions and speculations.
- The causal chain promoted by mainstream science is naïve and wrong.
- In scientific terms, the case of the magnified importance of CO_2, the focus on human emissions thereof, and the neglect of the ~25 times greater natural CO_2 emissions constitute a historical accident.
- This accident was exploited in non-scientific (politico-economic) terms—mostly dark ones.
- For complex systems, observational data are the only scientific test bed for making hypotheses and assessing their validity.
- The real-world data do not agree with the “mainstream science” (a euphemism for sophistry).
- The results I have presented are scientific and therefore may not be relevant to the climate narrative, which has a non-scientific aim.

References

Cox, D.R., 1992. Causality: Some statistical aspects. *J. Roy. Stat. Soc. A* 155 (2), 291-301.

Granger, C.W., 1969. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, 37(3), 424-438.

IEA (International Energy Agency), 2020. *Global Energy Review 2020*. IEA: Paris, French,. https://www.iea.org/reports/global-energy-review-2020.

IPCC (Intergovernmental Panel on Climate Change), 2013. *Climate Change 2013: The Physical Science Basis*. Contribution of Working Group I to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex V., Midgley, P.M., Eds.]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp. 2013.

IPCC (Intergovernmental Panel on Climate Change),, 2021. *Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report (AR6_ of the Intergovernmental Panel on Climate Change; Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, doi: 10.1017/9781009157896.

Joos, F., Roth, R., Fuglestvedt, J.S., et al., 2013. Carbon dioxide and climate impulse response functions for the computation of greenhouse gas metrics: a multi-model analysis. *Atmos. Chem. Phys.*, 13, 2793–2825, doi: 10.5194/acp-13-2793-2013.

Koutsoyiannis, D., 2006. A toy model of climatic variability with scaling behaviour, *Journal of Hydrology*, 322, 25–48, doi: 10.1016/j.jhydrol.2005.02.030.

Koutsoyiannis, D., 2010. A random walk on water, *Hydrology and Earth System Sciences*, 14, 585–601, doi: 10.5194/hess-14-585-2010.

Koutsoyiannis, D., 2013. Hydrology and Change, *Hydrological Sciences Journal*, 58 (6), 1177–1197, doi: 10.1080/02626667.2013.804626. Koutsoyiannis, D., 2021. Rethinking climate, climate change, and their relationship with water, *Water*, 13 (6), 849, doi :10.3390/w13060849.

Koutsoyiannis, D., 2024a. Net isotopic signature of atmospheric CO_2 sources and sinks: No change since the Little Ice Age, *Sci*, 6 (1), 17, doi: 10.3390/sci6010017.

Koutsoyiannis, D., 2024b. Stochastic assessment of temperature – CO_2 causal relationship in climate from the Phanerozoic through modern times, *Mathematical Biosciences and Engineering*, 21 (7), 6560–6602, doi: 10.3934/mbe.2024287.

Koutsoyiannis, D., 2024c. Refined reservoir routing (RRR) and its application to atmospheric carbon dioxide balance, *Water*, 16 (17), 2402, doi: 10.3390/w16172402.

Koutsoyiannis, D., 2024d. Definite change since the formation of the Earth [Reply to Kleber, A. Comment on “Koutsoyiannis, D. Net isotopic signature of atmospheric CO2 sources and sinks: No change since the Little Ice Age. Sci 2024, 6, 17”], *Sci*, 6 (4), 63, doi:10.3390/sci6040063.

Koutsoyiannis, D. 2024e. Relative importance of carbon dioxide and water in the greenhouse effect: Does the tail wag the dog?, *Science of Climate Change*, 4 (2), 36–78, doi: 10.53234/scc202411/01.

References (2)

Koutsoyiannis, D. 2024f. The superiority of refined reservoir routing (RRR) in modelling atmospheric carbon dioxide, ResearchGate, https://www.researchgate.net/publication/384868011.

Koutsoyiannis, D., and Kundzewicz, Z.W., 2020. Atmospheric temperature and CO_2: Hen-or-egg causality?, *Sci*, 2 (4), 83, doi: 10.3390/sci2040083.

Koutsoyiannis, D., and Vournas, C. , 2024. Revisiting the greenhouse effect—a hydrological perspective, *Hydrological Sciences Journal*, 69 (2), 151–164, doi:10.1080/02626667.2023.2287047 .

Koutsoyiannis, D., Onof, C., Christofides, A., and Kundzewicz, Z.W., 2022a. Revisiting causality using stochastics: 1. Theory, *Proceedings of The Royal Society A*, 478 (2261), 20210835, doi: 10.1098/rspa.2021.0835.

Koutsoyiannis, D., Onof, C., Christofides, A., and Kundzewicz, Z.W., 2022b. Revisiting causality using stochastics: 2. Applications, *Proceedings of The Royal Society A*, 478 (2261), 20210836, doi: 10.1098/rspa.2021.0836.

Koutsoyiannis, D., Onof, C., Kundzewicz, Z.W., and Christofides, A., 2023. On hens, eggs, temperatures and CO_2: Causal links in Earth's atmosphere, *Sci*, 5 (3), 35, doi:10.3390/sci5030035.

Lai, J., Kooijmans, L.M., Sun, W., Lombardozzi, D., Campbell, J.E., Gu, L., Luo, Y., Kuai, L. and Sun, Y., 2024. Terrestrial photosynthesis inferred from plant carbonyl sulfide uptake. *Nature*, 634, 855–861.

Makita, N., Kosugi, Y., Sakabe, A., Kanazawa, A., Ohkubo, S., and Tani, M., 2018. Seasonal and diurnal patterns of soil respiration in an evergreen coniferous forest: Evidence from six years of observation with automatic chambers. *PLoS ONE*, 13 (2), e0192622, doi: 10.1371/journal.pone.0192622.

Moore, D., Heilweck, M. and Petros, P., 2021. Saving the planet with appropriate biotechnology: 1. Diagnosing the problems. *Mexican Journal of Biotechnology*, 6 (1), 1-3, https://www.researchgate.net/publication/347563973.

Patel, K.F., Bond-Lamberty, B., Jian, J., Morris, K.A., McKever, S.A., Norris, C.G., Zheng, J., Bailey, V.L., 2022. Carbon flux estimates are sensitive to data source: a comparison of field and lab temperature sensitivity data. *Environmental Research Letters*, 17 (11), 113003.

Pearl, J. 2009. Causal inference in statistics: An overview. *Statistics Surveys*, 3, 96-146, doi: 10.1214/09-SS057.

Pearl, J., Glymour, M., and Jewell, N.P., 2016. *Causal Inference in Statistics: A Primer*. Wiley, Chichester, UK.

Suess, H.E., 1955. Radiocarbon concentration in modern wood. *Science*, 122, 415–417.

Suppes, P., 1970. *A Probabilistic Theory of Causality.* North-Holland Publishing, Amsterdam, The Netherlands.

Trumbore, S.E., and Druffel, E.R.M., 1995. Carbon isotopes for characterizing sources and turnover of nonliving organic matter. In R. G. Zepp, & C. Sonntag (Eds.), *Role of Nonliving Organic Matter in the Earth's Carbon Cycle*, pp. 7-22, John Wiley & Sons Ltd, Chichester. https://books.google.gr/books?id=GtfKG8XVyqkC.