International conference: Beyond the Climate Change Consensus
Grand Hall of the Hungarian Academy of Sciences, Budapest
8 December 2025

H_2O, CO_2, Climate Change

A holistic refutation of "climate science"

Demetris Koutsoyiannis
Department of Water Resources and Environmental Engineering
School of Civil Engineering, National Technical University of Athens
(dk@ntua.gr, http://itia.ntua.gr/dk/)

Available online: http://www.itia.ntua.gr/2573/

Telltale signs that “climate science” is not science

- **Mixing** of scientific knowledge with **politics**.
- **Hostility** towards scientific **dialogue**.
- Endless predictions of **catastrophes** that are almost always proven wrong.
- Promotion of the idea of **world salvation**.
- Promotion of **ambiguity and inaccuracy**.
- Appeal to **consensus**.
- **Censorship and silencing** of dissenting voices.
- Labelling of dissenting scientific opinion as “**denialism**” and of those expressing them as “**deniers**”.
- Reversal of **cause and effect**.
- Preference of **model outputs** to observational data.
- Discrimination in **research funding** and banning of non-conforming ideas.
- Laughable “scientific” studies to instil fear of various **fanciful climate impacts** (e.g. kidney stones).

“The climate change scam is so stupid, cruel and obvious [that] anyone promoting it is viewed by the sensible as either corrupt or stupid and probably both.”

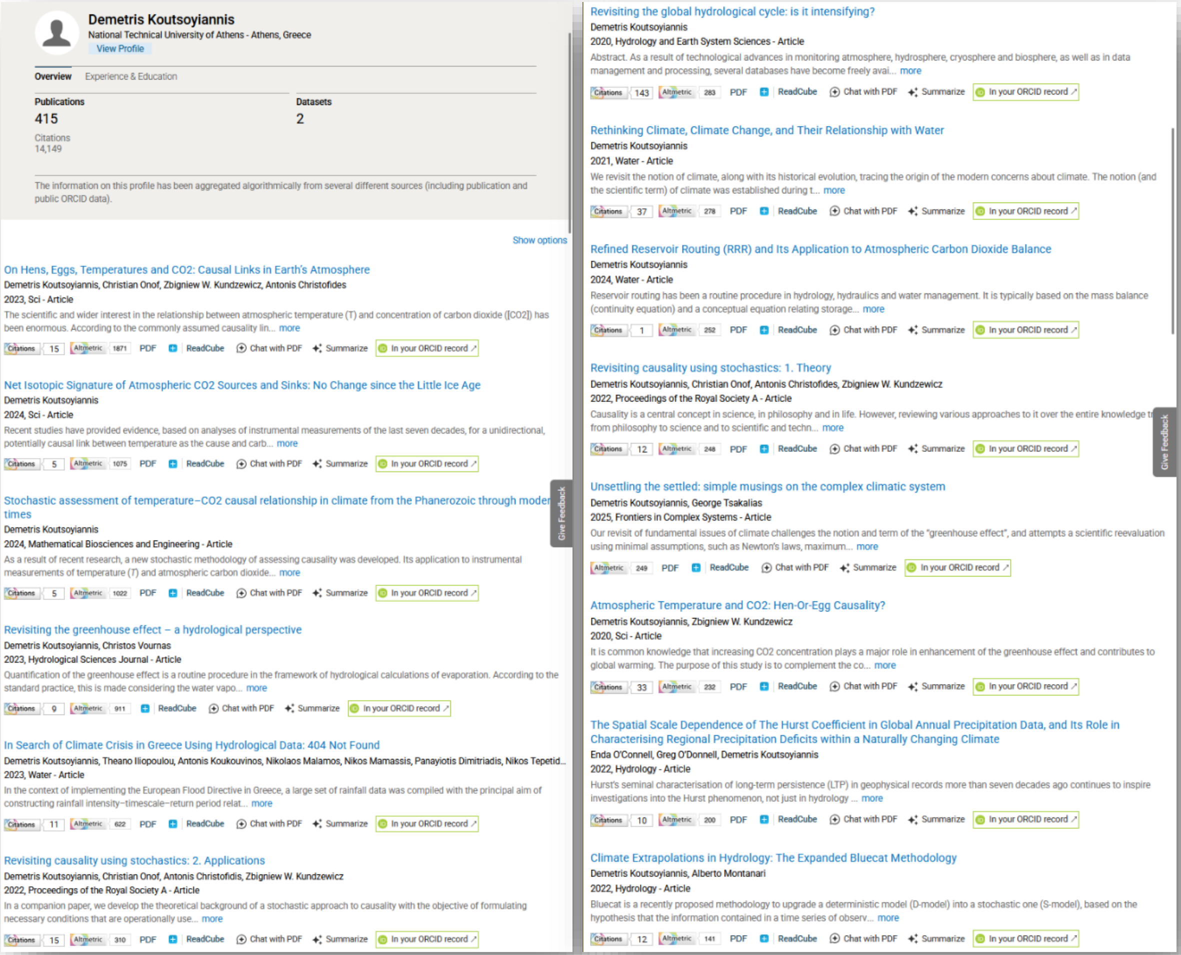
Elizabeth Nickson, https://elizabethnickson.substack.com/p/our-revulsion-has-created-a-new-populist

Some striking examples of misguidance

- Ambiguous language and replacement of scientific terminology with **political slogans**.
  - This includes fundamental notions, such as "**climate change**" (as if climate has ever been unchanging) and "**greenhouse effect**" (as if the atmosphere resembles a greenhouse).
- Downgrade in the **importance of H_2O** and clouds in climate.
- Elevation of **minor agents** in climatic processes — **mostly of CO_2** as the climate control knob.
- Avoidance of stating **time lags** for atmospheric CO_2.
- Construction of **fallacious conceptions**, such as:
  - The dependence of the CO_2 behaviour on its origin, with anthropogenic CO_2 staying longer in the atmosphere.
  - The "Suess effect".
- Use of a blatantly **erroneous response function** of atmospheric CO_2.
- Neglect of **natural CO_2** dynamics.

My recent climate research…

- … is documented in **14 peer-reviewed journal papers** in the last 5 years (+ 1 book + 2 booklets + replies to commentaries + preprints).
- Excepting one (#5), they received **no funding** but were conducted out of scientific curiosity.
- Most of them have been among the top-visited papers of the respective journals.
- Their high altmetric scores show that all were **heavily discussed** in media (blogs, X, news, etc.).
- All **withstood well** post-publication criticisms (mostly by “sceptics” ☺).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On Hens, Eggs, Temperatures and CO2: Causal Links in Earth's Atmosphere
Demetris Koutsoyiannis, Christian Onof, Zbigniew W. Kundzewicz, Antonis Christofides
2023, Sci - Article
The scientific and wider interest in the relationship between atmospheric temperature (T) and concentration of carbon dioxide ([CO2]) has been enormous. According to the commonly assumed causality lin... more
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Net Isotopic Signature of Atmospheric CO2 Sources and Sinks: No Change since the Little Ice Age
Demetris Koutsoyiannis
2024, Sci - Article
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 carb... more
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Stochastic assessment of temperature–CO2 causal relationship in climate from the Phanerozoic through modern times
Demetris Koutsoyiannis
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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... more
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Revisiting the greenhouse effect – a hydrological perspective
Demetris Koutsoyiannis, Christos Vournas
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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 vapo... more
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In Search of Climate Crisis in Greece Using Hydrological Data: 404 Not Found
Demetris Koutsoyiannis, Theano Iliopoulou, Antonis Koukouvinos, Nikolaos Malamos, Nikos Mamassis, Panayiotis Dimitriadis, Nikos Tepetid...
2023, Water - Article
In the context of implementing the European Flood Directive in Greece, a large set of rainfall data was compiled with the principal aim of constructing rainfall intensity–timescale–return period relat... more
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Revisiting causality using stochastics: 2. Applications
Demetris Koutsoyiannis, Christian Onof, Antonis Christofidis, Zbigniew W. Kundzewicz
2022, Proceedings of the Royal Society A - Article
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 use... more
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Revisiting the global hydrological cycle: is it intensifying?
Demetris Koutsoyiannis
2020, Hydrology and Earth System Sciences - Article
Abstract. As a result of technological advances in monitoring atmosphere, hydrosphere, cryosphere and biosphere, as well as in data management and processing, several databases have become freely avai... more
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Rethinking Climate, Climate Change, and Their Relationship with Water
Demetris Koutsoyiannis
2021, Water - Article
We revisit the notion of climate, along with its historical evolution, tracing the origin of the modern concerns about climate. The notion (and the scientific term) of climate was established during t... more
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Refined Reservoir Routing (RRR) and Its Application to Atmospheric Carbon Dioxide Balance
Demetris Koutsoyiannis
2024, Water - Article
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... more
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Revisiting causality using stochastics: 1. Theory
Demetris Koutsoyiannis, Christian Onof, Antonis Christofides, Zbigniew W. Kundzewicz
2022, Proceedings of the Royal Society A - Article
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 techn... more
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Unsettling the settled: simple musings on the complex climatic system
Demetris Koutsoyiannis, George Tsakalias
2025, Frontiers in Complex Systems - Article
Our revisit of fundamental issues of climate challenges the notion and term of the “greenhouse effect”, and attempts a scientific reevaluation using minimal assumptions, such as Newton's laws, maximum... more
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Atmospheric Temperature and CO2: Hen-Or-Egg Causality?
Demetris Koutsoyiannis, Zbigniew W. Kundzewicz
2020, Sci - Article
It is common knowledge that increasing CO2 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 co... more
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The Spatial Scale Dependence of The Hurst Coefficient in Global Annual Precipitation Data, and Its Role in Characterising Regional Precipitation Deficits within a Naturally Changing Climate
Enda O'Connell, Greg O'Donnell, Demetris Koutsoyiannis
2022, Hydrology - Article
Hurst's seminal characterisation of long-term persistence (LTP) in geophysical records more than seven decades ago continues to inspire investigations into the Hurst phenomenon, not just in hydrology ... more
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Climate Extrapolations in Hydrology: The Expanded Bluecat Methodology
Demetris Koutsoyiannis, Alberto Montanari
2022, Hydrology - Article
Bluecat is a recently proposed methodology to upgrade a deterministic model (D-model) into a stochastic one (S-model), based on the hypothesis that the information contained in a time series of observ... more
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My climate decalogue: Main results of my recent research

1. **Climate change is real** —and climate crisis too (but only in politics).
   - Climate change has been real throughout Earth's entire 4.5-billion-year history.
   - Climate crisis is a purely political issue, with no relationship to the real world.
2. There is **no greenhouse effect** (GHE), nor greenhouse gases (GHG), in the atmosphere.
   - These are misleading terms, whose real meanings are "atmospheric radiation effect" (ARE) and "radiatively active gas" (RAG), respectively.
3. The ARE mostly depends on the **temperature gradient** in the atmosphere.
   - At the equilibrium (an isothermal atmosphere) the ARE is zero.
   - In case of temperature inversion, the ARE results in cooling, not warming of the Earth.
4. In the standard atmosphere (with gradient of 6.5 K/km) the **ARE is dominated by H_2O** (water vapour and clouds).
   - CO_2 is playing a very minor role (quantified at 4-5%).
5. The **century-long observations** of longwave (LW) radiation show **no change in the ARE**.
   - The substantial increase of atmospheric [CO_2] did not give a discernible signal.

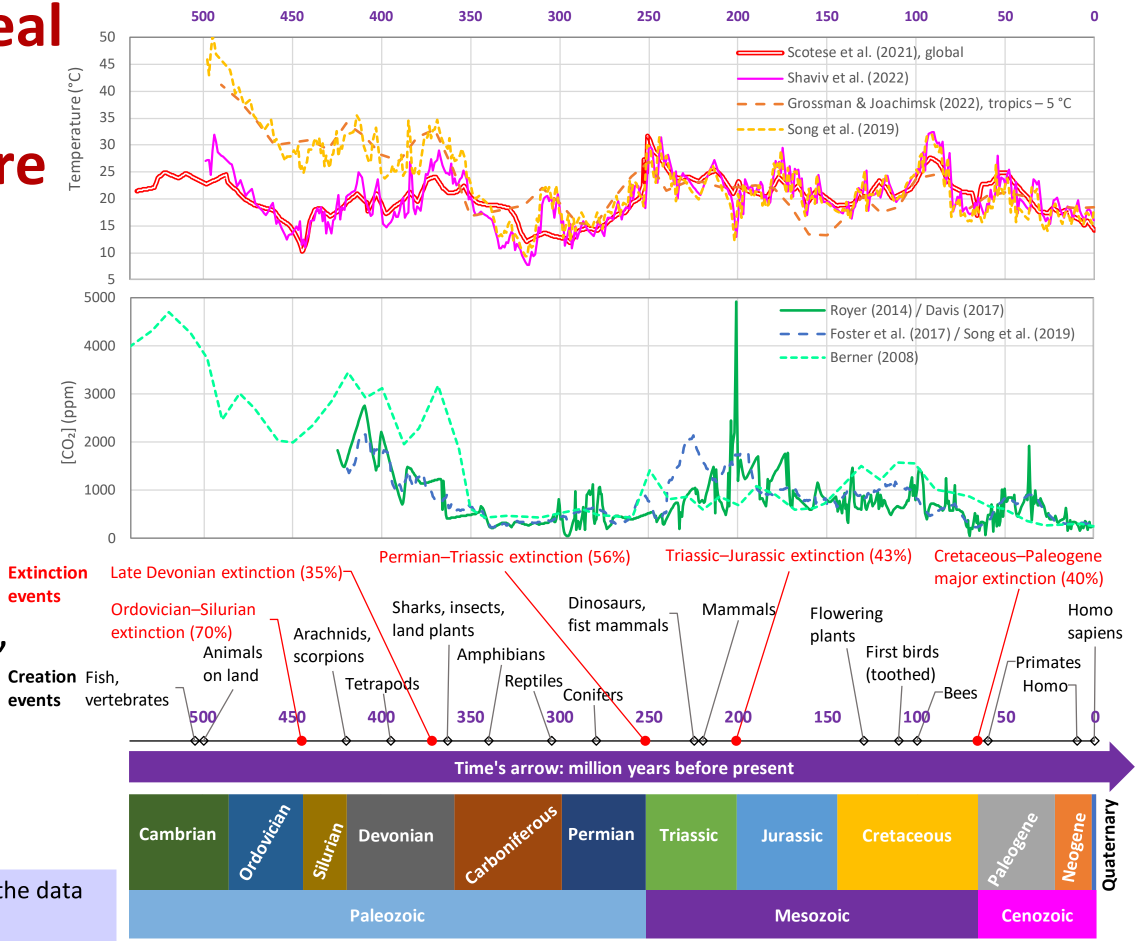
My climate decalogue: Main results of my recent research (2)

6. There is **no proof** that the increase of atmospheric **[CO_2] causes temperature increase**.
   - On the contrary, paleoclimatic and modern observational data support the reverse causality as the increase of temperature happens before that of [CO_2].
   - Climate models suggest a causality direction opposite from that seen in the data.
7. The carbon balance in the atmosphere is **dominated by natural processes**.
   - Human CO_2 emissions (by burning fossil fuels etc.) are only 4% of the total.
   - The increase of temperature resulted in substantial increase of natural CO_2 emissions.
8. The **isotopic carbon data** ($\delta^{13}C$, $\Delta^{14}C$) show changes in the isotopic synthesis of atmospheric CO_2, but **no sign of human influence**.
   - They show that the changes seen are driven by natural processes.
9. The dynamics of atmospheric CO_2 can be recovered from **natural processes only**.
   - Multiple evidence confirms a residence time of atmospheric CO_2 at 4 years, despite “climate science” longer estimates reaching thousands of years.
10. Temperature increase in the 21st century is **consistent with changes in the solar (shortwave—SW) radiation** absorbed by the Earth.

#1a Climate change is real and has been so throughout Earth's entire 4.5-billion-year history

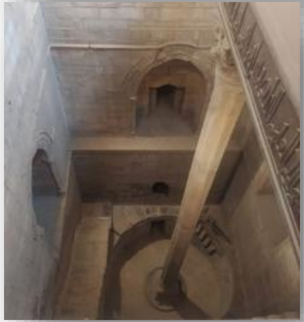
- Temperature range could have been as high as 40 °C.
- [CO_2] range appears to be **higher than an order of magnitude**.
- In general [CO_2] changes followed those of temperature, but there were periods of antithesis or decoupling.
- **The role of the evolving biosphere has been dominant.**

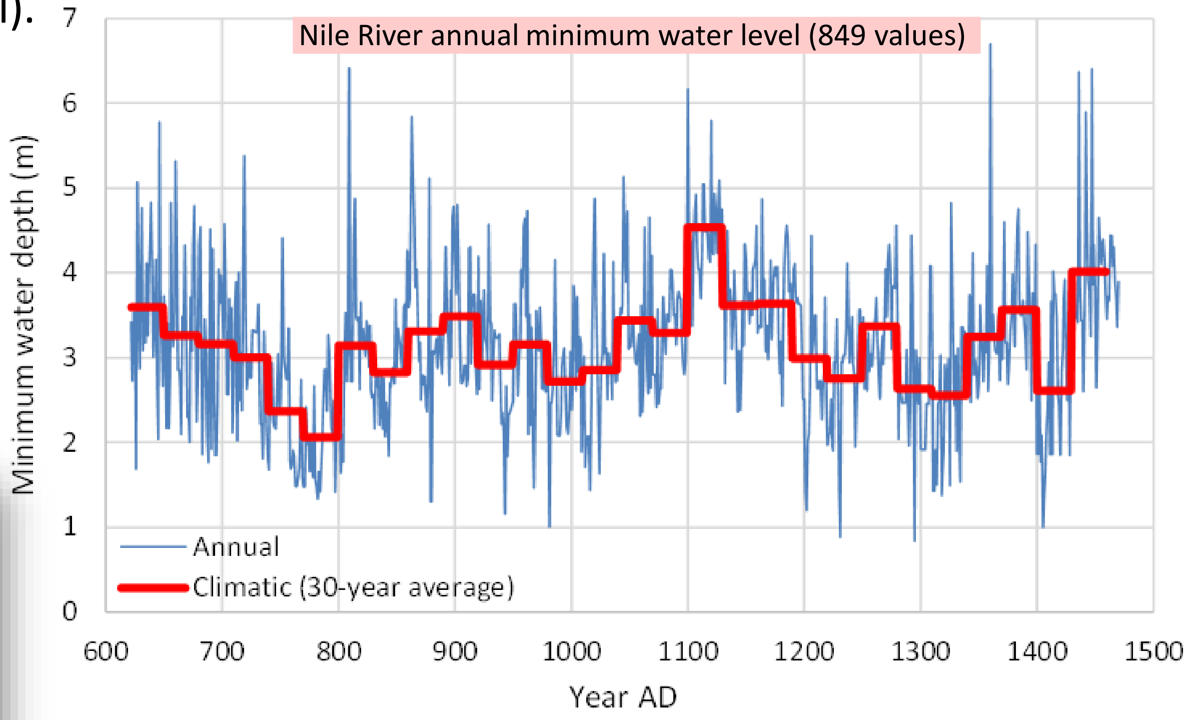
Source: Koutsoyiannis (2024b), in which the origin of the data series can be found.



Old instrumental data confirm that climate change is real

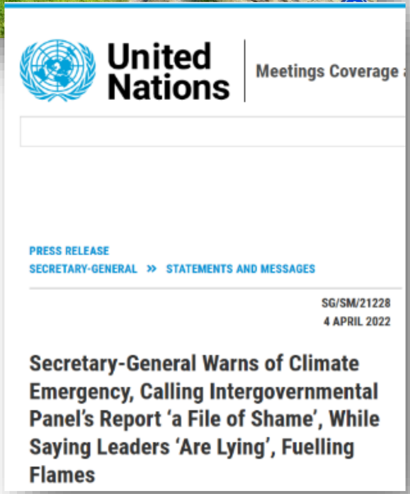
The graph shows the **longest instrumental record on Earth**, that of the Roda Nilometer (849 years of Nile's water level).





Data from Koutsoyiannis (2013), available at https://www.itia.ntua.gr/1351/; graph from Koutsoyiannis and Iliopoulou (2024); photos from Koutsoyiannis (2024g), courtesy of Nikos Mamassis.

#1b Climate crisis is also real — but only in politics



- This assertion is illustrated e.g. by:
  - (a) the decision of the European Parliament (Nov. 2019);
  - (b) the creation of Ministry of Climate Crisis in Greece (Sep. 2021);
  - (c) the announcement of the UN (Apr. 2022).
- However western politics has lost connection with reality.
- **In nature (the real world), there is no climate crisis.**
- **Question**: Which one is a bigger threat for humans?
  - ❑ A natural climate crisis?
  - ❑ Or a political "climate crisis"?

https://www.europarl.europa.eu/news/en/press-room/20191121IPR67110/

https://civilprotection.gov.gr/klimatiki-krisi
https://press.un.org/en/2022/sgsm21228.doc.htm

See also:
https://climath.substack.com/p/introducing-climath

#2 There is no *greenhouse effect* (GHE), nor *greenhouse gases* (GHG), in the atmosphere

- The **functioning of the atmosphere has no similarity** with what happens in a **greenhouse**.
- The usage of the misleading term “greenhouse” since the late 1970s, in association with CO_2 and its human emissions into the atmosphere, has been motivated by political interests.
- This is evident from the allegations that human emissions cause disastrous effects on climate, economy and every aspect of life.

See details in Koutsoyiannis and Tsakalias (2025).

Real greenhouse covered by Low-Density Polyethylene (LDPE), **transparent to LW radiation**

Photo: https://fer-plast.com/en/product/packing/heat-shrinking-equipment/shrink-materials/dpe-polythene-heatshrink-film-detail

> the loss of temperature of the ground by radiation is very small in comparison to the loss by convection, in other words that we gain very little from the circumstance that the radiation is trapped.

Wood (1909)

American Institute of Physics (2025): https://history.aip.org/climate/ simple.htm

> glass but did not speak of a greenhouse. The key publication explaining that greenhouses are kept warm less by the radiation properties of glass than because the heated air cannot rise and blow away see Wood (1909); for the science, see also Lee (1973); Lee (1974). Probably the

New terms to replace misleading ones: *atmospheric radiation effect* (ARE, not GHE) and *radiatively active gas* (RAG, not GHG)

- The recent paper by Koutsoyiannis and Tsakalias tried to clarify several issues related to atmospheric physics, including the inappropriateness of terms like “greenhouse effect ”, “hothouse effect” or “blanket effect”.
- It is true that composite molecules of noncondensing gases (CO_2, CH_4, O_3) are radiatively active (NC RAG), even though the diatomic molecules, most abundant in the atmosphere (N_2, O_2), are transparent to the Earth’s LW radiation.
- The condensing H_2O is a more important RAG.
- This does not make the atmosphere a greenhouse, nor does it allow neglecting the atmospheric radiation effect (ARE).

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Unsettling the settled: simple musings on the complex climatic system

Demetris Koutsoyiannis* and George Tsakalias

Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Athens, Greece

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EDITED BY
Ning Wang,
Ministry of Emergency Management, China

REVIEWED BY
Stavros Alexandris,
Agricultural University of Athens, Greece
Patrice Poyet,
Independent Researcher, Moorea, French Polynesia

*CORRESPONDENCE
Demetris Koutsoyiannis,
dk@itia.ntua.gr

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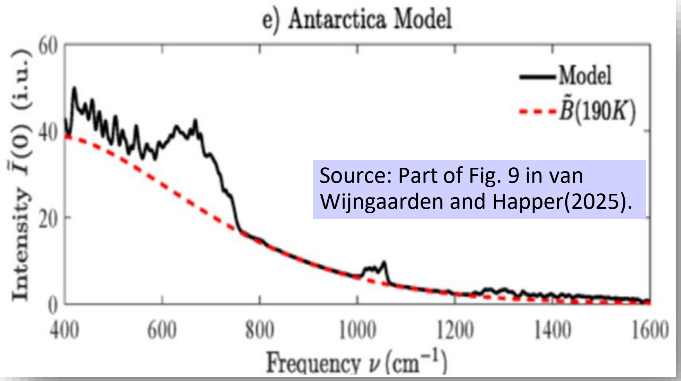
Our revisit of fundamental issues of climate challenges the notion and term of the “greenhouse effect”, and attempts a scientific reevaluation using minimal assumptions, such as Newton’s laws, maximum entropy and gas spectroscopy. It replaces terms like “greenhouse gas” with “radiatively active gas” (RAG) and “greenhouse effect” with “atmospheric radiative effect” (ARE). While ARE exists in several planets’ atmospheres, on Earth it is primarily driven by water vapor and clouds, with CO_2 playing a minor role (especially anthropogenic CO_2 which represents 4% of total emissions). Equilibrium thermodynamics, via entropy maximization or molecular collision simulation, leads to an isothermal atmosphere at about 250 K (the average temperature of the troposphere and stratosphere) irrespective of RAG presence or not. It is the troposphere’s 6.5 K/km temperature gradient (lapse rate), partly shaped by moist adiabatic processes, that drives the atmosphere away from this equilibrium and warms the surface to about 288 K on average, with ARE (mainly water vapor and clouds) contributing to the warming, but only when this gradient exists. The temperature gradient varies spatially and temporally and, since 1950, has weakened in the tropics and grown in the polar areas, resulting in a decrease of the surface equator-to-pole gradient, as expected in global warming conditions.

KEYWORDS
climate, climatic system, atmosphere, thermodynamics, greenhouse

#3 The ARE mostly depends on the temperature gradient in the atmosphere

- In the beginning of the satellite era, measurements from space of the outgoing LW radiation have been conducted (Hanel and Conrath, 1970).
- Recently, van Wijngaarden and Happer(2025), revisited these measurements.
- However, little or no attention has been paid to the fact that the **measurements reveal the importance of the vertical temperature gradient (lapse rate)** on the ARE.
- In particular, in the **Antarctica, where atmospheric inversion is common, the ARE amplifies the LW radiation that leaves the ground.** This is tantamount to a cooling effect.
- Harde and Schnell (2025) and Schnell and Harde (2025) provided **experimental evidence that the ARE can cool rather than warm** the atmosphere.
- Following earlier studies (Schmithüsen et al., 2015; Sejas et al., 2018) they used the termed "**negative greenhouse effect**"—an **oxymoron**.



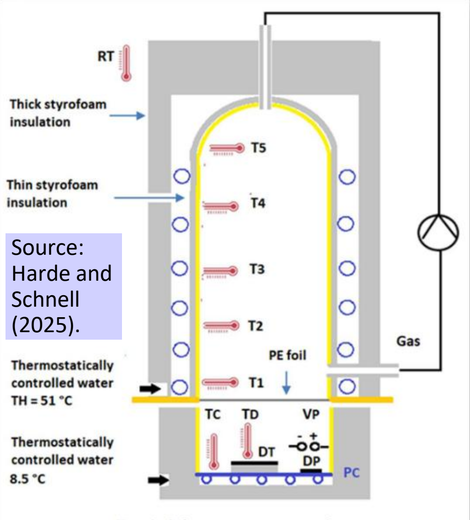
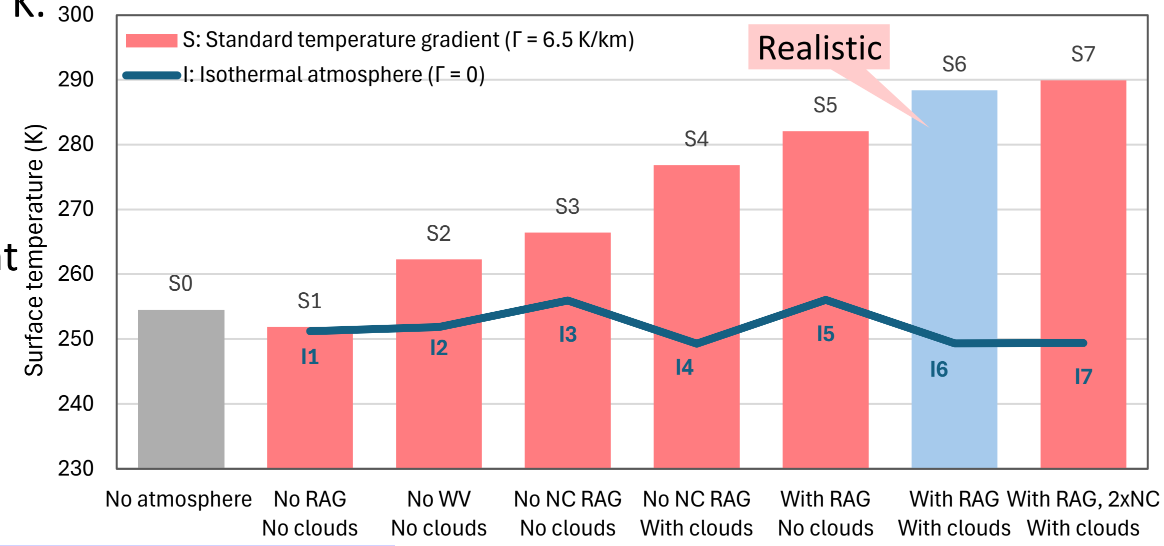


Fig. 1: Schematic experimental setup.

Isothermal atmosphere vs. temperature gradient

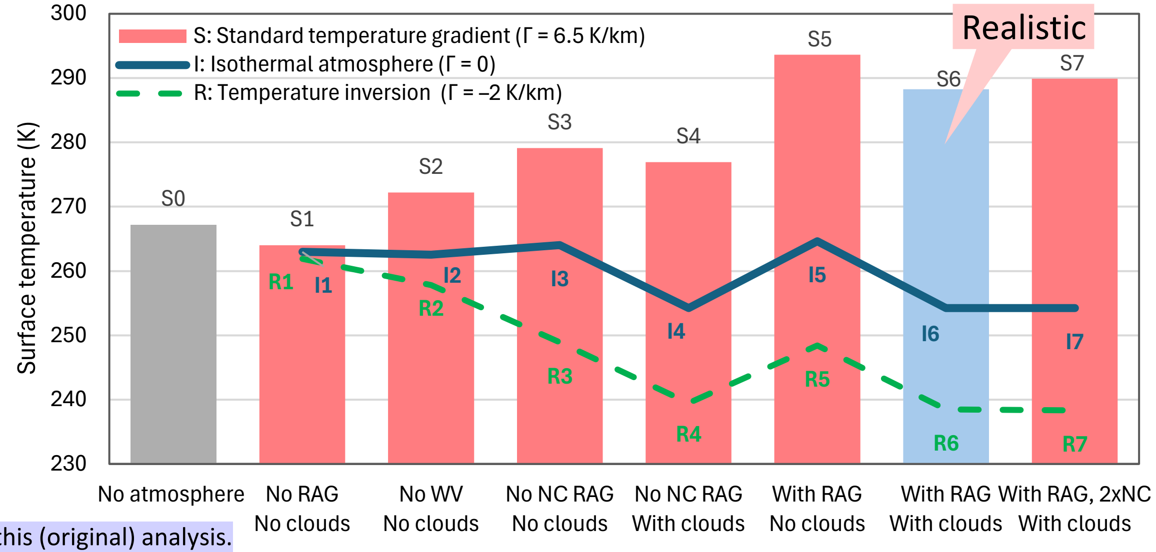
- At **thermodynamic equilibrium, the atmosphere would be isothermal**; this is proved by Koutsoyiannis and Tsakalias (2025) using both entropy maximization and simulation.
- In an isothermal atmosphere, the RAGs do not have an effect on surface temperature; this is proved using the RRTM software (rapid radiative transfer model; Mlawer et al., 1997).
- Hence the RAGs are not the reason behind the Earth's temperature increase above an "effective temperature" of 255 K.
- The atmosphere is not isothermal (not at equilibrium) because of a series of changes (e.g. day and night).
- Observations suggest a gradient $\Gamma \coloneqq -\mathrm{d}T/\mathrm{d}z = 6.5$ K/km ("**standard atmosphere**").
- **Given that gradient**, H_2O, clouds, and NC RAGs (mostly CO_2) contribute to increasing the surface temperature.



Source: Koutsoyiannis and Tsakalias (2025).

Additional remarks: when ARE cools the Earth's surface

- The graph below was constructed again by alternative runs of RRTM (a model which is far from perfect), but using a surface albedo of 0.15 (against 0.30 at the TOA) with increased cloud cover (70%) so that a realistic (288 K) surface temperature is attained.
- In addition to the isothermal atmosphere and the standard temperature gradient, $\Gamma = 6.5$ K/km, an atmosphere with temperature inversion , $\Gamma = -2$ K/km is also examined.
- Again, in the **isothermal case the RAGs do not have a remarkable effect on temperature**.
- In standard atmosphere, the ARE on surface temperature is smaller as the "effective temperature" is higher, 267 K.
- The increased cloud area is cooling the Earth's surface in these alternative cases.
- In the case of **temperature inversion, the ARE always cools the Earth's surface**.



Thanks to Dr. József Szilágyi for the discussion triggering this (original) analysis.

#4 In the standard atmosphere the ARE is dominated by H_2O (water vapour and clouds)

Atmospheric CO_2: Principal Control Knob Governing Earth's Temperature

Andrew A. Lacis,* Gavin A. Schmidt, David Rind, Reto A. Ruedy

Ample physical evidence shows that carbon dioxide (CO_2) is the single most important climate-relevant greenhouse gas in Earth's atmosphere. This is because CO_2, like ozone, N_2O, CH_4, and chlorofluorocarbons, does not condense and precipitate from the atmosphere at current climate temperatures, whereas water vapor can and does. Noncondensing greenhouse gases, which account for 25% of the total terrestrial greenhouse effect, thus serve to provide the stable temperature structure that sustains the current levels of atmospheric water vapor and clouds via feedback processes that account for the remaining 75% of the greenhouse effect. Without the radiative forcing supplied by CO_2 and the other noncondensing greenhouse gases, the terrestrial greenhouse would collapse, plunging the global climate into an icebound Earth state.

- The paper above is very popular in "climate science".
- However, it is mistaken and cannot serve as a scientific basis to assess the relative importance of the factors affecting the ARE, because it is based on imaginary assumptions.
- The paper seen on the right has refuted it.

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

Factors affecting ARE: An innovative theoretical basis

- The temperature offset from the "effective temperature" (~30 K; 33 K per Lacis et al., 2010) cannot be attributed solely to the ARE, once the main factor is the temperature gradient.
- Compared to the imaginary case of no RAG and clouds, the total effect of the NC-RAGs is:
  - Zero in an isothermal atmosphere.
  - 10 K in an atmosphere with temperature gradient of 6.5 K/km.
- These are results of the study by Koutsoyiannis and Tsakalias (2025), which however cannot accurately assess the ARE's drivers, as it makes comparisons of realistic to unrealistic states.
- The **scientific methodology is to take partial log-log derivatives** (LLD) of a multivariate function L expressing the dependence on several influencing factors F_i, evaluate them at the **point representing the current state**, and intercompare them; namely:

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

- This was done in the study by Koutsoyiannis (2024e), based on the standard theory and an established model of atmospheric radiation (MODTRAN), as well as on satellite radiation data. (Nb. MODTRAN is more accurate than RRTM but does not include SW radiation.)

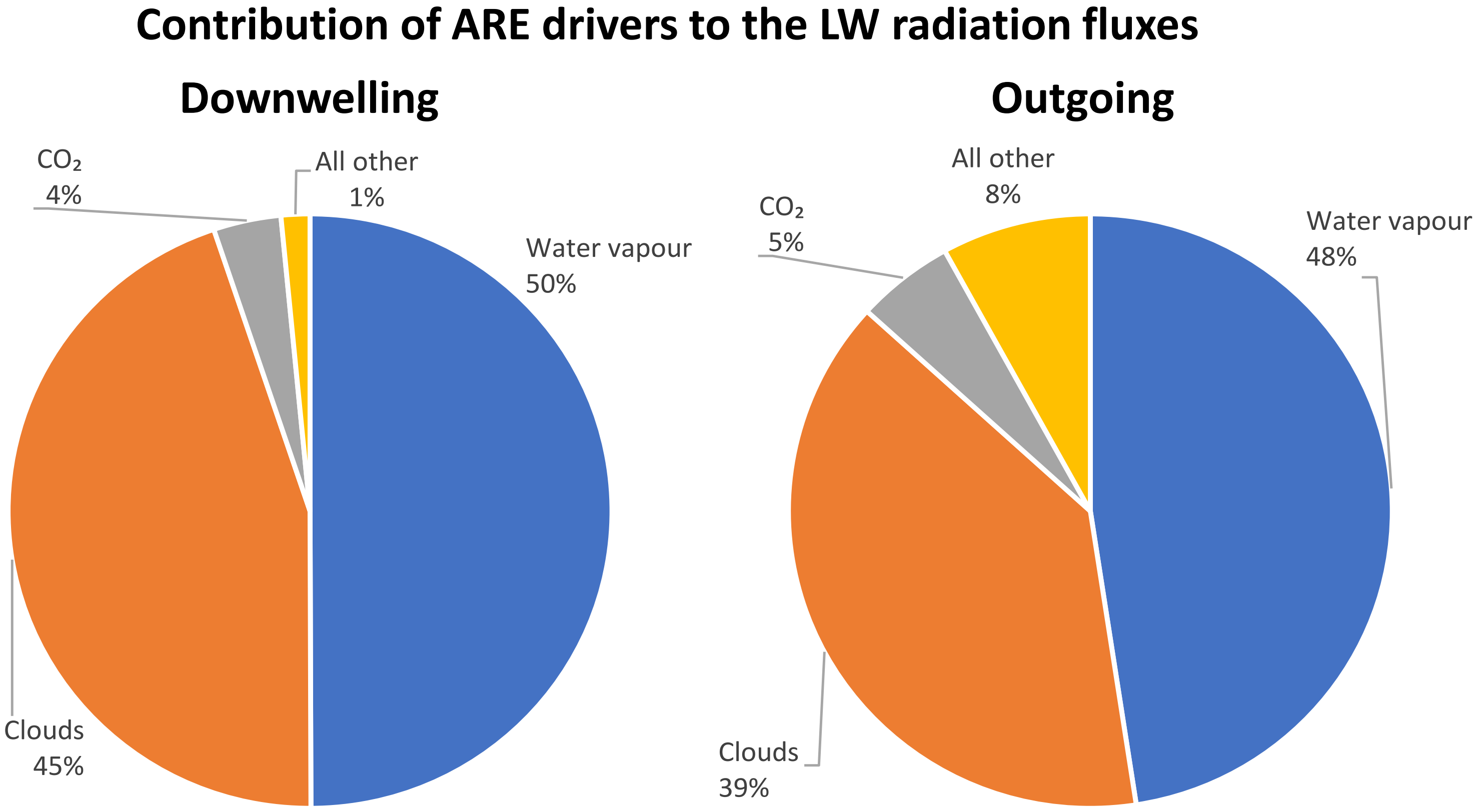
Further innovation of the *SCC* paper: Macroscopic relationships

- **Basic relationship constructed from MODTRAN results and CERES satellite 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) LW radiation flux;
  - T: temperature near the ground level;
  - e_a: water vapour pressure near the ground level;
  - $[\mathrm{CO_2}]$: atmospheric 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;
  - $\eta_T, \eta_e, a_{\mathrm{CO_2}}, a_C$: dimensionless parameters.
- The parameter values are optimized based on clear-sky MODTRAN results, except a_C, which has estimated from CERES satellite data.
- The main factors F_i whose relative importance is sought are $\{T, e_\mathrm{a}, [\mathrm{CO_2}], C\}$, while all other factors not contained in the above equation were also accounted for by MODRAN runs.

Result: CO_2 is playing a very minor role (quantified at 4-5%)



Source of graph: Koutsoyiannis (2024e).

#5 The century-long observations of LW radiation show no change in the ARE

- While “climate science” babbles on about CO_2 as the determinant “greenhouse gas”, **hydrology has routinely quantified the ARE for 70 years**.
- This is necessary in **evaporation calculations,** and the related formulae are based on data of atmospheric moisture.
- **Data exist** for an even **longer time**, beginning in 1912 (Ångström, 1916).
- Koutsoyiannis and Vournas (2024) analysed a large **collection of data on downwelling LW radiation** at Earth’s surface.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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

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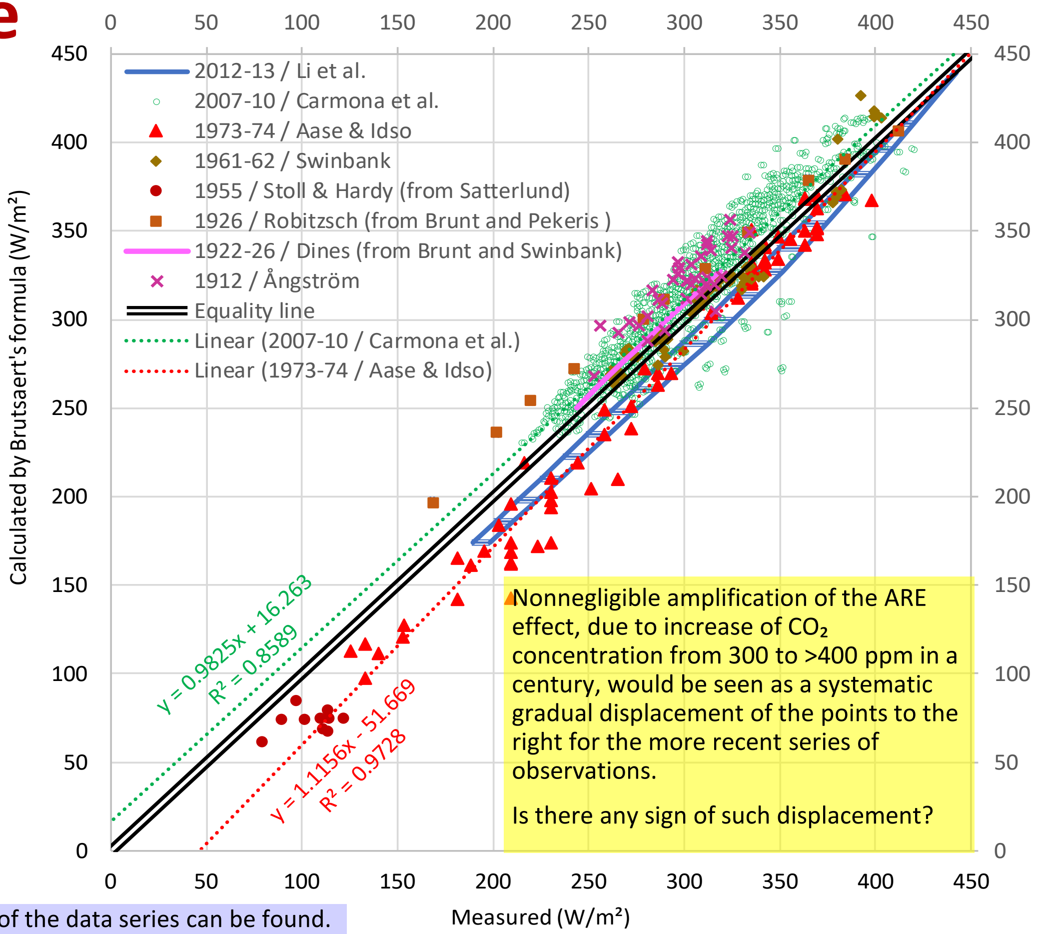
ABSTRACT

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.

The substantial increase of atmospheric [CO_2] did not give a discernible signal

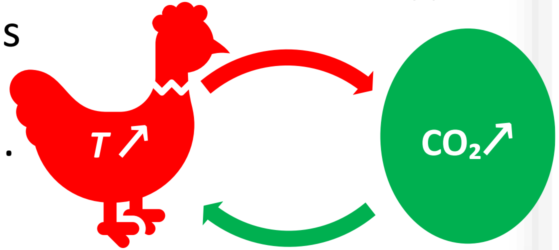
- Analysis of this data set shows **no discernible effect on the ARE (“greenhouse”) intensity**, despite the increase of atmospheric [CO_2] from 300 to >400 ppm in a century.
- This **confirms the theoretical result** that the [CO_2] importance is so small (4%) that could not be discerned in measurements.



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

#6 There is no proof that the increase of atmospheric [CO_2] causes temperature increase

- The paper seen on the right questioned the causal relationship between [CO_2] & temperature (T): Is it of type **“hen or egg?”** (**“ὄρνις ἢ ᾠὸν;”**).
- Examining **earlier studies** that claimed to have established a causation of the type [CO_2] → T, it was found that they **are flawed**.



Open Access Article

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

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

1 Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, 157 80 Athens, Greece

2 Institute for Agricultural and Forest Environment, Polish Academy of Sciences, 60-809 Poznań, Poland

* Author to whom correspondence should be addressed.

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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

Development and application of a new causality framework

As problems were spotted in existing methods, we 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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MATHEMATICAL, PHYSICAL AND ENGINEERING SCIENCES

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.

Approaches to causality and our methodology

- 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 models 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:

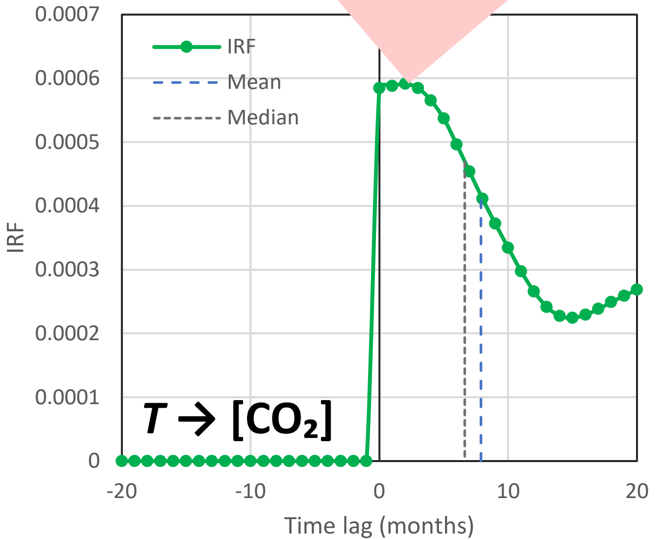
1. **potentially hen-or-egg (HOE) causal** if $g(h) \neq 0$ for some $h > 0$ and some $h < 0$, while the explained variance is non negligible;
2. **potentially causal** if $g(h) = 0$ for any $h < 0$, while the explained variance is non negligible;
3. **potentially anticausal** if $g(h) = 0$ for any $h > 0$, 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.

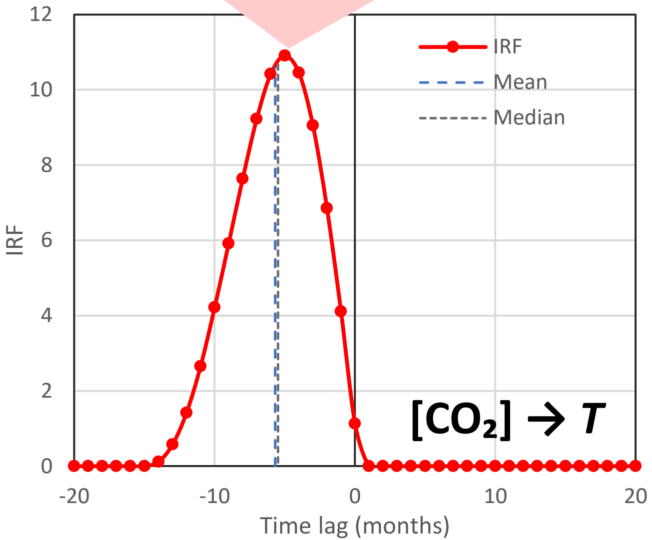
- The framework of causality identification is constructed for case 1, with the other three cases resulting as special cases.

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 (unidirectional)** 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%.





Source of graph: Koutsoyiannis et al. (2022b).

Data for T: University of Alabama in Huntsville (UAH); for [CO_2] Mauna Loa Observator

Period: 1979-2021

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 (left) extended the approach to **multiple scales** and the application to a longer period covered by instrumental data.

The *MBE* (2024) paper (right) 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

by Demetris Koutsoyiannis [1,*], Christian Onof [2], Zbigniew W. Kundzewicz [3] and Antonis Christofides [1]

1 Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, 15778 Zographou, Greece

2 Department of Civil and Environmental Engineering, Faculty of Engineering, Imperial College London, London SW7 2BX, UK

3 Meteorology Lab, Department of Construction and Geoengineering, Faculty of Environmental Engineering and Mechanical Engineering, Poznan University of Life Sciences, 60-637 Poznań, Poland

* Author to whom correspondence should be addressed.

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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.

Mathematical Biosciences and Engineering

Mathematical Biosciences and Engineering
2024, Volume 21, Issue 7: 6560-6602.
doi: 10.3934/mbe.2024287
Research article | Special Issues

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

Demetris Koutsoyiannis

Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Zographou, Greece

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

Abstract | Full Text(HTML) | Download PDF | Supplements

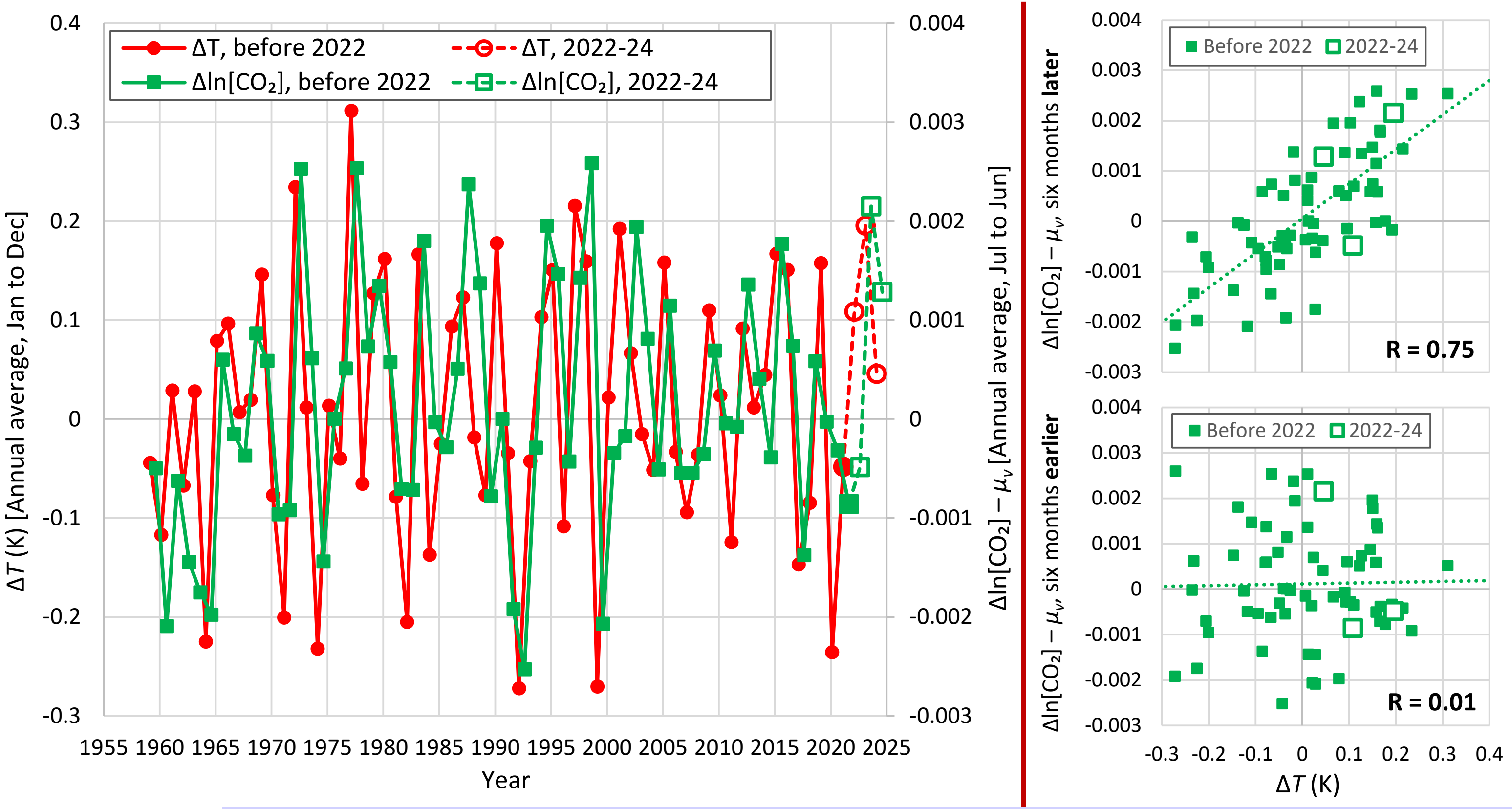
As a result of recent research, a new stochastic methodology of assessing causality was developed. Its application to instrumental measurements of temperature (T) and atmospheric carbon dioxide concentration ([CO_2]) over the last seven decades provided evidence for a unidirectional, potentially causal 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, $T \to [CO_2]$, 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**.

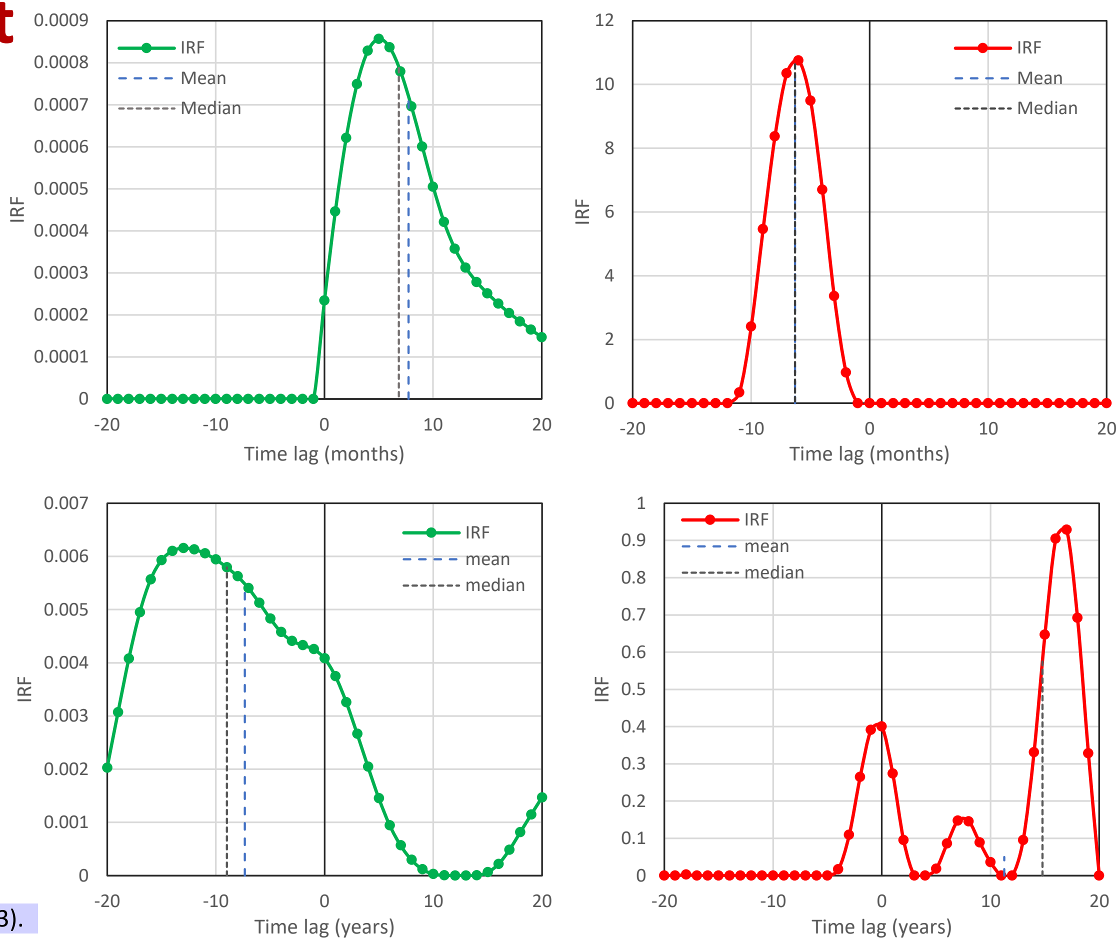


Source: Koutsoyiannis et al. (2023, graphical abstract) completed by addition of three most recent years (empty rectangles).

Climate models suggest a causality direction opposite from that seen in the data

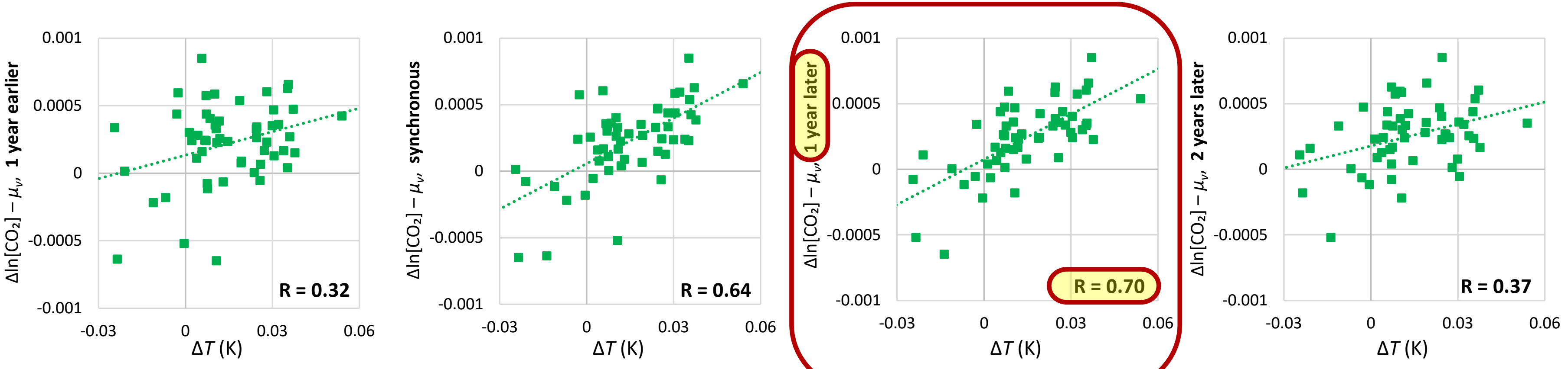
- Upper: IRFs **from data** (*T* from NCEP/NCAR Reanalysis; [CO_2] from Mauna Loa) for 1958-2021; left: $\Delta T \rightarrow \Delta \ln[CO_2]$ (**potentially causal system**); right: $\Delta \ln[CO_2] \rightarrow \Delta T$ (**potentially anticausal system**).
- Lower: As above but with time series **from climate models**, i.e. CMIP6 *T* and SSP2-4.5 [CO_2] for 1850–2021; left: $\Delta T \rightarrow \Delta \ln[CO_2]$; right: $\Delta \ln[CO_2] \rightarrow \Delta T$.

Source: Koutsoyiannis et al. (2023).



Decadal time scale – real-world data

- Some critics (e.g. Åsbrink, 2023) claimed (without providing calculations) that the T→[CO_2] causality direction is only valid for annual/sub-annual scales, while in larger scales the direction is reversed.
- However, the IRFs for **decadal scale** again **suggest a potentially causal system in the same direction** with a lag > 3 years and **exclude the direction [CO_2]→T** (see Koutsoyiannis, 2024b).
- This is also illustrated in the graph below, where the values plotted are **decadal averages** (calculated per year) of differenced time series for a differencing time step of 1 year.
- The case where **[CO_2] lags T by one year gives the highest correlation** coefficient.



Original graph of this presentation; data from Koutsoyiannis (2024).

A simple toy model based on the causality direction $T \rightarrow [CO_2]$ is fully consistent with the measured $[CO_2]$ changes

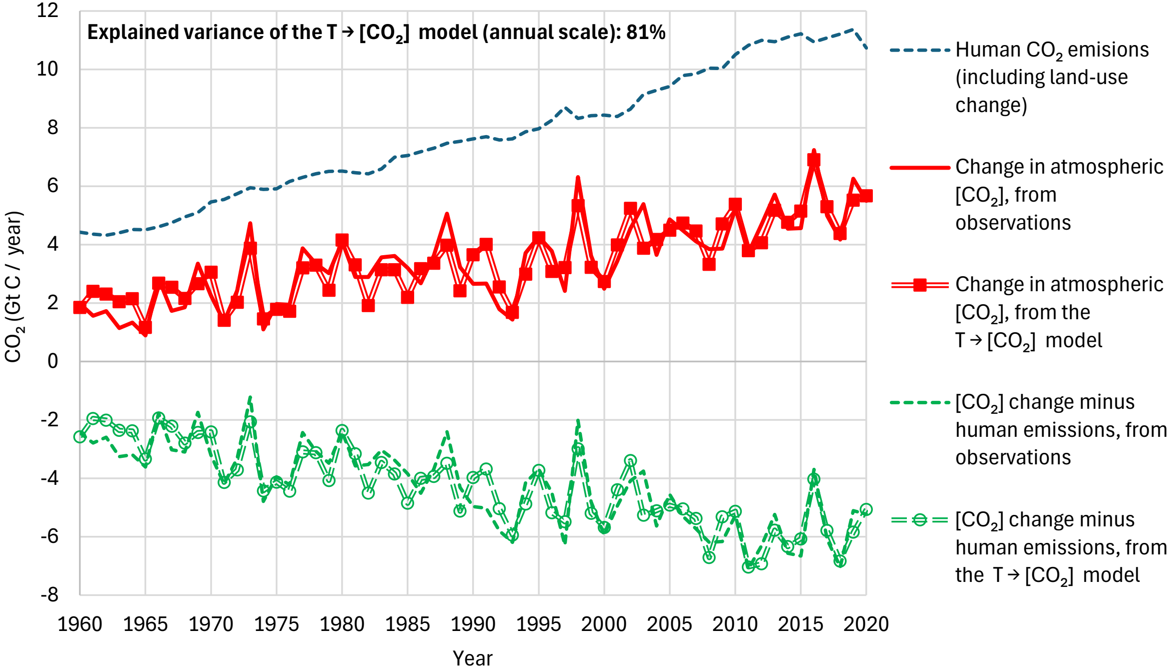
- The **toy model** has the simple expression:

  $\Delta\ln[\mathrm{CO_2}] = \sum_{j=0}^{20} g_j \Delta T_{\tau-j} + \mu_v$

  $g_j = 0.00076\, j^{0.67} e^{-0.2j}/\mathrm{K}$

  $\mu_v = 0.0034\,(T_4/\mathrm{K} - 285.84)$

  where T_4 is the average temperature of the previous four years and K is the unit of kelvin.
- By aggregation and exponentiation, we find the time series of $[CO_2]$ from earlier values of *T*.



Toy model source: Koutsoyiannis et al. (2023); graph source: Koutsoyiannis (2024e). The lower part of the graph (green lines) is included for consistency with a widely circulated graph (aka “Excalibur”), which supposedly shows that human CO_2 emissions are the cause of the atmospheric $[CO_2]$ increase.

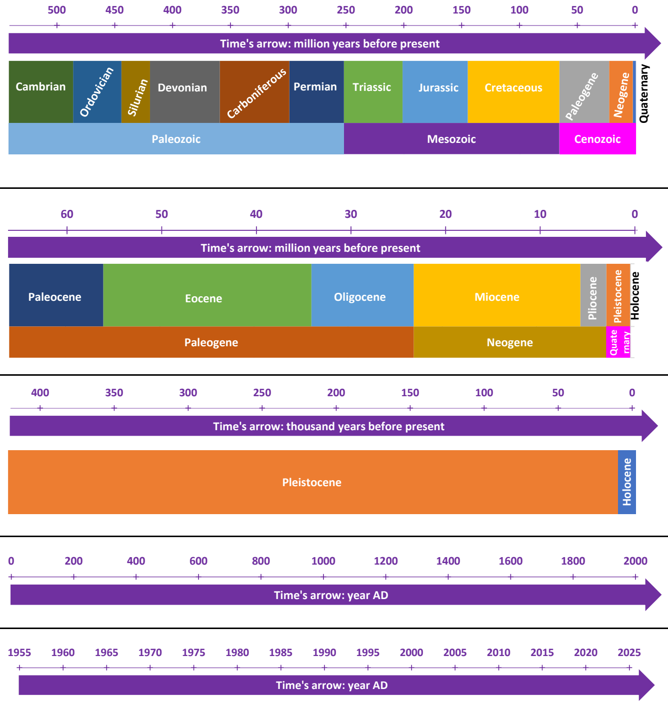
Extracting information on causality from multiple records

"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."*

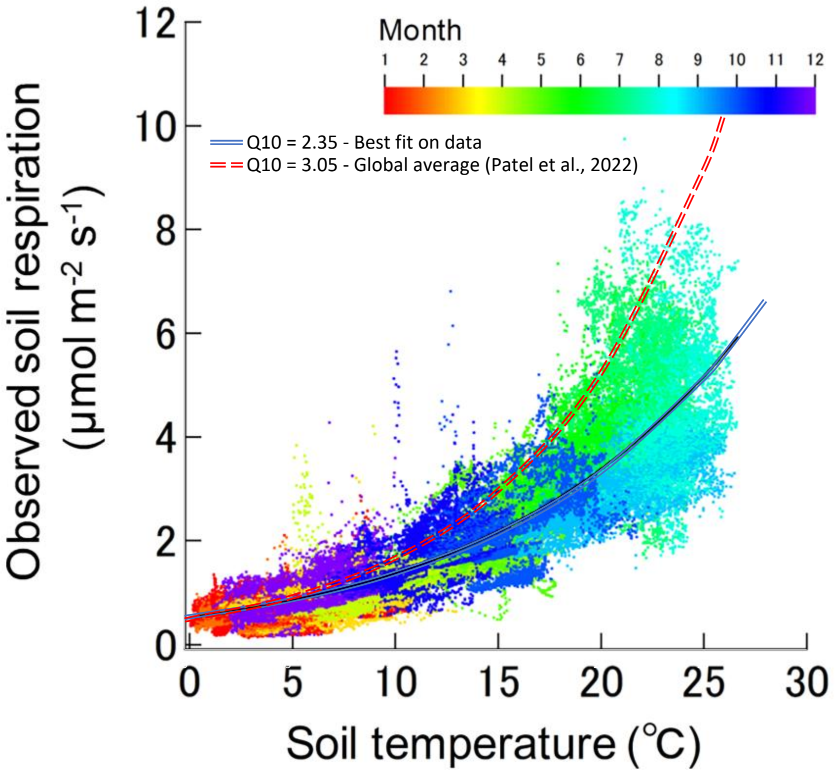
Source: Koutsoyiannis (2024b, abstract and graphical abstract).

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)

Period	Analyzed timescale	Time lags, $h_{1/2}, \mu_h$
Phanerozoic	10^6	2.3×10^6, 6.4×10^6
Cenozoic	10^5	7.6×10^5, 9.1×10^5
Late Quaternary	500	1200, 3300
	1000	1200, 4500
Common Era	1	25, 33
	10	26, 33
Modern (instrumental)	1	0.6, 0.7
	10	3.2, 3.3



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).

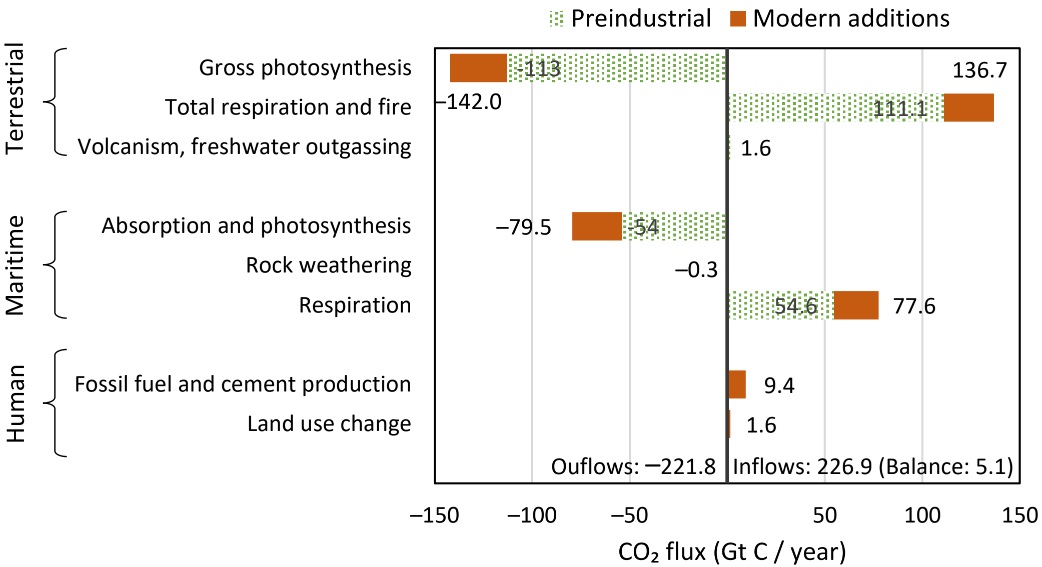
Graph with soil respiration and temperature data during 2005-10 in a temperate evergreen coniferous forest area in Japan, adapted from Makita et al. (2018).

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

Photo from Moore et al. (2021)

#7 The carbon balance in the atmosphere is dominated by natural processes

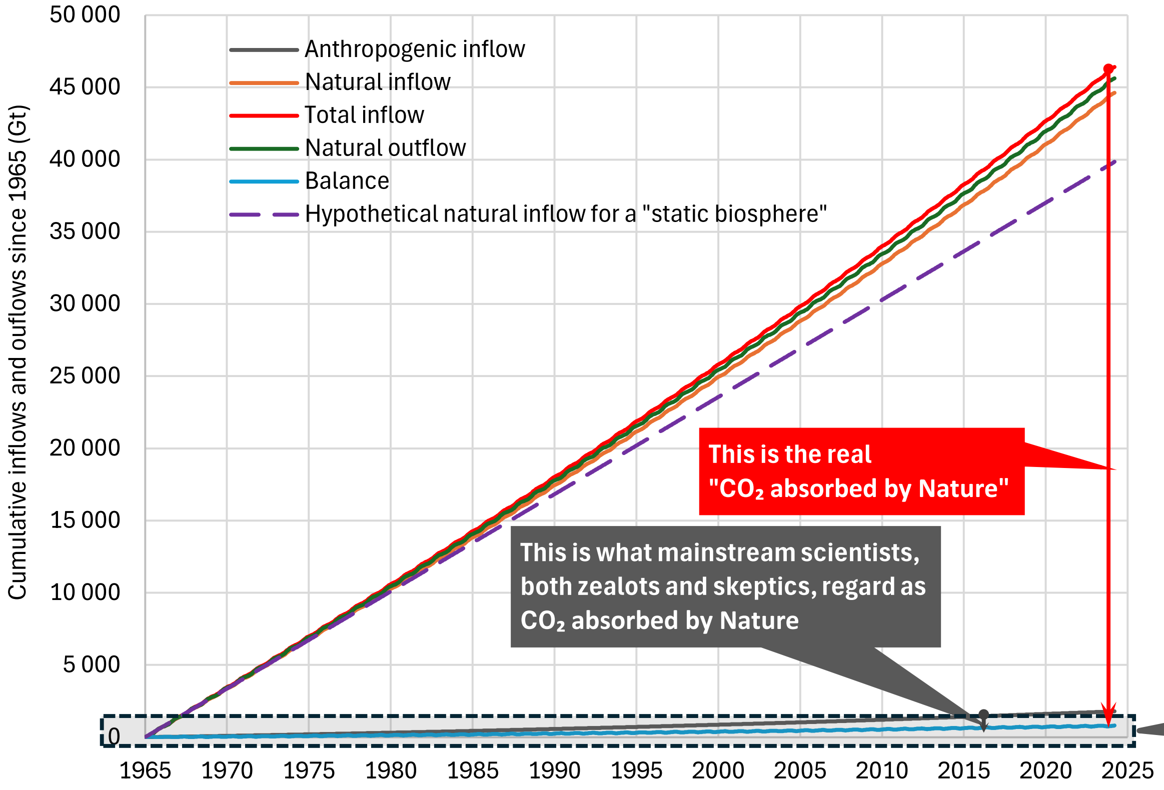
1. **Humans** are responsible for **only 4%** of carbon emissions (based on IPCC data).
2. The vast **majority of changes** in the atmosphere since 1750 (red bars in the graph) are **due to natural processes**, respiration and photosynthesis.
3. The increases in both CO_2 emissions and sinks are due 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.

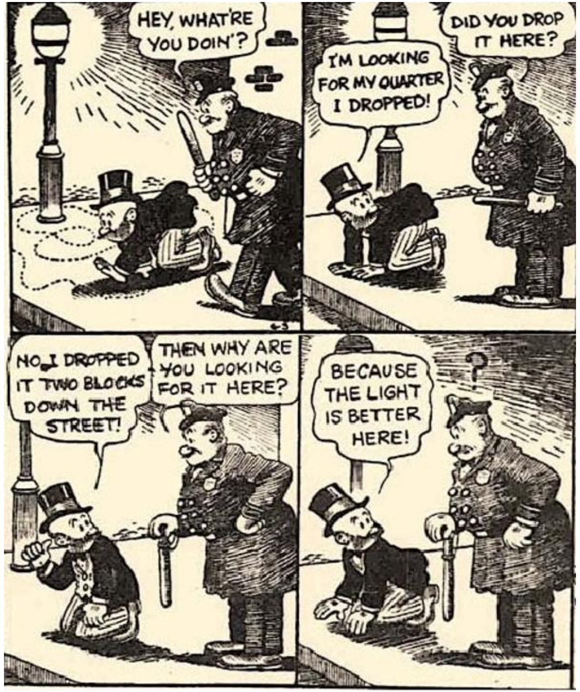


The estimates are "official" from IPCC (2021; Fig. 5.12). The presentation in the figure above is "unofficial", adapted from Koutsoyiannis (2024c). In the recent publication by Lai et al. (2024) the estimates of gross photosynthesis and respiration are even higher, 157 and 149 Gt C/year (instead of 142.0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

The rise of natural CO_2 emissions due to temperature increase





This is the area covered by mainstream graphs (streetlight effect)

Graph source: Are my works wrong for several reasons?; Cartoon source: Florence Morning News, 1942-06-03, Mutt and Jeff Comic Strip, p. 7, Florence, South Carolina; retrieved and adapted from Australian study of fluoridation neurotoxicity: Streetlight Effect Fallacy.

The neglect of natural processes: Arrhenius's fundamental errors that still affect "climate science"

- Svante Arrhenius (Swedish physicist and chemist, 1859 –1927; Nobel Prize in Chemistry, 1903) supported the **mistaken idea that changes in atmospheric [CO_2] caused the temperature changes** throughout Earth's history.
- Also, Arrhenius mistakenly thought that "**vegetative processes**" (respiration and photosynthesis) "**may be omitted**" in the carbon balance.
- Note that at Arrhenius's time, human CO_2 emissions (which are now ≈4% of the total emissions) were ≈4% of the current ones. This translates to 0.25% of the then total emissions. That is, **Arrhenius thought that a percentage >99.75% "may be omitted", and only a percentage of 0.25% is significant**.

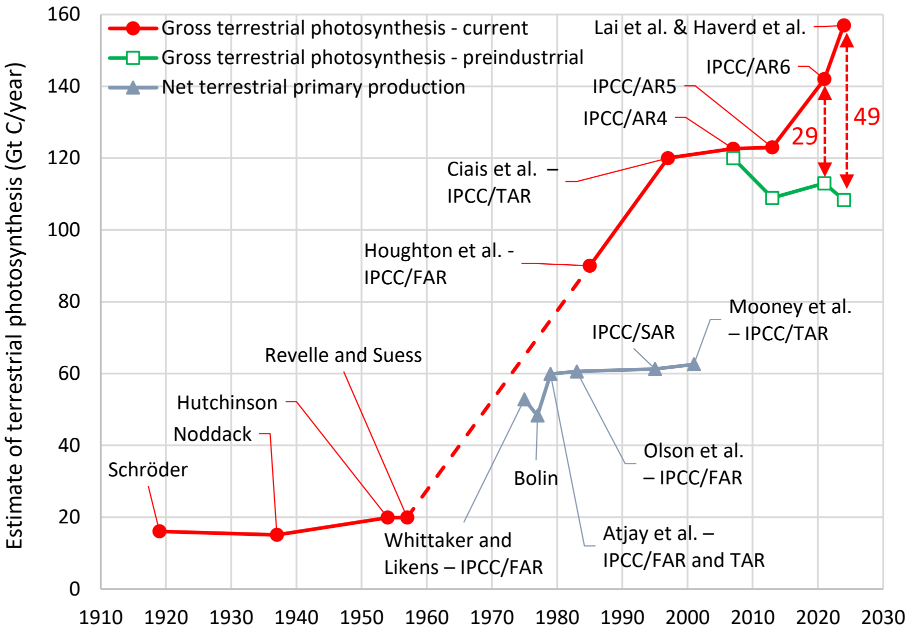
> absorbs it as it cools. The processes named under (4) and (5) are of little significance, so that they may be omitted. So too the processes (3) and (7), for the circulation of matter in the organic world goes on so rapidly that their variations cannot have any sensible influence. From this we must

Source: Arrhenius (1896).

Explanation:
(4): decomposition of carbonates;
(5): liberation of CO_2 from minerals;
(3): combustion and decay of organic bodies;
(7): consumption of CO_2 by vegetative processes.

Timeline of the underestimation of biosphere's role

- Complete quantification of all components of carbon balance has been provided by IPCC **only after 2007** (Assessment Reports 4-6 – AR4 – AR6).
- The misestimation dominating in early periods is exemplified by the graph below, which reviews estimates of the component most studied, i.e., terrestrial photosynthesis (or primary production).
- Before 1970, the **estimates were too low.** (Nb., similar were those of land respiration: 15 – 25 Gt C/year per Leith, 1963).
- The IPCC AR 1-3, provided estimates of the net (not the gross) primary production, which were nearly constant at 60 Gt C/year.
- The subsequent reports gave estimates for the gross photosynthesis—also for preindustrial conditions.
- The last report (**IPCC, 2021) estimated a large difference between current and preindustrial conditions**.
- **Newer studies give higher estimates** both for the total production and the difference.

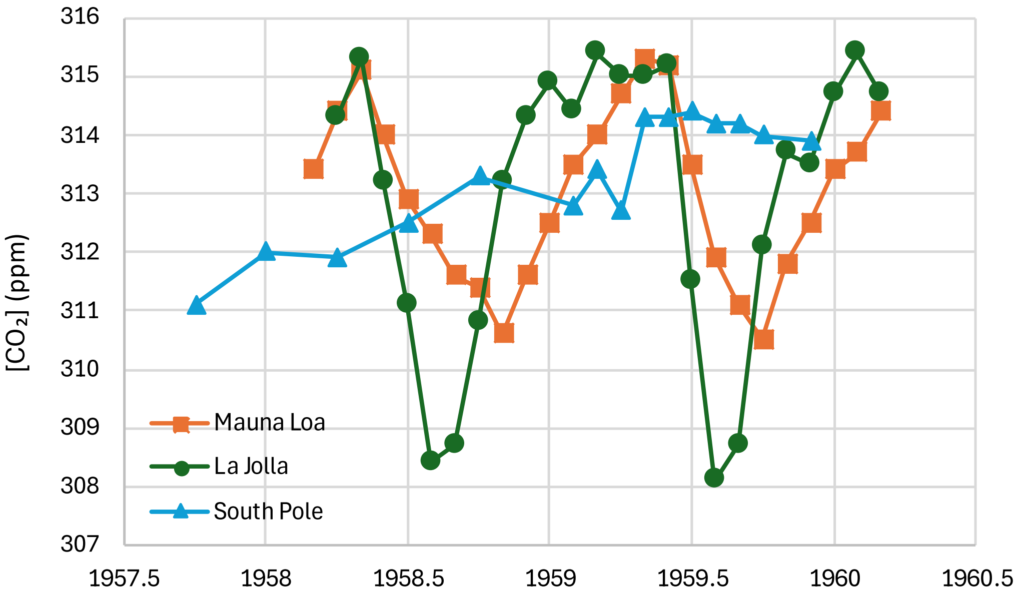


Original graph.

Systematic [CO_2] measurements should have dismissed the idea that natural emissions are insignificant

- Charles David Keeling (American scientist; 1928 –2005) was the father of systematic [CO_2] observations at 3 stations, Mauna Loa, La Jolla and South Pole; the plot of the former data series has become known as the Keeling curve.
- Keeling (1960) published the measurements of the first two years in tabulated form.
- He must have **expected to see rising trends, but found seasonal variation,** as seen in his Abstract:

  A systematic variation with season and latitude in the concentration and isotopic abundance of atmospheric carbon dioxide has been found in the northern hemisphere. In Antarctica, however, a small but persistent increase in concentration has been found.
- Nb., temperature was not rising then.



The graph was constructed from Keeling's (1960) tabulated data. Keeling included separate graphs for Mauna Loa and South Pole, but not for La Jolla.

Keeling's approach

- Observing the seasonality in the CO_2 changes, he **correctly attributed it to the plants**.
- However, he subsequently dismissed this function by hiding the graph for La Jolla and **only considering South Pole** (cherry-picking).
- Nb., in Arctic the seasonal effect is more pronounced.

Source: Keeling (1960).

1952). These data, therefore, indicate that the seasonal trend in concentration observed in the northern hemisphere is the result of the activity of land plants. This interpretation receives further support from the fact that maximum concentrations have been found to occur in spring at the outset of the summer growing season for plants in the temperate zone; that minimum concentrations occur in the fall, approximately at the end of the growing season.

available in the future. At the South Pole the observed rate of increase is nearly that to be expected from the combustion of fossil fuel (1.4 p.p.m.), if no removal from the atmosphere takes place (REVELLE and SUESS, 1957). From this agreement, one might be led to conclude that the oceans have been without effect in reducing the annual increase in concentration resulting from the combustion of fossil fuel. Since the seasonal variation in concentration observed in the northern hemisphere is several times larger than the annual increase, it is as reasonable to suppose, however, that a small change in the factors producing this seasonal variation may also have produced an annual change counteracting an oceanic effect.

#8 The isotopic carbon data ($\delta^{13}C$, $\Delta^{14}C$) show changes in the isotopic synthesis of atmospheric CO_2, but no sign of human influence

- The paper on the right revisited the changes in the isotopic synthesis of CO_2 in the atmosphere and proceeded to its modelling.
- The paper has been based on mass balance dynamics applied with [CO_2] and $\delta^{13}C$ data: **modern measurements and proxy records** since 1500 AD.
- No climate model outputs were used.

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

by Demetris Koutsoyiannis

Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Heroon Polytechneiou 5, 157 72 Zographou, Greece

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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.

IPCC's mistaken interpretations of isotopic signatures

Multiple lines of evidence unequivocally establish the dominant role of human activities in the growth of atmospheric CO_2. First, the systematic increase in the difference between the MLO and SPO records (Figure 5.6a) is caused primarily by the increase in emissions from fossil fuel combustion in industrialized regions that are situated predominantly in the Northern Hemisphere (Ciais et al., 2019). Second, measurements of the stable carbon isotope in the atmosphere ($d^{13}C$–CO_2) are more negative over time because CO_2 from fossil fuels extracted from geological storage is depleted in ^{13}C (Figure 5.6c; Rubino et al., 2013; Keeling et al., 2017). Third, measurements of the $d(O_2/N_2)$ ratio show a declining trend because for every molecule of carbon burned, 1.17 to 1.98 molecules of oxygen (O_2) is consumed (Figure 5.6d; Ishidoya et al., 2012; Keeling and Manning, 2014). These three lines of evidence confirm unambiguously that the atmospheric increase of CO_2 is due to an oxidative process (i.e., combustion). Fourth, measurements of radiocarbon (^{14}C–CO_2) at sites around the world (Levin et al., 2010; Graven et al., 2017; Turnbull et al., 2017) show a continued long-term decrease in the $^{14}C/^{12}C$ ratio. Fossil fuels are devoid of ^{14}C and therefore fossil fuel-derived CO_2 additions decrease the atmospheric $^{14}C/^{12}C$ ratio (Suess, 1955).

IPCC's "evidence" missed the facts that:

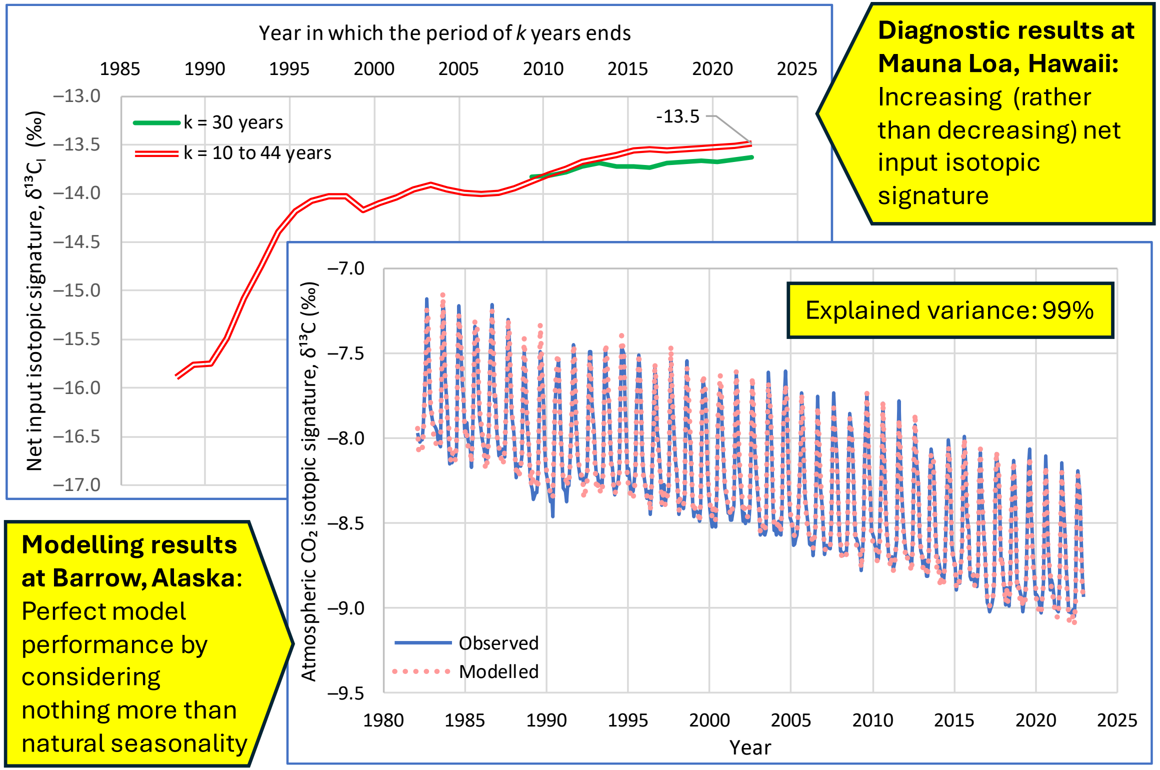
- **Land** is "situated predominantly" in **the NH** (and so are plants and their processes).
- **Plants** are also "depleted in ^{13}C" (see below).
- **Plant respiration** consumes O_2: 6 molecules for every molecule of glucose oxidized.
- Plants are also "devoid of ^{14}C", whose decrease is due to cessation of nuclear tests.
- Suess (1955) analysed very few trees and **did not present conclusive results**.

At present it is not possible to make conclusive interpretations concerning the reasons for the differences (in excess of experimental uncertainties) between individual samples grown at the same time.

Sources: left: IPCC (2021, p. 689); right: Suess (1955).

What do carbon isotopic data ^{13}C reveal?

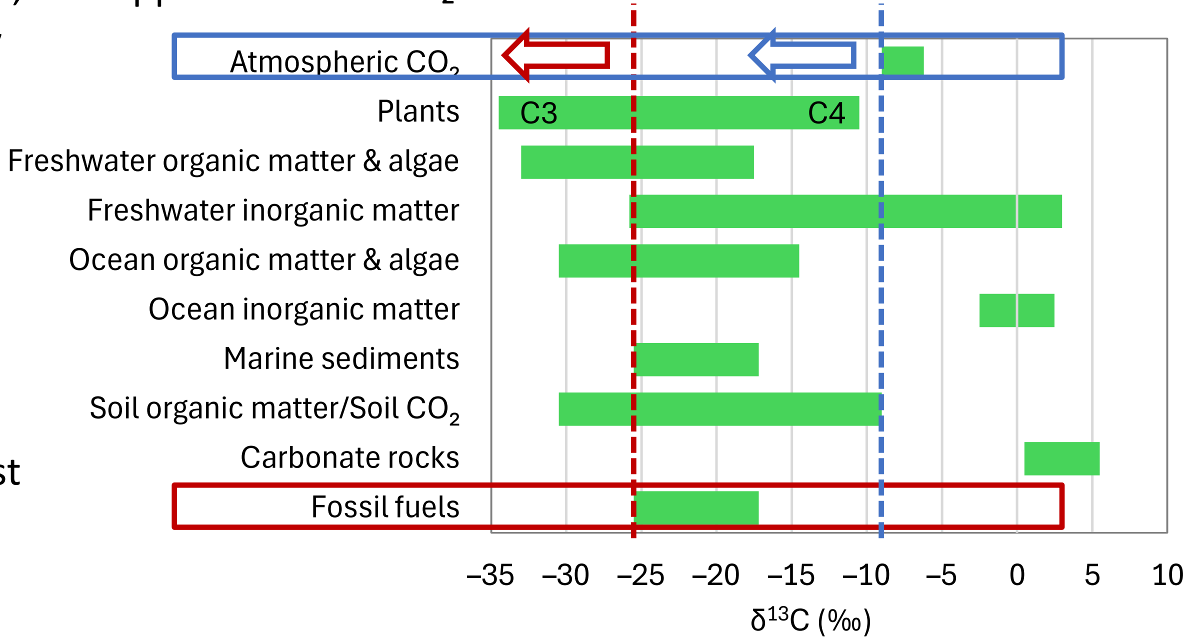
- The atmospheric $\delta^{13}C$ has been decreasing (see lower graph).
- However, the **net input signal** of the atmospheric $\delta^{13}C_I$ is not decreasing—in some cases, it is increasing (see upper graph).
- A **constant $\delta^{13}C_I$ of about –13‰** (or less) at an overannual time scale is 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") is **non-discernible**.



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

The “Suess effect” does not have a logical basis

- Fossil fuels have a small δ^{13}C signature, down to –26‰ and hence their input δ$^{13}C_I$ is low.
- However, **C3 plants** (e.g., evergreen trees, deciduous trees and weedy plants) have **much lower** δ^{13}C values than fossil fuels, down to – 34‰, and thus their input δ$^{13}C_I$ 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 δ$^{13}C_I$, decreasing the atmospheric δ^{13}C content.
- The dominance of plants’ processes is obvious in the **seasonal variation of δ^{13}C** (see lower graph in previous slide).
- It is therefore **absurd** to suggest that it is **the emission from burning fossil fuels (4% of the total) that causes the atmospheric δ^{13}C value to fall.**



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

#9 The dynamics of atmospheric CO_2 can be recovered from natural processes only

- The paper seen on the right is based on observational data, fully **excluding** anything originating from **climate models**.
- Specifically, the data used are **measurements** of $[CO_2]$, $\delta^{13}C$, $\Delta^{14}C$, and anthropogenic emissions.
- The model developed is **simple, transparent** and reproducible in a spreadsheet.
- It is based on the **differential equation of mass exchange** and a reservoir routing technique, common in hydrology and hydraulics, refined for the purpose of more general application.

Open Access Article

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

by Demetris Koutsoyiannis

Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, 157 72 Zographou, Greece

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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.

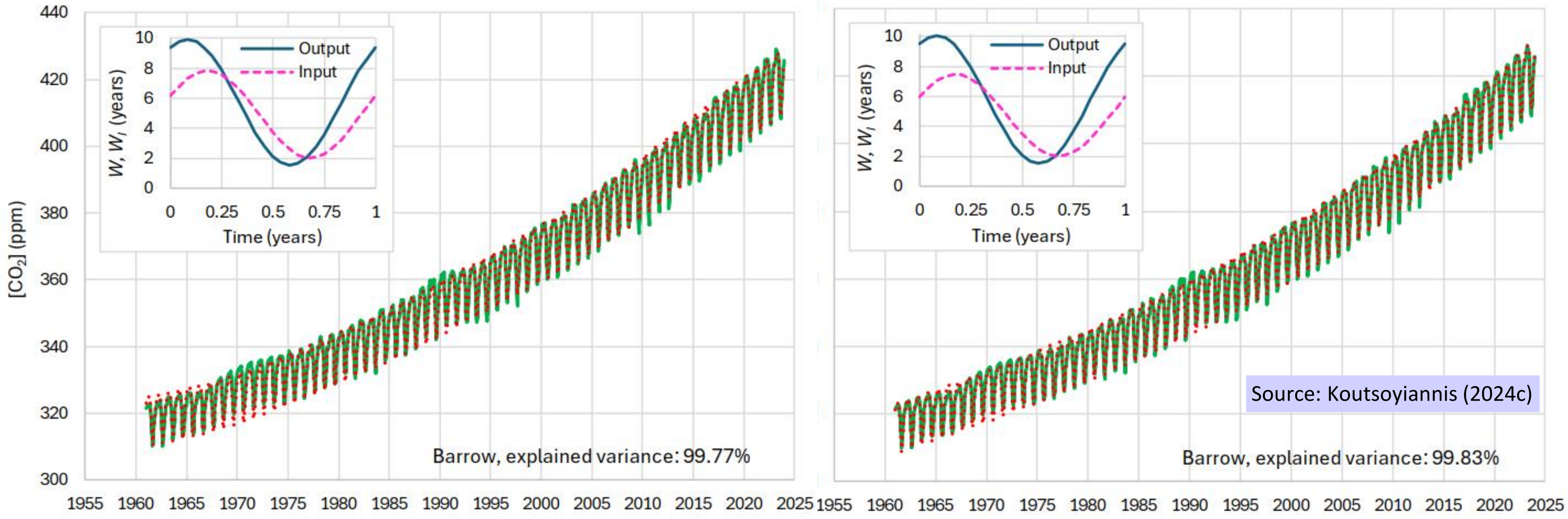
The "intentionally vague"* IPCC approach does not offer a scientific basis and needs to be rejected outright

- When referring to **characteristic times** of gas inflow to, and outflow from, the atmosphere, 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.
- When referring to CO_2 (and in contrast to other substances), IPCC **set a record of vagueness**:
  - *[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] (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.*"

Quiz—Spot the differences in model fits: (left) considering and (right) neglecting human CO_2 emissions

- The main part in each graph compares the **observed** (continuous lines) and **simulated** $[CO_2]$ (dotted lines).
- The inset shows the CO_2 mean residence time (W) and a similar quantity for inflow (W_I).



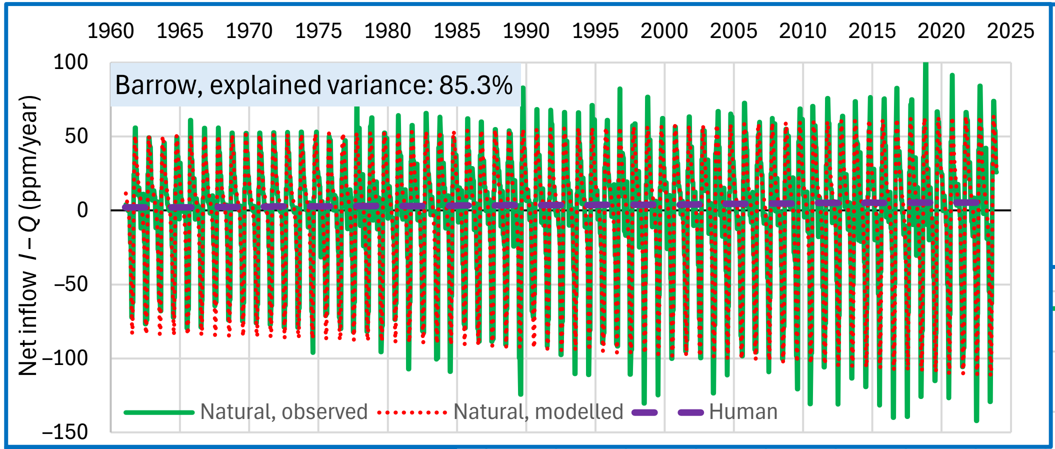
Full account of the atmospheric CO_2 dynamics

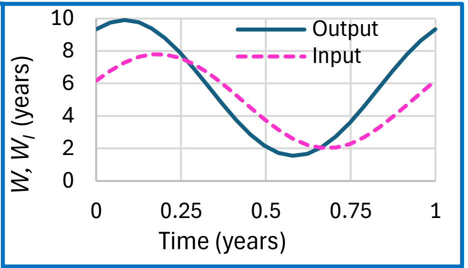
Evidently (and contrary to popular beliefs), the CO_2 mean residence time (W) in the atmosphere is:

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.

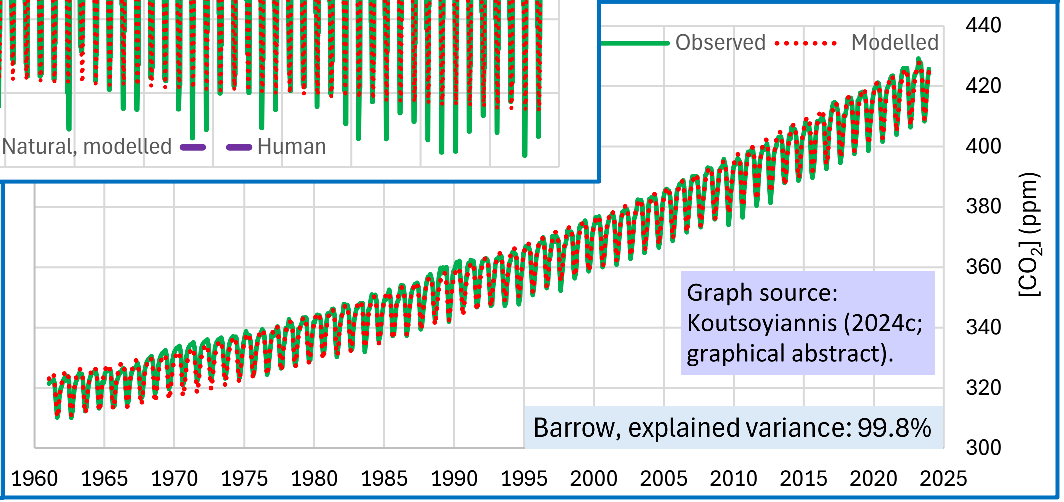




Mean residence time (W)**:** 3.9 years (seasonal variation: 1.6 – 9.9 years).

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).

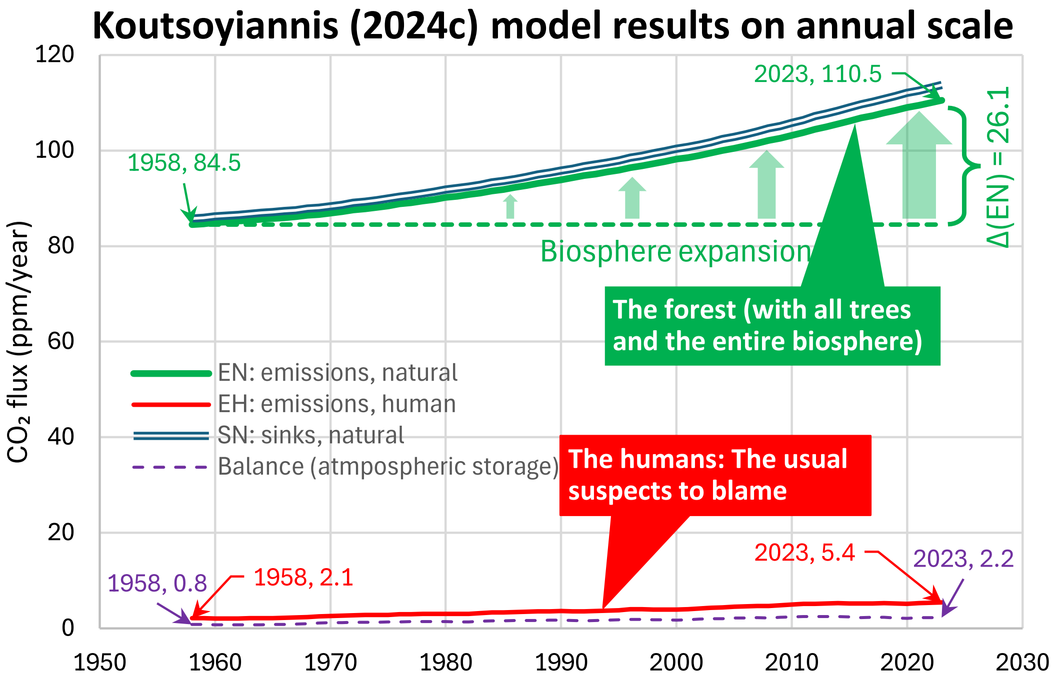
Model performance: excellent.



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

The biosphere expansion and the rise of natural emissions (EN)

1. Apparently (and contrary to IPCC's* position), **the biosphere expansion** (the upsurge Δ(EN) = 26.1 ppm CO_2/year) has **not** been caused **by human emissions** (2.1 to 5.4 ppm CO_2/year).
2. The fact that the net increase of the mass of atmospheric CO_2 (2.2 ppm/year) is less than half of human emissions (5.4 ppm/year) does not imply that natural processes are not adding CO_2 to the atmosphere.
3. The fact that land and oceans constitute a net sink does not imply anything about the cause of the CO_2 rise. It is none other than a mathematical necessity dictated by mass conservation.



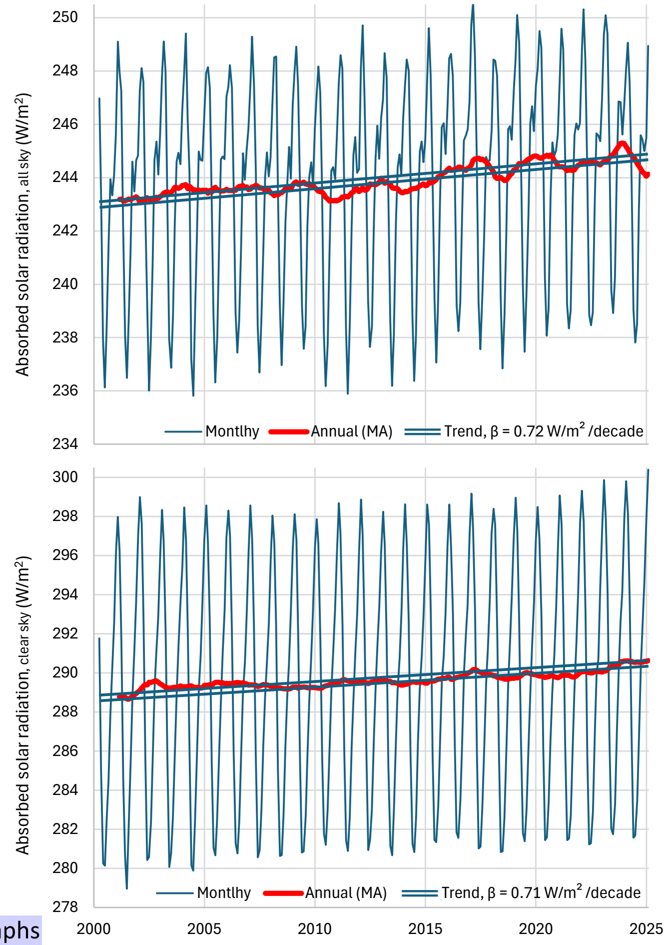
The graph was prepared from the RRR model results in Koutsoyiannis (2024c), after aggregation to the annual scale.

* 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).

#10: Temperature increase in the 21st century is consistent with changes in the solar radiation absorbed by the Earth

- Recent studies have pointed out **the decrease of Earth's albedo in the 21st century** (Koutsoyiannis et al., 2023, Nikolov and Zeller, 2024). This means that the **absorption of solar radiation has increased**.
- CERES satellite measurements of the SW radiation **suggest an increase of the solar radiation absorbed** by the Earth, at a rate of ≈ 0.7 W m^{-2} decade^{-1}.
- Importantly, about the same rate of increase is observed **for clear sky** (lower graph).
- This suggests that the change in albedo is more likely related to Earth's surface, not its atmosphere.

Original graphs



Calculation of SW absorption increase vs. total energy imbalance

- The CERES data are associated with considerable uncertainties and result in an erroneous net imbalance of over 4 W/m^2 (Koutsoyiannis, 2024e); therefore, the absolute values provided are not suitable for characterizing the actual energy imbalance of the Earth.
- Here we use temporal changes (trends) instead of absolute values.
- The slope of the linear trend in the absorbed SW radiation is $\beta \approx 0.7$ W m^{-2} decade^{-1}.
- The average change (increase) in the absorbed radiation in a time period of d = 24.8 years is:

$$(1/d) \int_0^d \beta\, t\, \mathrm{dt} = \beta d/2 = (1/2)\ (0.7\ \mathrm{W\ m^{-2}\ decade^{-1}})\ (2.48\ \mathrm{decade}) \approx \mathbf{0.9\ W\ m^{-2}}.$$

- The ocean heat content from Argo data for depths 0 – 2000 m for the period 2005-2025 is increasing at a rate of $\approx 1 \times 10^{22}$ J year^{-1} (data retrieved from climexp.knmi.nl). Considering that the Earth's area is 5.101×10^{14} m^2, this translates to:

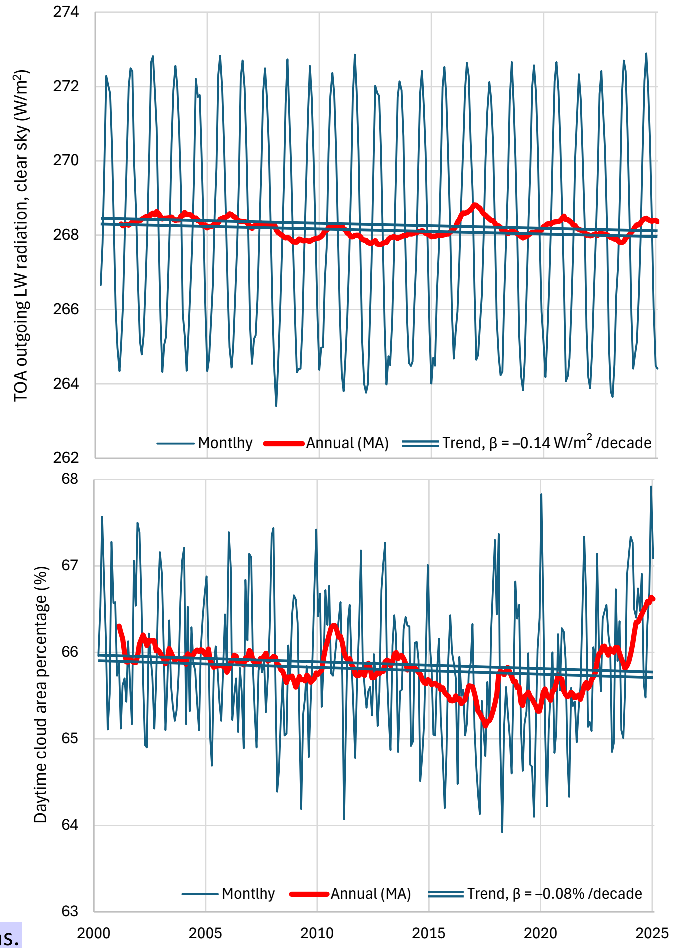
$$(1 \times 10^{22}\ \mathrm{J\ year^{-1}}) / (5.101 \times 10^{14}\ \mathrm{m^2}) / (365.25 \times 86\,400)\ \mathrm{s\ year^{-1}}) = \mathbf{0.62\ W\ m^{-2}}.$$

- Considering the contribution of land heating, melting ice, etc., at 9% (IPCC, 2021, Section 7.2.2; Koutsoyiannis, 2021, Appendix D), and ocean heating below 2000 m at 8% (IPCC, 2021, Table 2.7) the Earth's energy imbalance in the recent years is 0.62/0.83 ≈ **0.75 W m^{-2}**.
- Hence the **changes in SW radiation exceed the recent energy imbalance** by about 17%.

Further notes on SW radiation change

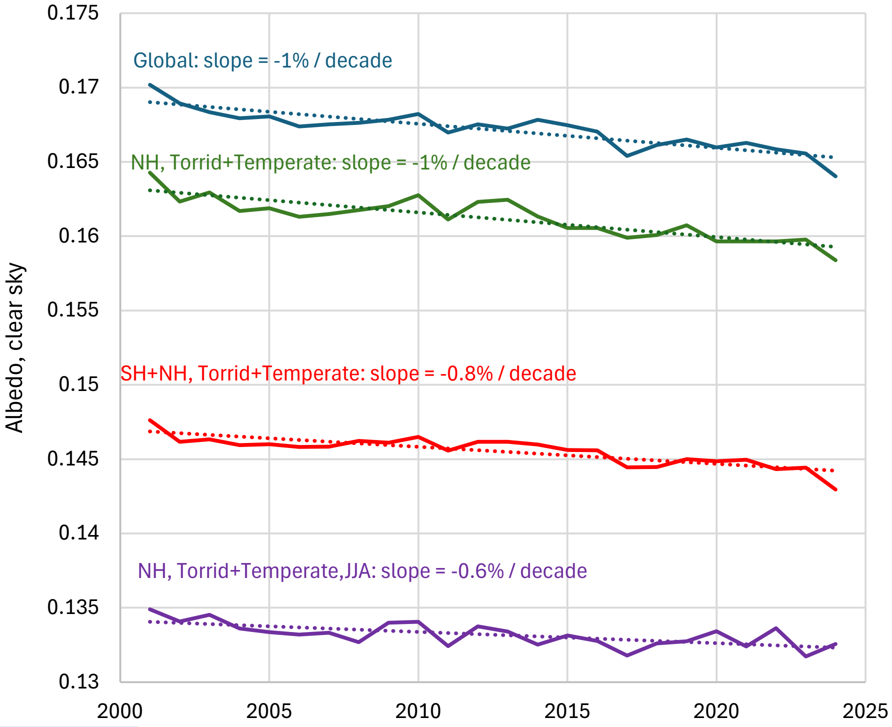
- Given the previous result for SW radiation, modelling of **LW radiation is of low importance**.
- Yet it is interesting to note that, according to the CERES satellite data, the trend in the TOA outgoing **LW radiation for clear sky is slightly decreasing** (see also Koutsoyiannis, 2024e, Fig. 20).
- This is surprising: **an increasing temperature would be expected to cause increase** in the outgoing LW radiation.
- Previous studies (Koutsoyiannis and Vournas, 2024; Nikolov and Zeller, 2024) pointed out a decreasing trend in cloud area fraction as a possible cause of the albedo decrease.
- However, more recent data show a **reversal of the cloud trend**, without changes in other variables' behaviour.
- Moreover, the reported behaviour in **clear sky does not support a cloud-based mechanism**.

Original graphs.



Further notes on SW radiation change (2)

- According to CERES satellite data, the observed TOA solar insolation flux (incoming) has not changed during the 21st century.
- However, Earth's albedo for clear sky has been decreasing **globally at a rate of 1% per decade** (see graph).
- If we exclude the frigid zones, the albedo is again decreasing at a similar rate; hence the **decrease cannot be attributed to polar ice area dynamics**.
- The albedo is also decreasing in summer months (JJA in NH); hence the **decrease is hardly related to snow dynamics**.
- The **Earth's greening** (net increase in leaf area of 2.3% per decade; Chen et al., 2019) can be a plausible cause as forests' albedo is lower than those of soil and desert.

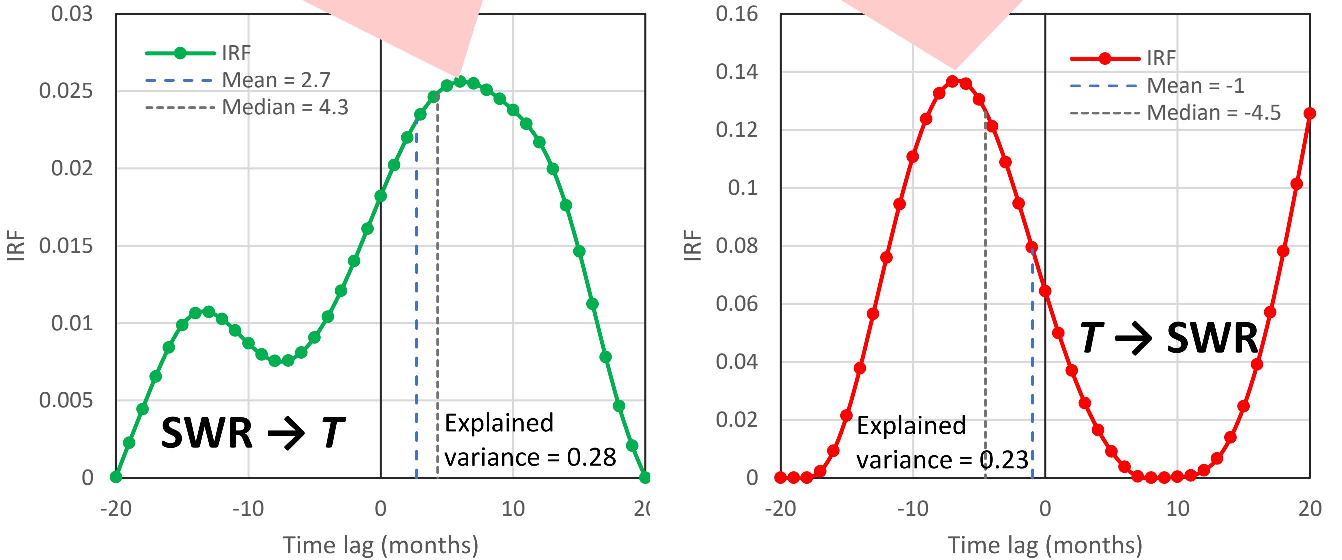


Original graph.

Detecting causality between *T* and SW radiation

The system (SWR, *T*) is potentially HOE causal (bidirectional), with principal direction SWR→*T* and explained variance 28%.

The system (*T*, SWR,) is potentially HOE causal (bidirectional), with principal direction SWR→*T* (again) and explained variance 23%.



Original graphs.

Conclusion: There is potential causality, of **HOE (bidirectional) type, with principal direction SWR→*T*** and lag time of 3-4 months.

Final remarks: What the evidence actually shows

- Human **CO_2 as the climate control knob is empirically untenable** once we properly account for:
    - (1) natural CO_2 fluxes (~25× larger);
    - (2) the effect of H_2O (vapour + clouds, ~20× larger);
    - (3) the huge complexity of the climate system, including the biosphere's role.
- Climate models are in disagreement with observation while **reversing cause and effect**.
- In complex systems, data are sovereign — and **data have falsified the mainstream climate theory**.
- The emission-centric paradigm was a **political project that conscripted science to provide authority**.
- "Climate science" is therefore not just corrupted science — it is purpose-built instrumentation **wearing the lab coat of science while abandoning its method**.
- **Scientists' job is to kill bad theories and rip science back from politics — not posture as saviours of the planet.**

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