frontiers | Frontiers in Earth Science

TYPE Perspective
PUBLISHED 08 April 2025
DOI 10.3389/feart.2025.1554362

Global warming, carbon cycles, forests and photosynthesis; a hypothesis for global cooling

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RECEIVED 02 January 2025
ACCEPTED 24 March 2025
PUBLISHED 08 April 2025

CITATION
John JE (2025) Global warming, carbon cycles, forests and photosynthesis; a hypothesis for global cooling.
Front. Earth Sci. 13:1554362.
doi: 10.3389/feart.2025.1554362

In relation to global warming and the role of carbon dioxide, the atmospheric residence-time of carbon dioxide from industrial emissions, and the carbon dioxide fixation capacity by photosynthesis in forests, land areas and oceans is considered, for the decades 1960 to 2010. Carbon dioxide fixation in forests, annually and worldwide, is estimated to be larger than the annual and global carbon dioxide emissions from industrial and land use activities, for the decades 1960 to 2010. Observations of the Keeling curve for the period 1960 to 2010, imply slow and rate-limiting steps for the atmospheric carbon dioxide cycle from industrial emissions, namely the transfer of carbon dioxide from the atmosphere to the Earth's surface, forests, land areas and oceans. It is proposed that these carbon dioxide emissions have a long residence-time with significant accumulation in the atmosphere. Carbon dioxide emissions from natural-biological sources, namely respiration of organisms and passive emissions from the land and oceans, remain close to the Earth's surface, with short atmospheric residence-times, rapid conversion into biomass and no significant accumulation in the atmosphere. This is known as the natural carbon dioxide cycle. Research and development are proposed as follows; (a) determination of the atmospheric residence times of industrial, urban and natural carbon dioxide emissions, (b) effective cooling of flue gases from industrial emissions to direct these emissions to lower atmospheric altitude(s), and thereby decrease the atmospheric residence-time(s) of carbon dioxide and (c) synthetic hydrocarbon fuels for aircraft, which are low-carbon in the complete cycle, developed with public-funded research. Global, public-funded research and development programs are proposed for achieving these goals, involving national and international organisations and industries.

KEYWORDS

Keeling curve, carbon dioxide, greenhouse gases, atmospheric residence-time, flue gases, environmental technology, forests, oceans

Introduction

In relation to global warming and the role of carbon dioxide, the atmospheric residence-time of carbon dioxide from industrial emissions, and the capacity of carbon dioxide fixation by photosynthesis in forests, land areas and oceans are reviewed, for the period 1960 to 2010.

Industrial emissions of carbon dioxide into the Earth's atmosphere were 23 billion tonnes in 2003 (Global Carbon Project, 2003; Global Carbon Project, 2010), and emissions of carbon dioxide and methane from global land use were 6 billion tonnes in 2000 (Houghton and Hackler, 2002). Lesser amounts of carbon dioxide were released by respiration of plants, soil micro-organisms, animals and humans, which remained at the Earth's surface, and were converted rapidly into biomass in forests and farms. Since then, annual and global carbon dioxide emissions have increased further to 35 billion tonnes in 2020 (Friedlingstein et al., 2022; Peters et al., 2017). In view of global warming through carbon dioxide and other greenhouse gases (GHG) such as methane, chlorofluorocarbons (CFC), nitric oxides, etc., it is essential to reduce GHG emissions as much and as soon as possible (Canadell et al., 2010; Global Carbon Project, 2010; Gore, 1992; Gore, 2006; Hulme, 2005; IPCC, 2007; IPCC, 2014; IPCC, 2023; King, 2005; LeClere et al., 2015; Leggett, 2007; Weizsaecker et al., 1995).

It is proposed that cooling of flue gases from industries with high carbon dioxide emissions, will reduce the atmospheric residence times, and promote carbon sequestration in forests and oceans, and enhance global cooling.

Carbon emissions and forest capacity

Global carbon cycles convert carbon dioxide into biomass through atmospheric transfer and photosynthesis in forests, land areas and oceans. Thereby, atmospheric carbon dioxide concentrations were maintained at a steady-state of 280 ppm before industrialisation. It may be estimated how many trees are needed for the amount of industrial carbon dioxide emissions of the year 2005, since on average a tree generates about 15 to 25 kg of biomass each year from 25 to 40 kg of carbon dioxide (Forestry Dept, Kabini Jungle Lodges & Resorts, Karnataka, 2009). The estimates are lower for the temperate than the tropical regions, due to the warmer and wetter climate in tropical regions, and are used by the UNFCCC to ascertain carbon credits for primary forests and secondary forest plantations (UNEP). This is an estimate of about 1.2 trillion trees worldwide or 185 trees per person (year 2005), which is equivalent to global forest areas of 10 to 25 million sq km, depending on tree density and climate. In forests, wherein trees grow 5 m apart, the tree density is about 40,000 trees per sq km, i.e. 400 trees per hectare. In dense forests the trees grow 3 m apart, which is equivalent to 100,000 trees per sq km, i.e. 1000 trees per hectare (FAO RoAP, 2008). This suggests that global, cumulative forest areas of 30 million sq km with 1.5 to 3 trillion trees, covering 20% of Earth's land areas (FAO, Philip's Atlas of the World, 2003), would have the capacity to convert carbon dioxide from industrial emissions into biomass, for the decades 1960–2010. This suggests that global forest areas covering 20%–30% of Earth's land areas, comparable to present, global forest areas, are essential to maintain carbon dioxide concentrations at steady-state. Global forest areas can be increased and maintained at 30%–40% of Earth's land areas through afforestation, whereby each person plants or donates at least one or two trees each year, which produce at least 5 new trees each year after 5 years (Billion Tree Campaign, 2006; Steiner, 2006). This would generate at least a trillion trees in 20 years, equivalent to 10 to 20 million sq km of forests, a large increase (20%) in global forest areas. It is essential to reduce atmospheric carbon dioxide emissions by increasing energy efficiency, usage of renewable energy, recycling, re-using, public transport, rain-water harvesting, and afforestation (Gore, 1992; Gore, 2006; IPCC, 2007; IPCC, 2014; IPCC, 2023; Billion Tree Campaign, 2006; Steiner, 2006; UNEP, 2025; Weizsaecker et al., 1995).

Carbon cycles and additional photosynthetic capacity

A second perspective, evaluates the required *additional* photosynthetic capacity of the Earth's vegetated land areas of 110 million sq km (FAO, 2022) and oceans of 360 million sq km (Philip's Atlas of the World, 2003), to convert 30 billion tonnes of carbon dioxide into biomass each year. On land, in forests and land areas, the required additional photosynthetic capacity is 270 gm of carbon dioxide fixation per sq metre (sqm) each year, equivalent to 170 gm of dry biomass formation. In oceans, the required additional photosynthetic capacity of marine algae is 80 gm of carbon dioxide fixation per sqm each year, equivalent to 50 gm of dry biomass formation. It is of scientific interest to determine the conversion of additional carbon dioxide to biomass in forests and vegetated land areas at 270 gm of carbon dioxide per sqm each year, or in the oceans at 80 gm of carbon dioxide per sqm each year. Else, an arithmetic combination of these two approaches may be tested. The stoichiometric equations of photosynthesis and cellulose biosynthesis indicate that 27 gm of dry biomass are generated from 44 gm of carbon dioxide (Botany and Plant Physiology, 1985; Calvin, 1961; Falkowski and Raven, 2007). The photosynthetic process in plants is directly dependent on the concentrations of raw materials, namely carbon dioxide, water, nutrients and sunlight energy. An increase in carbon dioxide concentration increases the rate of photosynthesis and biomass formation, when growth conditions are optimal (Botany and Plant Physiology, 1985; Calvin, 1961; Falkowski and Raven, 2007).

Rate-limiting steps and carbon cycles

Estimates for the global capacity of carbon dioxide fixation through photosynthesis in forests during the decade 2000 to 2010 are above 50 billion tonnes of carbon dioxide fixation per annum, and may be atleast 100 billion tonnes of carbon dioxide fixation per annum (UNEP). Estimates for previous decades are larger, in view of deforestation. This is larger than the annual and global anthropogenic emissions of carbon dioxide, for the time period 1960 to 2010. Considering that atmospheric carbon dioxide concentrations and average temperatures have been rising since seven decades, globally, this implies that the atmospheric

Abbreviations: CO_2, carbon dioxide; CFC, chlorofluorocarbons; CSIRO, Commonwealth Scientific and Industrial Research Organisation; FAO, Food and Agricultural Organisation; GCP, Global Carbon Project; GHG, greenhouse gases; IPCC, Intergovernmental Panel on Climate Change; gm, gram; kg, kilogram; km, kilometre; msl, metre above sea level; ppm, parts per million; RoAP, Region of Asia and Pacific; sq, square; sq km, square kilometre; sqm, square metre; UNEP, United Nations Environment Program; UNFCCC, United Nations Framework Convention on Climate Change; UNO, United Nations Organisation; WMO, World Meteorological Organisation.

carbon cycles at higher altitudes are slow in comparison to the annual growth seasons in forests and farmland in temperate, sub-tropical and tropical climate zones. This may be observed by detailed analysis of the Keeling curve, for each annual cycle (Keeling Curve, 2025). The Keeling curve indicates that atmospheric carbon dioxide concentrations have been rising steadily since many decades, also when the annual and global carbon dioxide emissions were two-fold, three-fold or four-fold lower than in the decade 2000 to 2010 (Friedlingstein et al., 2022; Keeling Curve, 2025). The Keeling curve measurements are performed at the Mauna Loa Observatory in Hawaii, at an altitude of 3397 msl (Keeling Curve, 2025).

This would indicate that carbon dioxide emissions from industries reach high atmospheric altitudes from which they are transported *relatively slowly* to the Earth's surface, leading to the net accumulation of carbon dioxide in the atmosphere at these altitudes. Scientific information on the Asian atmospheric brown cloud indicates that these emissions reach an altitude of about 4000 msl, and requires a few weeks to spread around south Asia and south-east Asia (Calle et al., 2016; Cervarich et al., 2016; Solomon et al., 2007; Thompson et al., 2016). It has been observed that the discoloration of the Himalayan glaciers (Gangotri 4200 msl) is attributed to carbon and soot from thermal power stations in the Indo-Gangetic plain (Calle et al., 2016; Cervarich et al., 2016; Solomon et al., 2007; Thompson et al., 2016). A topographical survey along the glacier would indicate the upper altitudes of these emissions. Increased carbon dioxide concentrations at higher altitudes of 5000 msl and above are caused by aircraft and air travel, which is estimated to contribute about 2% of all industrial and anthropogenic carbon dioxide emissions (Lee et al., 2021).

Slow steps and steady-state atmospheric distribution

A fourth perspective on the atmospheric carbon cycle and the hypothesis mentioned here is described. It is known that about 45% of the anthropogenic carbon dioxide emissions remained in the atmosphere each year during the decade 2001 to 2010 (Friedlingstein et al., 2022; LeClere et al., 2009; Peters et al., 2017). It is also known that about 40% of the anthropogenic carbon dioxide emissions remained in the atmosphere about 50 years ago, in the decade 1960–1970 C.E. (Friedlingstein et al., 2022; LeClere et al., 2009; Peters et al., 2017), when the annual and global anthropogenic carbon dioxide emissions were fourfold lower than in 2010 (Friedlingstein et al., 2022). This steady-state distribution of carbon dioxide in the atmosphere is independent of the amount of anthropogenic carbon dioxide emissions. This would be consistent with slow step(s) in the atmospheric carbon cycle, at altitudes of 3400 msl and above. As atmospheric carbon dioxide concentrations were rising in the decades 1960 to 1980 with a constant, averaged gradient, when global carbon dioxide emissions were a fraction (1/4 and 1/3) of what they were in 2010, this would imply slow step(s) in the atmospheric carbon cycle (Keeling Curve, 2025). This hypothesis may be tested through research.

Summary and outlook

The validation of this hypothesis would enable the development of technologies for reducing the atmospheric residence time of carbon dioxide, by directing industrial carbon dioxide emissions to lower altitudes, through effective cooling of flue gases from industries such as thermal power, iron and steel, oil & gas, petrochemicals, cement, metals, etc. Thereby, industrial carbon dioxide emissions would reach lower altitudes only (2000–2500 msl), which would reduce the mean residence time of carbon dioxide in the atmosphere, increase the transfer of carbon dioxide to forests, land areas and oceans, and increase photosynthetic conversion of carbon dioxide into biomass. It is proposed that this would reduce carbon dioxide concentrations in the atmosphere. It is proposed that this would require global, co-ordinated and public-funded research, involving national and international organisations and industries.

Other approaches that have been proposed include carbon sequestration (or carbon capture and storage), and certain forms of geo-engineering (Balaram, 2008). The hypothesis and approach described in this manuscript have not been researched (Solomon et al., 2009). With systems ecological approaches, slow and fast steps have been researched in ecological cycles of nature, where the fluxes and accumulation of substances are determined by multiple and cyclic processes, such as conservation and afforestation, rainfall, forests and rivers, forests and soil conservation, forests and the water table, lakes and the water table.

Energy systems that are ecologically sustainable and affordable are essential, and so are life-styles that are supportive for the common good and planet Earth, our global village and only home (Carlson, 1962; Gandhi, 1925; Gore, 1992; Gore, 2006; Rosenstock-Huessy, 1910; Weizsaecker et al., 1995). Planting or donating a few trees each year is a green contribution to afforestation and the common good (Billion Tree Campaign, 2006; Steiner, 2006). Increasing energy efficiency is at least as important (King, 2005; Leggett, 2007; Weizsaecker et al., 1995). Significantly, synthetic hydrocarbon fuels for cooking, travel and industries may be manufactured by processes that are overall low in carbon dioxide emissions (Alipour et al., 2023; Challiwala et al., 2021; John, 2007; Zhang et al., 2024).

Systems ecological approaches and environmental technologies that direct carbon dioxide emissions from industries along *lower* atmospheric altitudes will result in *shorter* atmospheric residence-times of carbon dioxide. This would be achievable with extensive cooling of flue gases from all carbon dioxide emitting industries. This would quicken and increase the transfer of atmospheric carbon dioxide to the Earth's surface, increase carbon dioxide uptake and photosynthesis in forests, land areas and oceans, and concomitantly increase biomass formation. This would require global and co-ordinated research and development programs, involving national and international organisations and industries. These systems ecological approaches and environmental technologies would, decrease atmospheric carbon dioxide concentrations, minimise global warming and be sustainable for nature, society and the world.

Objectives

Novel concepts on the anthropogenic carbon cycle, forests and oceans, and environmental technologies are described, for research, development and implementation for climate protection and global cooling, worldwide.

Classification

Biological Sciences; Environmental Sciences; Sustainability Science.

Physical Sciences, Earth, Atmospheric, and Planetary Sciences; Engineering; Environmental Sciences; Sustainability Science.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: United Nations Environment Program.

Author contributions

JJ: Conceptualization, Formal Analysis, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing.

Funding

The author(s) declare that no financial support was received for the research and/or publication of this article.

Acknowledgments

The author acknowledges prior correspondence on these topics with Dr. Richard Houghton (Woodswell Climate Research Centre, Falmouth, MA, USA), Dr. Joseph Canadell (Global Carbon Project, WMO and CSIRO Oceans and Atmosphere, Canberra, Australia), Dr. Achim Steiner, (Executive Director, UNEP, Nairobi, Kenya), Dr. Wangari Maathai (Green Belt Movement, Nairobi, Kenya), Dr. R. Srinivasan (Divecha Centre for Climate Change, Indian Institute of Science, Bangalore, India).

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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