*Journal of Geography, Environment and Earth Science International*

*19(4): 1-8, 2019; Article no.JGEESI.47650*
*ISSN: 2454-7352*

# Role of Atmospheric Convection in Global Warming

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***Author's contribution***

*The sole author designed, analysed, interpreted and prepared the manuscript.*

***Article Information***

DOI: 10.9734/JGEESI/2019/v19i430091
*Editor(s):*
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Complete Peer review History: http://www.sdiarticle3.com/review-history/47650

***Original Research Article***

***Received 17 December 2018***
***Accepted 28 February 2019***
***Published 13 March 2019***

## ABSTRACT

**Aims:** Geophysical convection calculations can potentially obscure details necessary to understand convective-heat-transfer changes caused by changes in the adverse temperature gradient. The objective is to ascertain the functional relationship between adverse temperature gradient and convection efficiency.

**Methodology:** A classroom-demonstration experiment was conducted to illustrate the principle that convection efficiency is a direct function of the adverse temperature gradient.

**Results:** Application of this principle to climate science has profound implications for global warming. A brief period of global warming during World War II followed by rapid global cooling afterward is attributable, not to carbon dioxide, but to particulate pollution and its generalization to post-1950 global warming. Rather than simply blocking sunlight and causing global cooling, aerosol particles are radiation absorbers that rapidly transfer heat to the surrounding atmosphere, raising its temperature relative to atmospheric temperature at Earth's surface. Thus the reduction of the adverse temperature gradient between the upper troposphere and the surface reduces atmospheric convection and concomitantly reduces convection-driven surface heat loss, causing global warming, heating the oceans, and reducing $CO_2$ solubility and releasing dissolved $CO_2$ to the atmosphere.

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**Conclusions:** Increasing levels of atmospheric $CO_2$, rather than causing global warming, are symptomatic of particulate-pollution-caused global warming. The Anthropocene idea cannot be justified by anthropogenic $CO_2$. Instead the Anthropocene is better characterized by anthropogenic particulate pollution. A drastic reduction in particulate-pollutant emissions will be followed by a rapid and drastic reduction in global warming, as tropospheric pollution-particulates fall to ground in days to weeks, thus increasing atmospheric convection efficiency and potentially providing a radical solution to the global climate crisis. Moreover, reduction of particulate-pollution, the greatest environmental health-threat, will potentially save millions of lives and reduce the suffering of many more.

*Keywords: Global warming; atmospheric convection; particulate pollution; aerosol heating.*

## 1. INTRODUCTION

Geophysical atmospheric convection models are generally complex [1,2], typically involving solution of hydrodynamic equations of motion coupled with assumptions [3,4]. Calculations become especially opaque when parameterization is used [5]. Consequently, critical details of the actual physical process of convection may be obscured, details that are necessary to make substantive advances in scientific understanding, and to correct misperceptions.

Thermal convection is an easily visualized process: Add a few tea leaves to a pot of water on the stovetop. Before the water starts to boil, the tea leaves circulate from bottom to top and top to bottom carried along by the motion of the water. This is convection.

Chandrasekhar described convection in the following, easy-to-understand way [6]: *The simplest example of thermally induced convection arises when a horizontal layer of fluid is heated from below and an adverse temperature gradient is maintained. The adjective 'adverse' is used to qualify the prevailing temperature gradient, since, on account of thermal expansion, the fluid at the bottom becomes lighter than the fluid at the top; and this is a top-heavy arrangement which is potentially unstable. Under these circumstances the fluid will try to redistribute itself to redress this weakness in its arrangement. This is how thermal convection originates: It represents the efforts of the fluid to restore to itself some degree of stability.*

Surprisingly, the consequences of the adverse temperature gradient on convection are rarely, if ever, explicitly considered in geophysical convection calculations [7]. For example, atmospheric heating by particulate matter has been said to cause "*changes in the atmospheric temperature structure*" [8] without mentioning the consequences on atmospheric convection and the concomitant surface-heat-transfer reduction that results from the diminished adverse temperature gradient.

Atmospheric convection calculations relating to the consequences of adverse temperature gradients are necessarily complex, and may not be possible without *ad hoc* assumptions and simplifications. Nevertheless, a simple classroom-demonstration experiment can serve as guidance for understanding.

## 2. METHODOLOGY

The convection classroom-demonstration experiment was conducted by this author using a 4 liter beaked-beaker, nearly filled with distilled water, and heated on a regulated hot plate. As an indicator of convection, celery seeds were added to be dragged along by convective motions in the water. After stable convection was obtained, a ceramic tile was placed atop the beaker to retard heat loss, thus increasing the temperature at the top relative to that at the bottom, thus decreasing the adverse temperature gradient. The reduction of the number of celery seeds in motion indicated the reduction in convection, which was recorded photographically [9].

## 3. RESULTS AND DISCUSSION

Fig. 1 presents images of the beaker on the regulated hot plate taken over a period of one minute abstracted from a video record [9]. The T=0 image was taken after stable convection was attained and just before the ceramic tile was placed atop the beaker. Placing the tile atop the beaker reduced heat-loss from the surface, raising the temperature at the top of the solution relative to that of the bottom, which reduced the adverse temperature gradient. In just one minute the number of celery seeds in motion, driven by convection, decreased markedly, demonstrating that reducing the adverse temperature gradient decreased convection.

The climate science community, including the United Nations' Intergovernmental Panel on Climate Change (IPCC), has promulgated the false idea that aerosol particulates cause global cooling by blocking sunlight [7,10-12]. However, it has recently become clear that aerosol particles are efficient absorbers of solar radiation, either separately as large particles or as assemblages of small particles which rapidly transfer that heat to the surrounding atmospheric gases [13-16].

One primary consequence of heating the upper troposphere through heat-absorbing particulate matter can be directly inferred from the experimental observations presented here.

Particles in the troposphere, heated by solar radiation or by radiation from Earth's surface, transfer that heat to the surrounding atmosphere, which raises its temperature relative to atmospheric temperature at Earth's surface. In other words, the adverse temperature gradient between the upper troposphere and the surface is lowered, which reduces atmospheric convection, and concomitantly *reduces convection-driven surface heat loss*.

The consequence is increased global warming. The lowering of the adverse temperature gradient in the lower atmosphere is the primary way global particulate pollution causes global warming.

Life on Earth is possible in part because a natural radiation balance exists between our planet and the sun. The widely promoted perception that anthropogenic greenhouse gases, mainly carbon dioxide [$CO_2$], cause global warming by trapping heat that should otherwise be radiated into space [7,17,18] is dubious. Further, those who argue that there is no unnatural global warming are often called "deniers" [19,20], and are also unlikely to be correct. As described below, it has recently become possible to show that neither of these perceptions about climate change is correct. Human activity is indeed causing global warming, but not principally by greenhouse gas emissions. Particulate pollution emissions are, instead, likely the main cause of ongoing global warming [16,21,22].

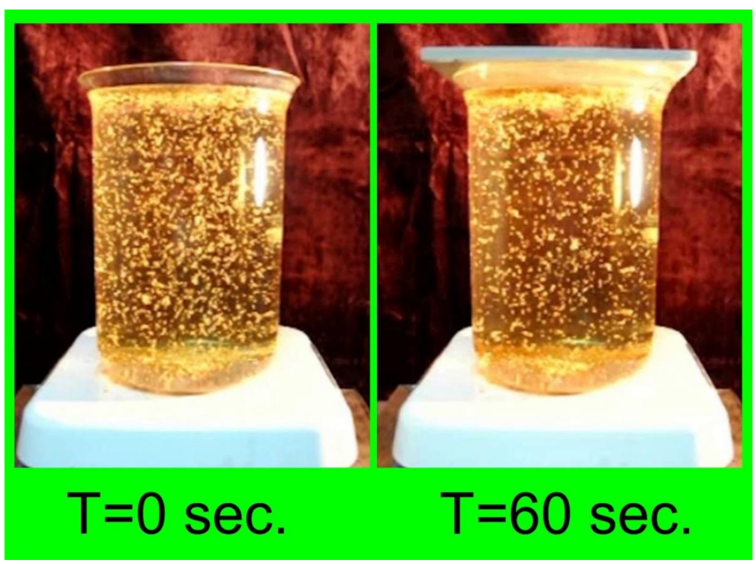


**Fig. 1. A beaker of water on a regulated hot plate with celery seeds pulled along by the fluid convection motions**

*Placing a ceramic tile atop the beaker a moment after T=0 reduced heat-loss, effectively warming the upper solution's temperature, thus lowering the adverse temperature gradient, and reducing convection, indicated by the decreased number of celery seeds in motion at T=60 sec. That reduction in convection is reasonable considering zero adverse temperature gradient is by definition zero thermal convection. This simple classroom-demonstration illustrates well the principle that convection efficiency is a direct function of adverse temperature gradient. The application of this principle to climate science has profound implications bearing on global warming*

The observations that led to this discovery began with an image on the front page of the January 19, 2017 *New York Times*, a global surface temperature presentation that showed a bump, an abrupt upward climb in temperatures coincident with World War II (WW2). Inspired by that image, Harvard physicist Bernard Gottschalk [23,24] applied sophisticated curve-fitting techniques and demonstrated the bump is a robust feature evident in eight independent NOAA datasets. The bump in relative temperature, Gottschalk concluded, “is a consequence of human activity during WW2” [23].

Inspired by Gottschalk’s work [23,24], this author [21] realized that two WW2 consequences were potentially capable of altering the sun-earth radiation balance to cause global warming: Particulate pollution and carbon dioxide.

Fig. 2 from [23] is a copy of Gottschalk’s figure to which has been added three relative-value proxies which represent major activities that produce particulate pollution [21]. The proxies are: Global coal production [25,26]; global crude oil production [26,27]; and, global aviation fuel consumption [26]. Each proxy dataset was normalized to its value at the date 1986 and each relative-value curve was then anchored at 1986 to Gottschalk’s boldface relative global warming curve. The particulate-proxies track well with the eight NOAA global datasets used by Gottschalk.

During WW2, a great spike in air pollution inevitably occurred from maximized industrial production, from smoke and coal fly ash spewing forth from the smokestacks of industries, utilities, and locomotive engines, from greatly increased marine and aeronautical transport, and from extensive military activities that polluted the air with aircraft, ship, and vehicle exhaust and with the consequences of vast numbers of munition detonations, including the demolition of entire cities, and their resulting debris and smoke. The implication is that global warming during WW2 was caused by the pollution particulates trapping heat that should have been returned to space, thus altering Earth’s delicate thermal balance [21].

The very activities that cause particulate pollution typically produce massive amounts of carbon dioxide. WW2 global warming, however, was not produced by atmospheric $CO_2$. The extremely-long atmospheric residence time of carbon dioxide (decades or longer) [7] eliminates it as the principal cause of WW2 global warming because, just after WW2, the global temperature plummeted. Rapid cessation of WW2 global warming is understandable as tropospheric pollution-particulates fall to ground in days to weeks [28].

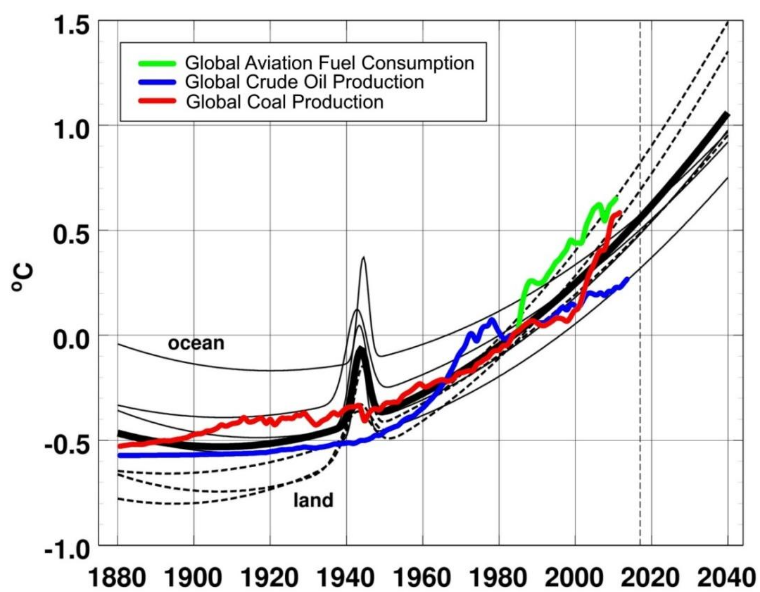


**Fig. 2. Copy of Gottschalk’s fitted curves for eight NOAA data sets showing relative temperature profiles over time [23] to which are added proxies for particulate pollution**
*Dashed line: land; light line: ocean; bold line: weighted average. From [21]*

As the aerosolized particulates settled to ground after the war, Earth radiated its excess trapped energy, and global warming abruptly subsided. But only for a brief time, as particulate pollution began to rise again from ramped-up post-WW2 industrial growth, initially in Europe and Japan, and later in China, India, and the rest of Asia, dramatically increasing worldwide aerosol particulate pollution [29].

To maintain thermal balance, Earth must return to space virtually all of the energy it receives from the sun as well as the energy it produces internally. That complex thermal balance has been maintained naturally without human intervention for most of Earth's lifetime.

Fig. 3 is a schematic representation of Earth's atmosphere. The vertical region where atmospheric convection principally occurs is indicated by the convection-beaker image. In this region pollution particles absorb solar radiation and radiation from Earth, become heated, and transfer that heat to the surrounding atmosphere, which reduces the adverse temperature gradient relative to the surface. The consequence of the reduced adverse temperature gradient is to reduce atmospheric convection, which in turn reduces convective heat-loss from the surface, causing global warming.

Science progresses by replacing less-precise understanding with more-precise understanding, a process that necessitates the constant questioning of current ideas. Even at the highest levels, however, the climate-science community has failed to question the belief that anthropogenic carbon dioxide is the causal agent of global warming. No one seems to have asked the basic scientific question, "What could be wrong with this picture?"

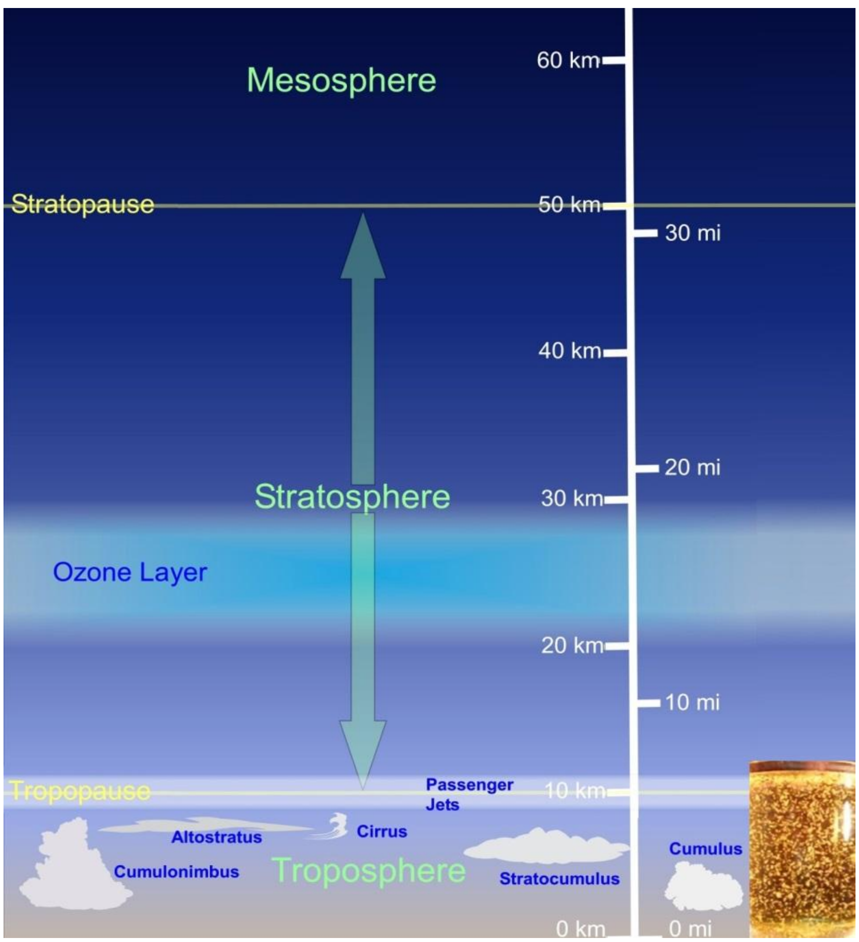


**Fig. 3. Schematic representation of Earth's atmosphere. The convection-beaker image indicates the vertical region of the atmosphere where convection is a common feature**

One thing that is wrong is that global warming unquestioningly warms the oceans, the main reservoir of $CO_2$. Warming the oceans not only lowers the solubility of $CO_2$, but also releases dissolved $CO_2$ into the atmosphere [22,30]. The increasing levels of atmospheric $CO_2$, rather than necessarily causing global warming, are symptomatic of an entirely different, unrecognized cause of global warming. It appears that the climate-science community took at face value the erroneous assertion that particulates cool the atmosphere [7,10-12].

Steffen, Crutzen, and McNeill [31] have been instrumental in developing the idea of the Anthropocene, the proposed post-Holocene epoch in which human activity has become a global geophysical force. They propose that the "Great Acceleration" of this new epoch happened when carbon dioxide's "growth rate hit a take-off point around 1950."

The idea of the Anthropocene cannot be justified by anthropogenic $CO_2$. The Anthropocene is better characterized by anthropogenic particulate pollution. The "Great Acceleration" of particulate pollution was ushered in during WW2, and after a few years pause, by the massive increase in global industrial growth with its concomitant particulate pollution.

The good news is that a drastic reduction in particulate-pollutant emissions will be quickly followed by a drastic reduction in global warming. As tropospheric pollution-particulates fall to ground in days to weeks [28], the atmospheric adverse temperature gradient relative to the surface increases, thus increasing convective-driven heat loss from the surface and concomitantly reducing global warming. Moreover, reduction of particulate-pollution, the greatest environmental health-threat, will potentially save millions of lives and reduce the suffering of many more [32].

## 4. CONCLUSION

During WW2 massive quantities of particulate-pollutants and carbon dioxide were released into the atmosphere. The WW2 "bump" in the relative global thermal profile in eight NOAA datasets shows abrupt anthropogenic global warming and abrupt global cooling. Because $CO_2$ has a long lifetime in the atmosphere, the rapid global cooling at the end of WW2 is inconsistent with $CO_2$-trapped heat. Instead, the sudden global cooling indicates global warming is caused by aerosolized particulate-pollution that falls to ground in a matter of days to weeks.

Recent scientific papers show that aerosolized particulates absorb incoming solar radiation as well as outgoing radiation from Earth's surface. Thus heated, the particles transfer that heat to the surrounding atmosphere. The consequence of heating the upper troposphere – illustrated by a classroom-convection demonstration – is to reduce the adverse temperature gradient between the upper troposphere and Earth's surface atmosphere; this, in turn, reduces convective heat loss and causes global warming.

Further, particulate-pollution-caused global warming heats the oceans, lowers the solubility of $CO_2$, and thus also acts to release into the atmosphere $CO_2$ dissolved in the oceans. Rather than causing global warming, increased levels of atmospheric $CO_2$ are symptomatic of an entirely different thermal-trapping process; particulate-pollution caused global warming. The Anthropocene idea cannot be justified by anthropogenic $CO_2$, but is better characterized by anthropogenic particulate pollution.

Trapping and reducing particulates is well within humanity's present technological and managerial know-how. The rapidity by which tropospheric pollution-particulates fall to ground, in days to weeks, assures swift restoration of atmospheric convection efficiency. If a worldwide effort to reduce aerosol particulate-pollution emissions were adopted, it would be followed by a rapid and drastic reduction in global warming and a significant improvement in planetary public health.

## COMPETING INTERESTS

Author has declared that no competing interests exist.

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