Climate Change versus Climate Crisis

(Teaching Math as if Our Survival Matters)

Marty Walter

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Shanghai,China
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200 Years of Climate Science

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Joseph Fourier

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Joseph Fourier (1768-1830)

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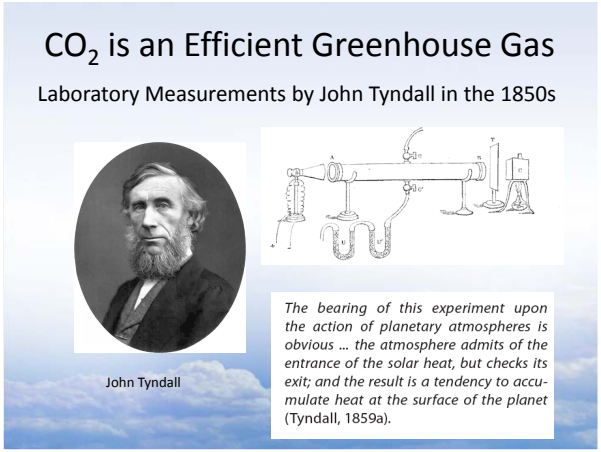

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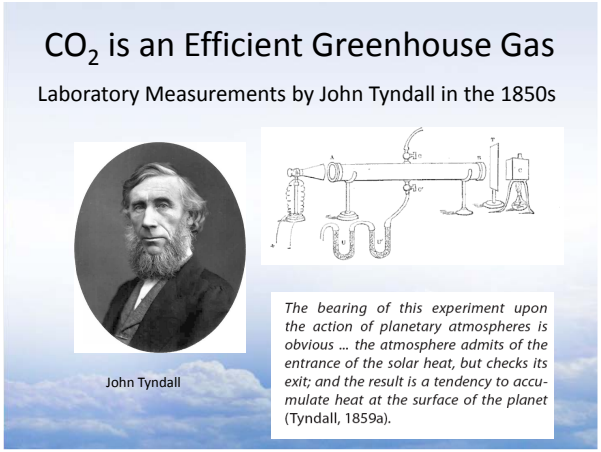

Partial Answer: CO_2 and H_2O

More Science

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Svante Arrhenius

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Give up TV remote!!

The CO_2 Greenhouse Gas Law of Svante Arrhenius

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What is this law?

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The CO_2 Greenhouse Gas Law of Svante Arrhenius

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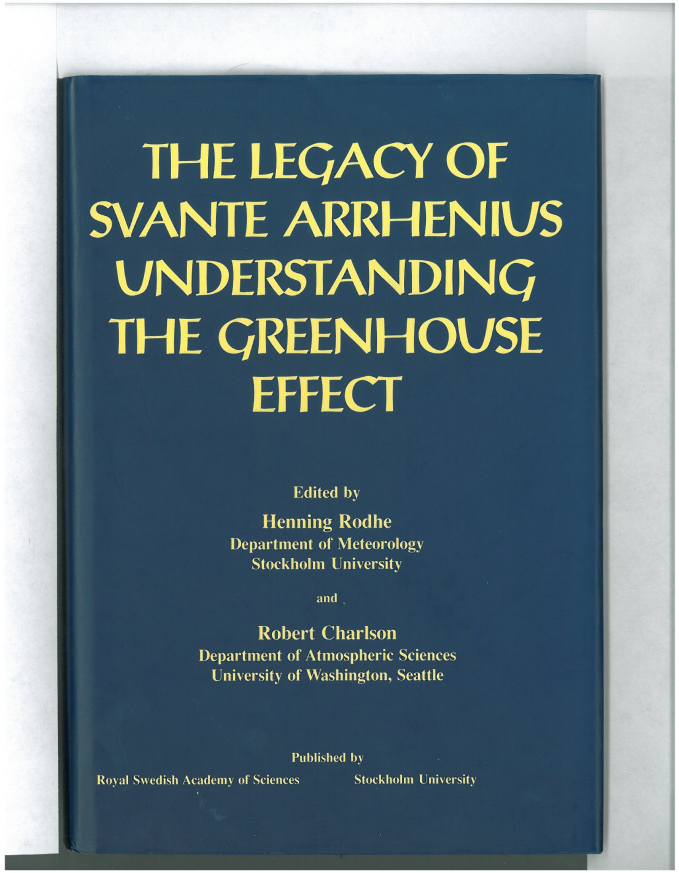
CONCLUSION: Increased CO_2 now increases

Solar Heating by $\approx 1\%$.

The Law of Arrhenius Still Holds!



This BOOK was recently published (1996) by
The Royal Swedish Academy of Sciences
Celebrating the 100^{th} Anniversary
of the discovery of the Law of Arrhenius

Still More Science

GEOPHYSICAL RESEARCH LETTERS, VOL. 25, NO.14, PAGES 2715-2718, JULY 15, 1998

New estimates of radiative forcing due to well mixed greenhouse gases

Gunnar Myhre
Department of Geophysics, University of Oslo, Norway

Eleanor J. Highwood and Keith P. Shine
Department of Meteorology, University of Reading, UK

Frode Stordal
Norwegian Institute for Air Research (NILU), Norway

Abstract. We have performed new calculations of the radiative forcing due to changes in the concentrations of the most important well mixed greenhouse gases (WMGG) since pre-industrial time. Three radiative transfer models are used. The radiative forcing due to CO_2, including shortwave absorption, is 15% lower than the previous IPCC estimate. The radiative forcing due to all the WMGG is calculated to 2.25 Wm^{-2}, which we estimate to be accurate to within about 5%. The importance of the CFCs is increased by about 20% relative to the total effect of all WMGG compared to previous estimates. We present updates to simple forcing-concentration relationships previously used by IPCC.

1. Introduction

The radiative forcing due to changes in the well-mixed greenhouse gases (WMGG) from pre-industrial times to the present day has been estimated to be 2.45 Wm^{-2}, carbon dioxide being the major contributor (64% of total) [*IPCC*, 1995]. However, several studies have since shown a lower radiative forcing due to CO_2 than the *IPCC* [1995] estimate [*Cess et al.*, 1993; *Pinnock et al.*, 1995; *Myhre and Stordal*, 1997; *Mitchell and Johns*, 1997]. Recent calculations also show a higher radiative forcing due to most of the halocarbons compared to *IPCC* [1995][*Pinnock et al.*,,1995; *Hansen et al.*, 1997a; *Myhre and Stordal*, 1997; *Christidis et al.*, Previous estimates of radiative forcing [*IPCC*, 1995] have not necessarily been based on consistent model conditions.

This work presents new calculations of radiative forcing due to the most important WMGG, using a consistent set of models and assumptions. Three radiative transfer schemes are used, a line-by-line (LBL) model, a narrow-band model (NBM) and a broad band model (BBM). *IPCC* [1990] presented simplified expressions relating the radiative forcing to the change in concentration and initial concentration of the WMGG. The coefficients of the simplified expressions must also be reviewed when discrepancies arise between the IPCC estimates of radiative forcing and more recent calculations. New coefficients are suggested based on the new model results. Only the direct forcing due to a change in WMGG concentration is considered here.

2. Models and Methods

The LBL model [*Edwards*, 1992] is used to calculate optical depths and radiative fluxes are calculated as in the work of *Myhre and Stordal* [1997]. The NBM is the 10cm^{-1} narrow band radiative transfer scheme of *Shine* [1991]. In this study, the scheme is used with spectral band data from HITRAN-1996 except for CFC-11, which uses the average cross-section from *Christidis et al.* [1997] and CFC-12, which is from HITRAN-92.

More Greenhouse Gas Laws

Table 3. Simplified expressions used in *IPCC* [1990] (Table 2.2)

Trace gas	Simplied expression Radiative forcing, ΔF, Wm^{-2}	Constants α IPCC	Best estimate this work[a]
CO_2	$\Delta F=\alpha\ \ln(C/C_0)$	6.3	5.35
CH_4	$\Delta F=\alpha\ (\sqrt{M}-\sqrt{M_0})-(f(M,N_0)-f(M_0,N_0))$	0.036	0.036
N_2O	$\Delta F=\alpha\ (\sqrt{N}-\sqrt{N_0})-(f(M_0,N)-f(M_0,N_0))$	0.14	0.12
CFC-11[b]	$\Delta F=\alpha\ (X-X_0)$	0.22	0.25
CFC-12	$\Delta F=\alpha\ (X-X_0)$	0.28	0.33

$f(M,N)=0.47\ \ln[1+2.01\times10^{-5}(MN)^{0.75}+5.31\times10^{-15}M(MN)^{1.52}]$
C is CO_2 in ppmv
M is CH_4 in ppbv
N is N_2O in ppbv
X is CFC in ppbv
The subscript 0 denotes the unperturbed concentration.
[a]Based on the NBM and BBM results the uncertainties associated with the constants are assumed to be 1% for CO_2, 10% for CH_4, 5% for N_2O and CFC-11, and 3% for CFC-12.
[b]The same expression is used for all CFCs, but with different values for α.

IPCC expressions are shown in Table 3. For CO_2 we have chosen the coefficients based on the BBM calculations, which is lower than the one derived from the NBM, due to inclusion of solar absorption by CO_2 only

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Money of the Few Buys Decision for the Many

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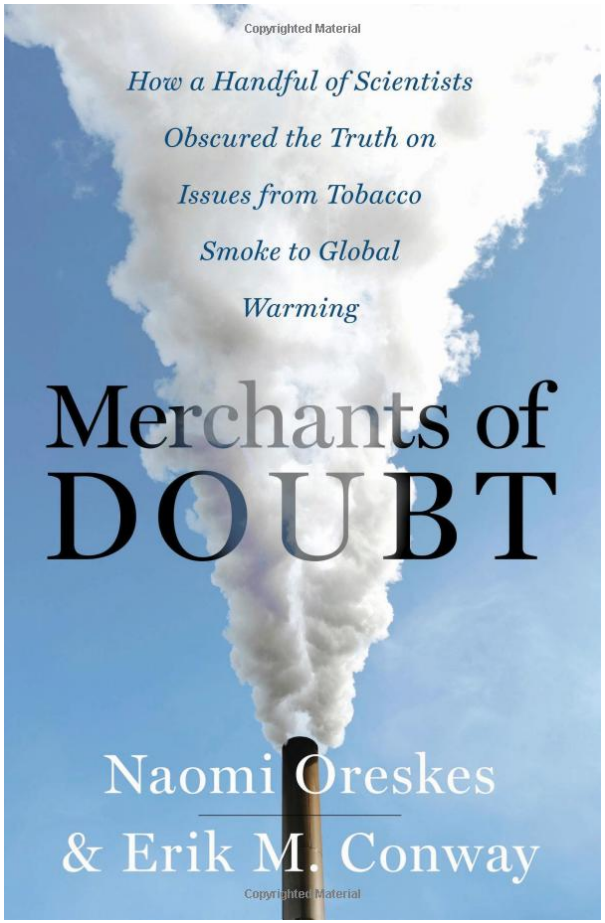

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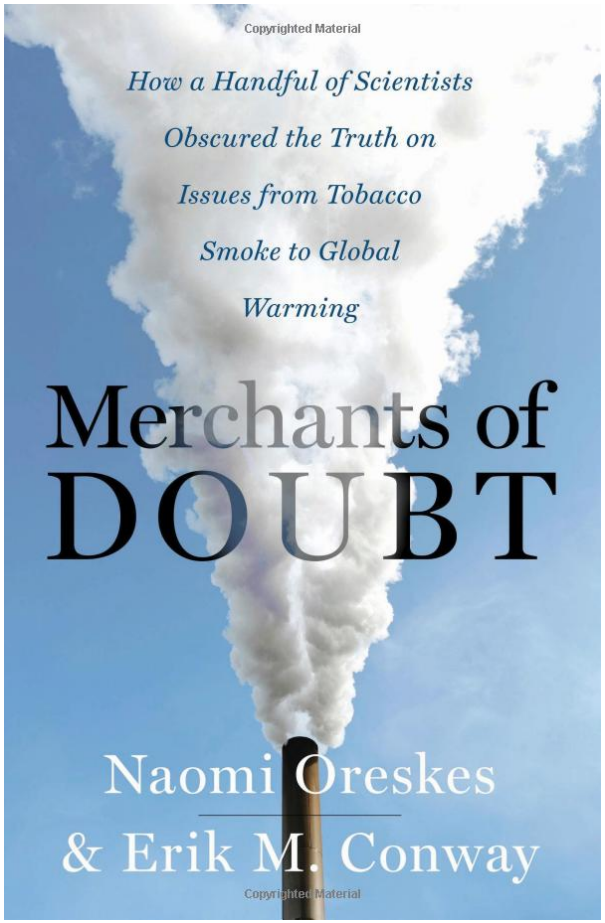
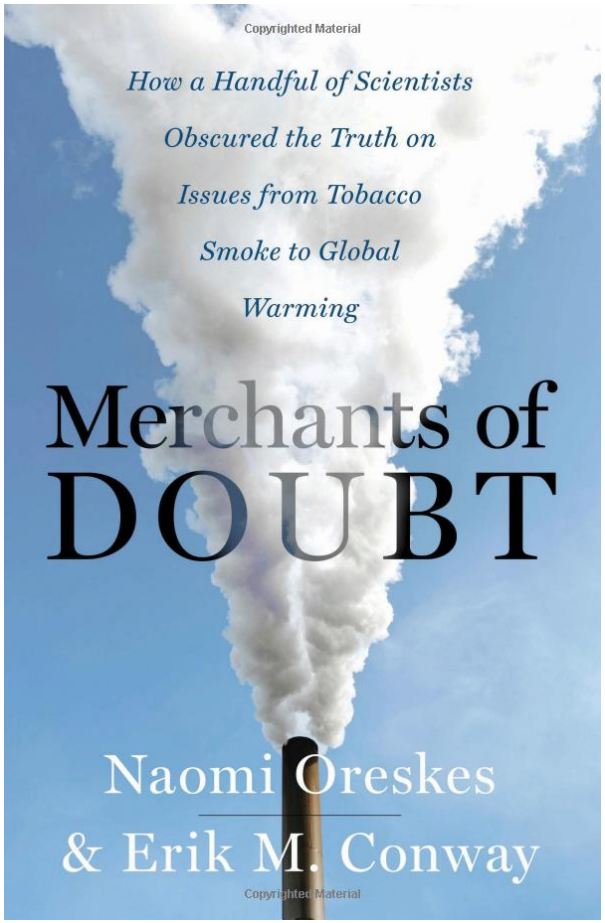


- Diggin up Fossil Fuels concentrates Money in the hands of a few

Money of the Few Buys Decision for the Many



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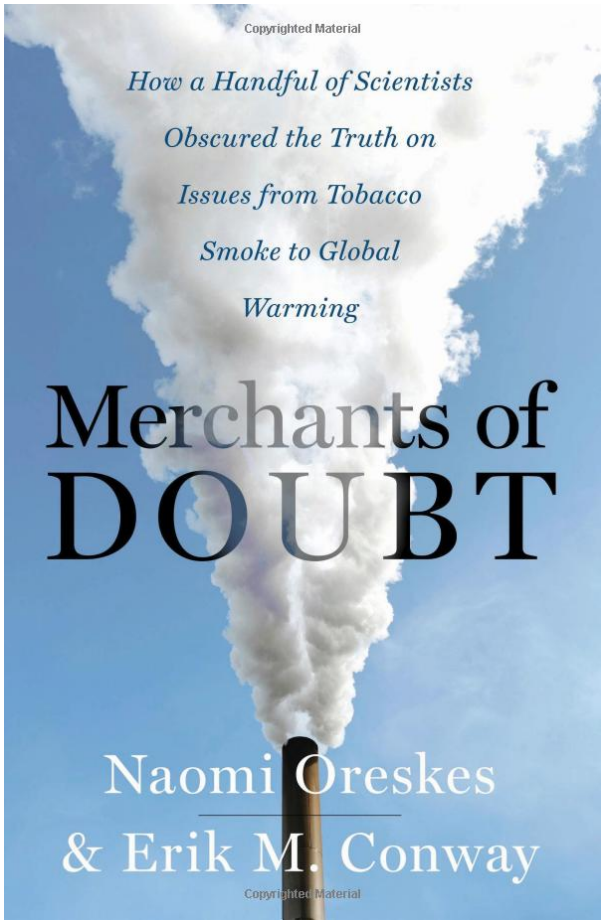

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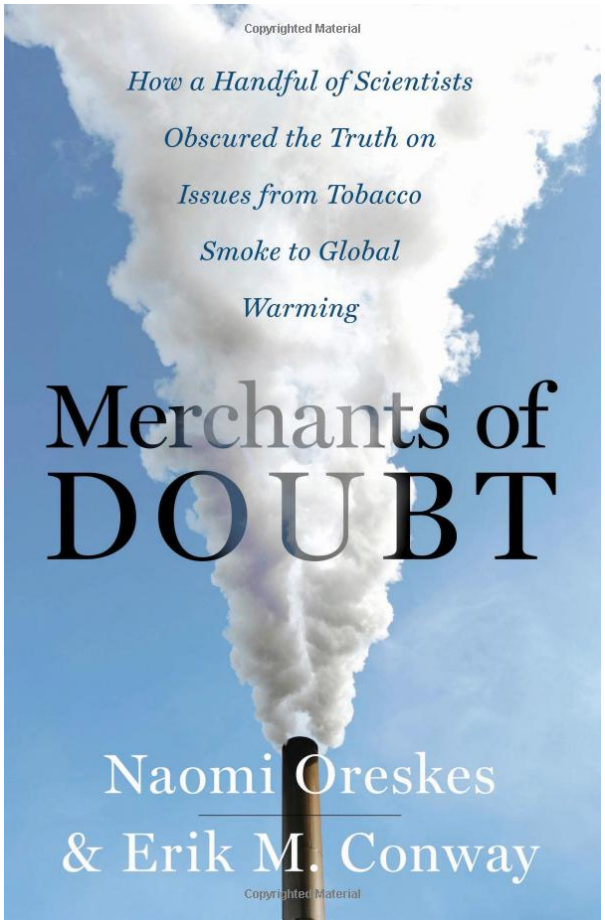

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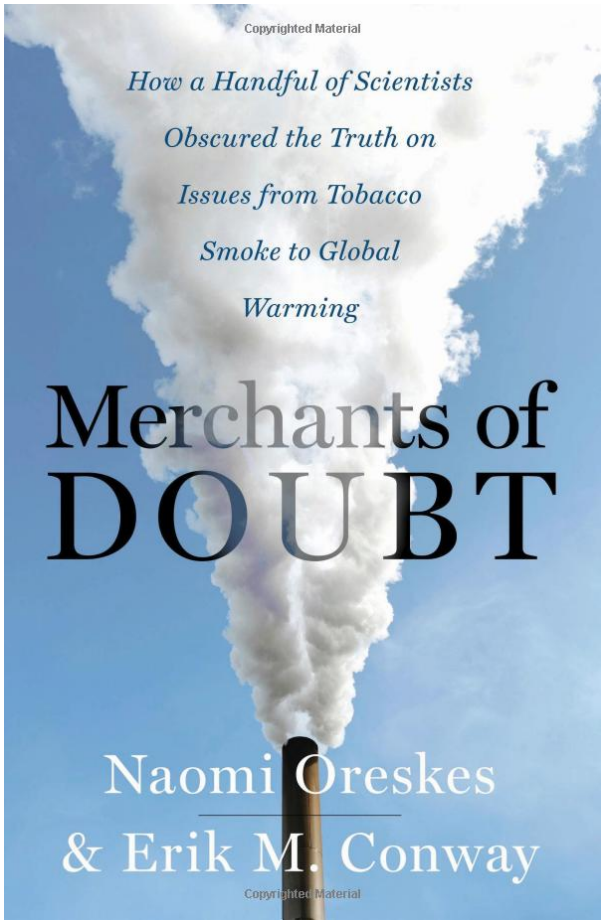

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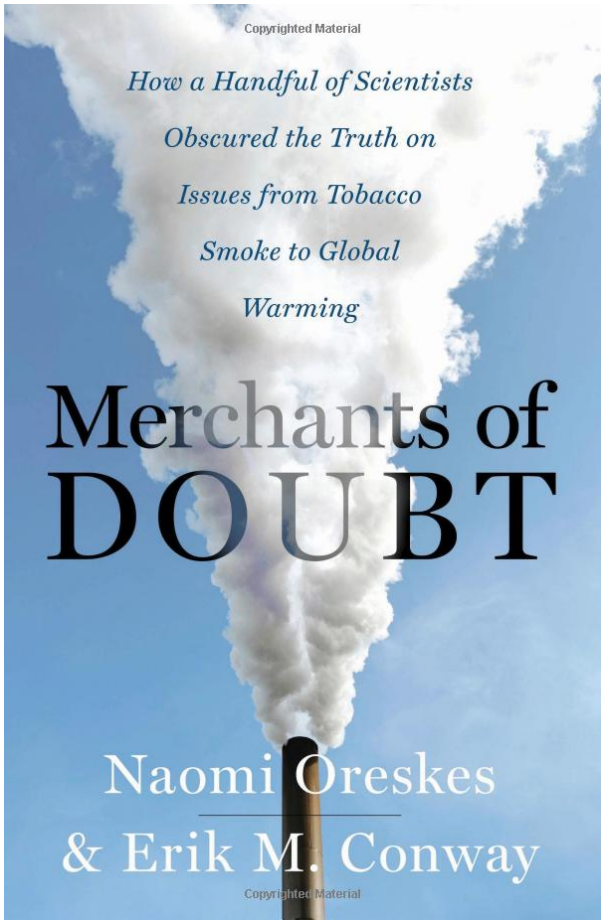

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To Continue burning Fossil Fuels

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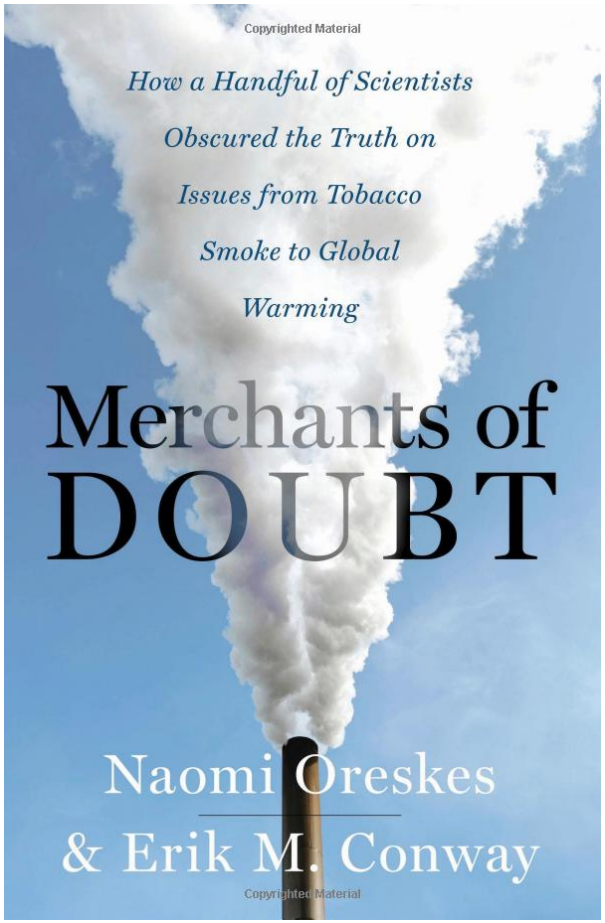

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Expensive-Sophisticated Propagandanda

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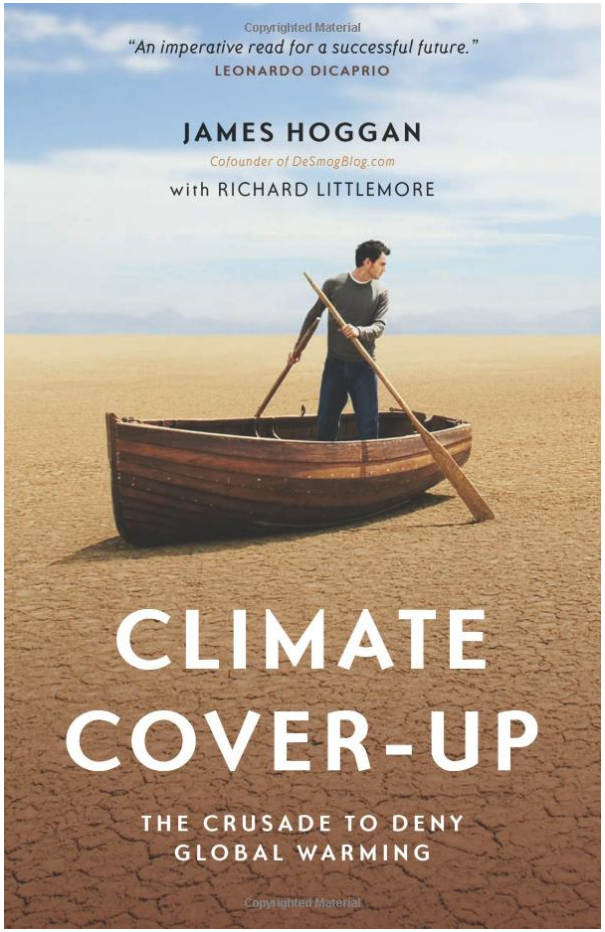

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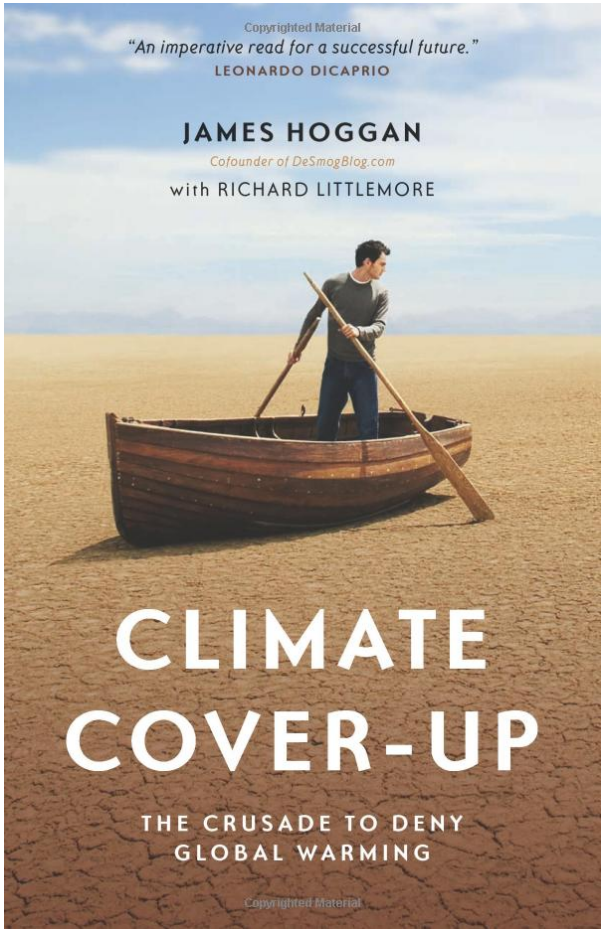

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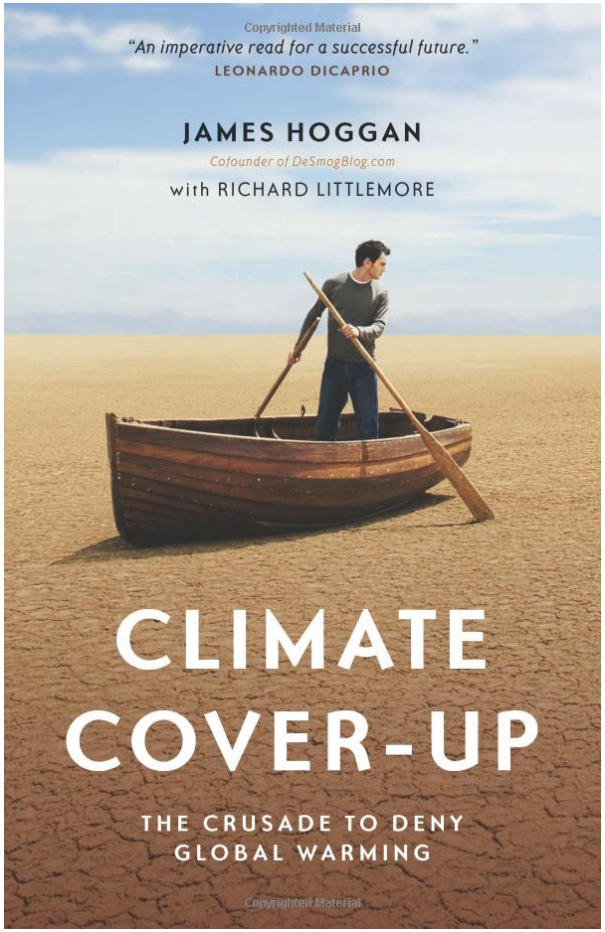

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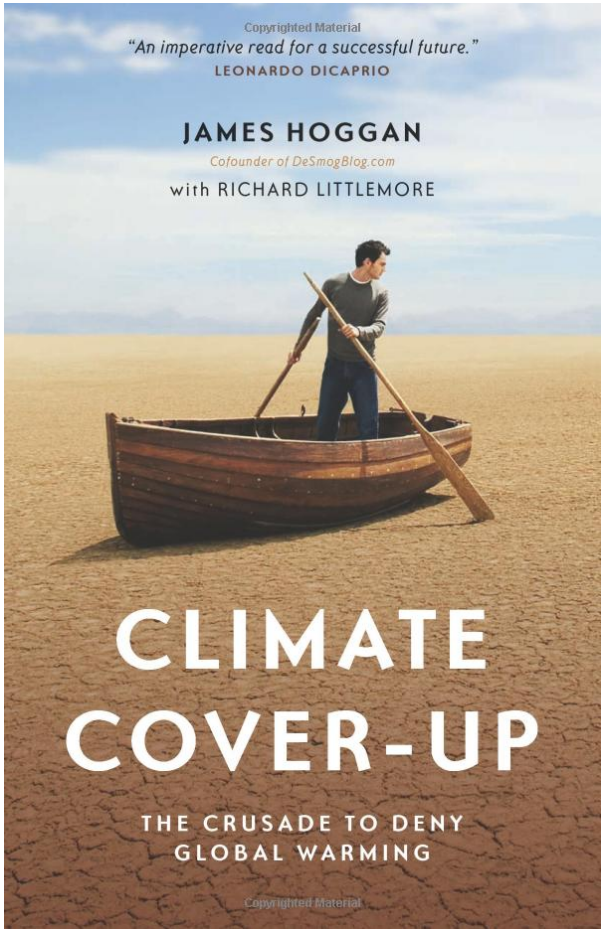

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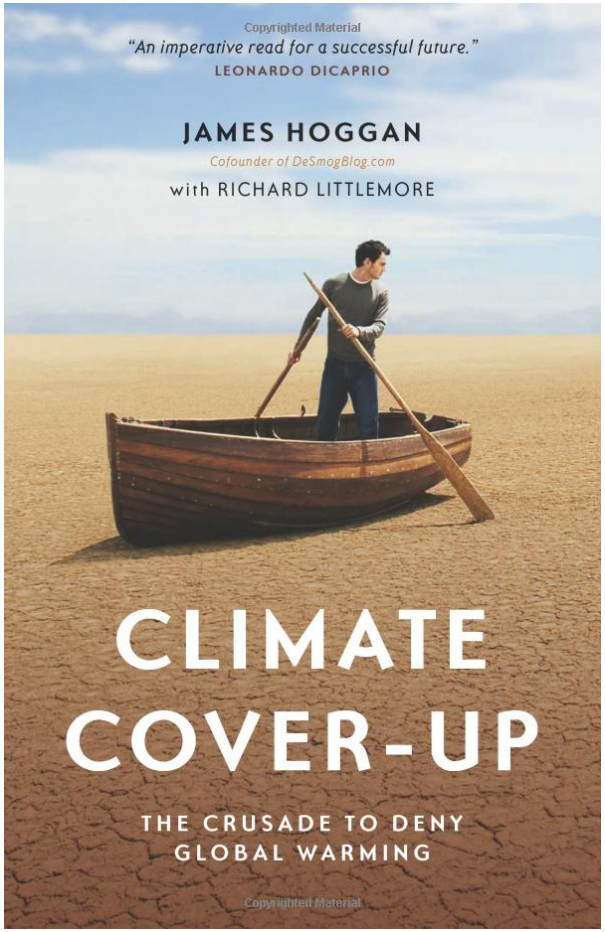

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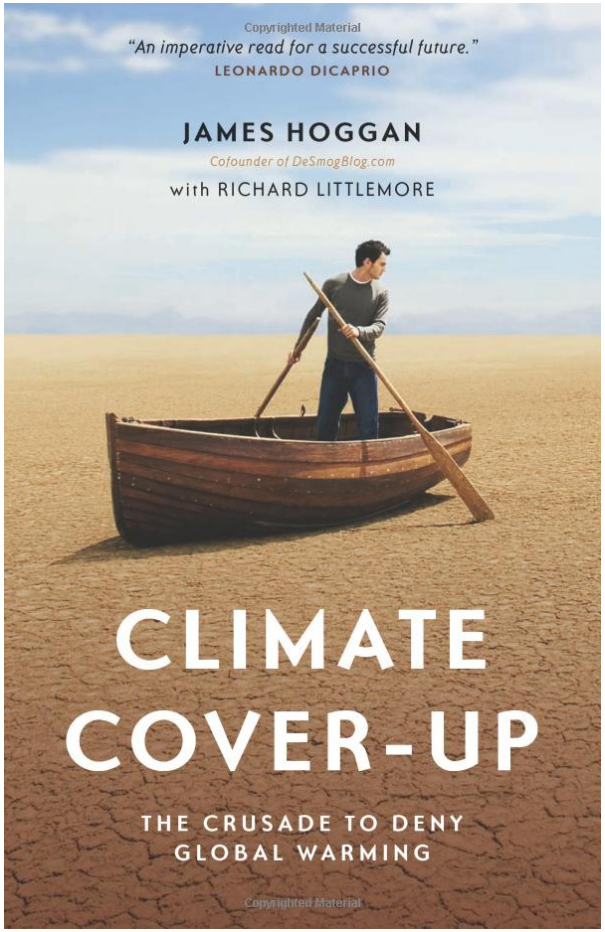

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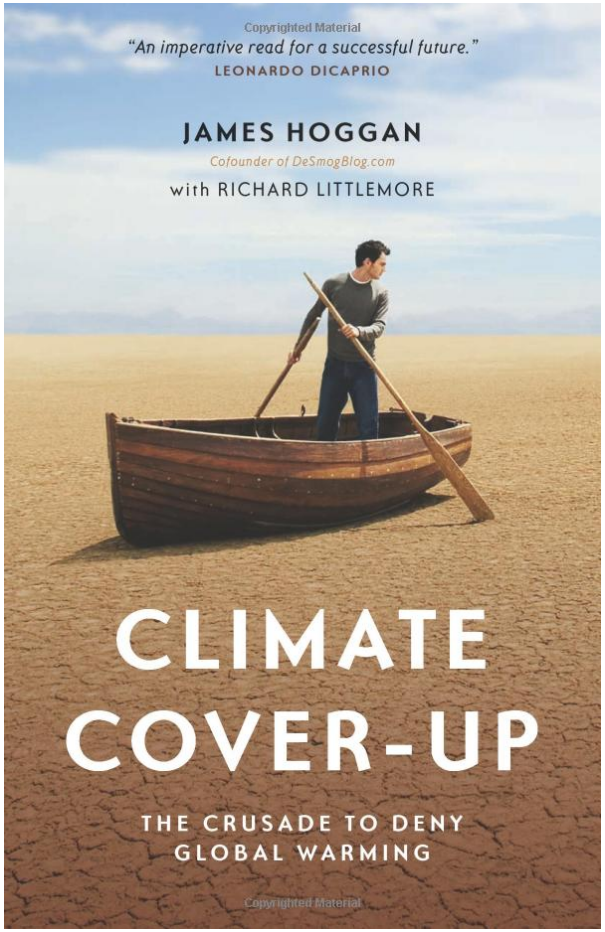

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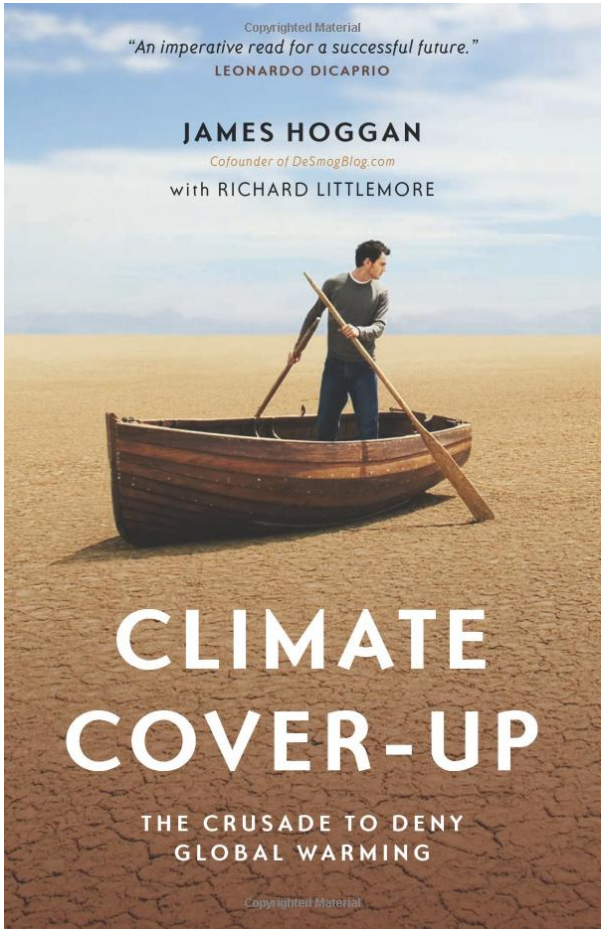

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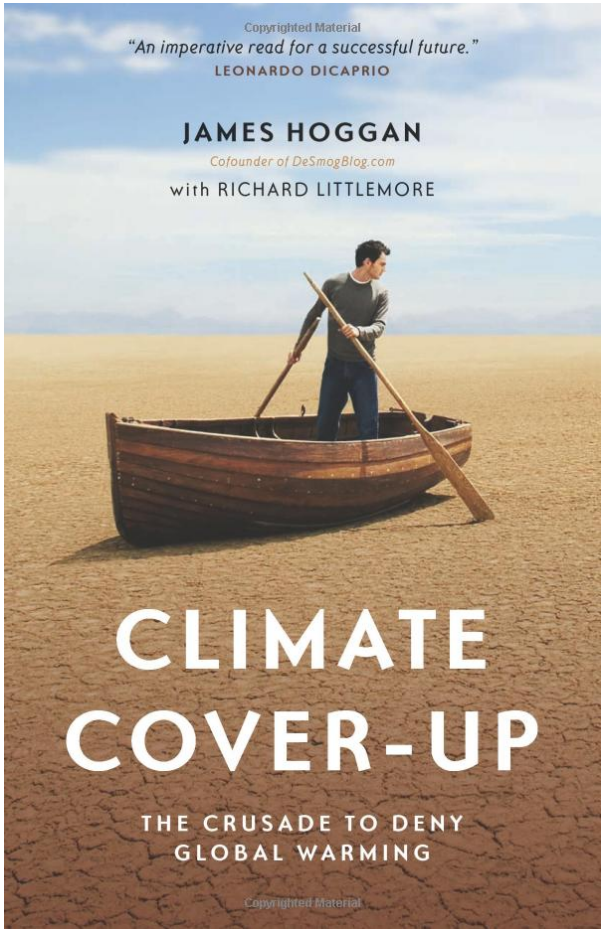

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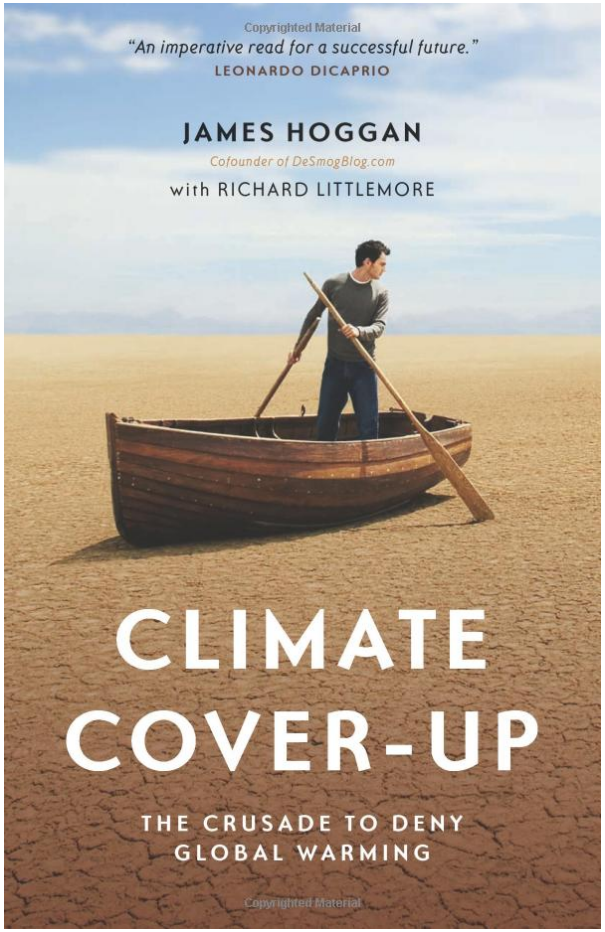

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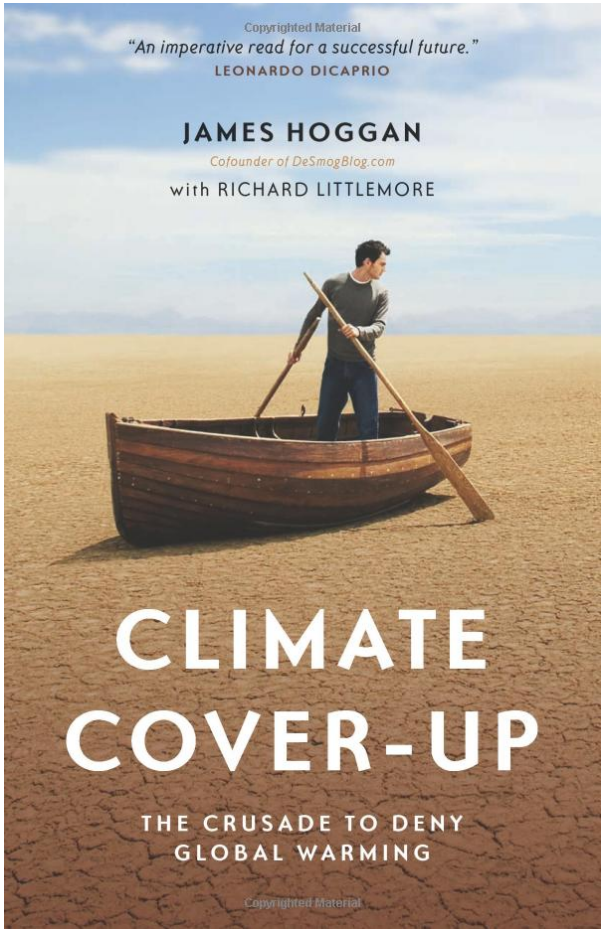

LIES

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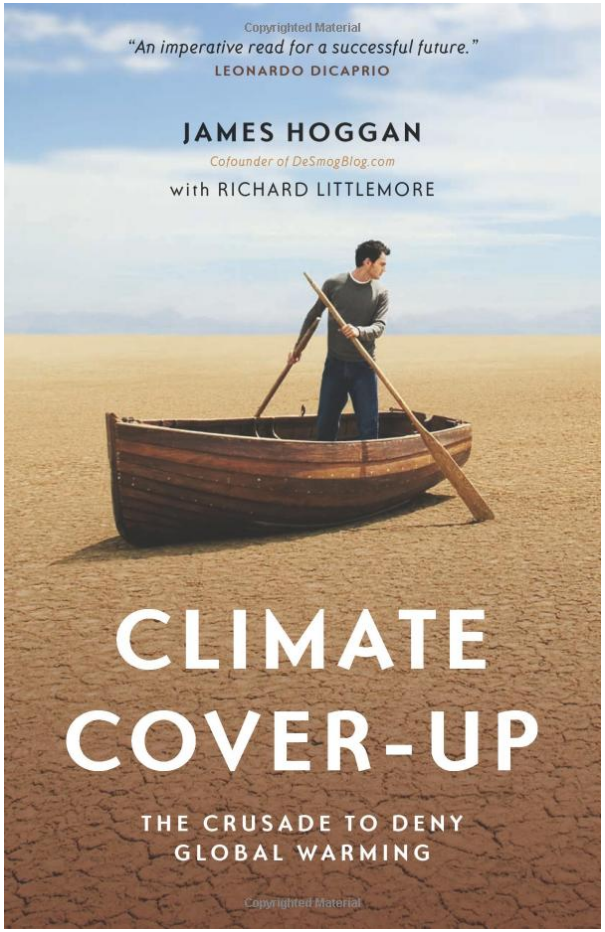

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LIES $\Rightarrow$ CONFUSION

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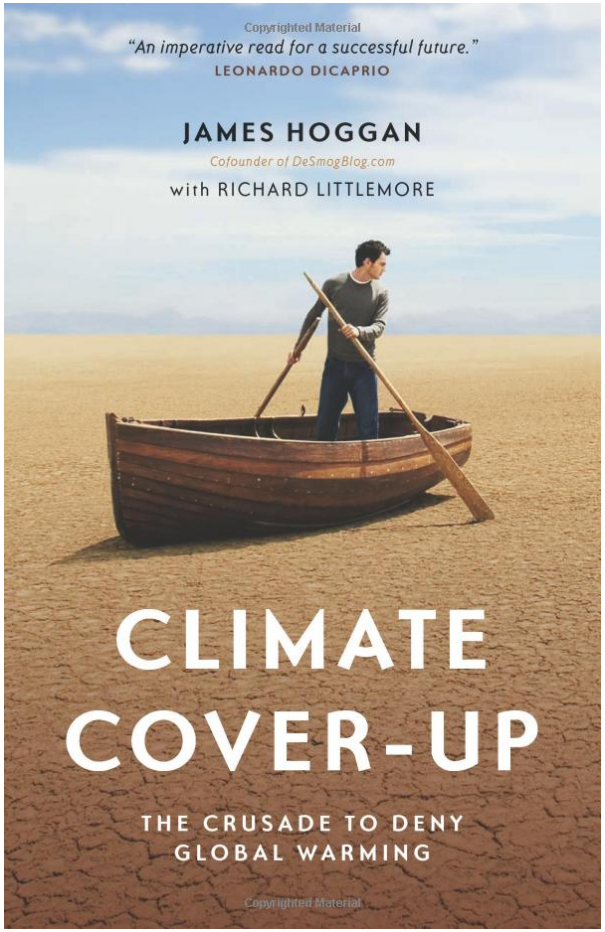

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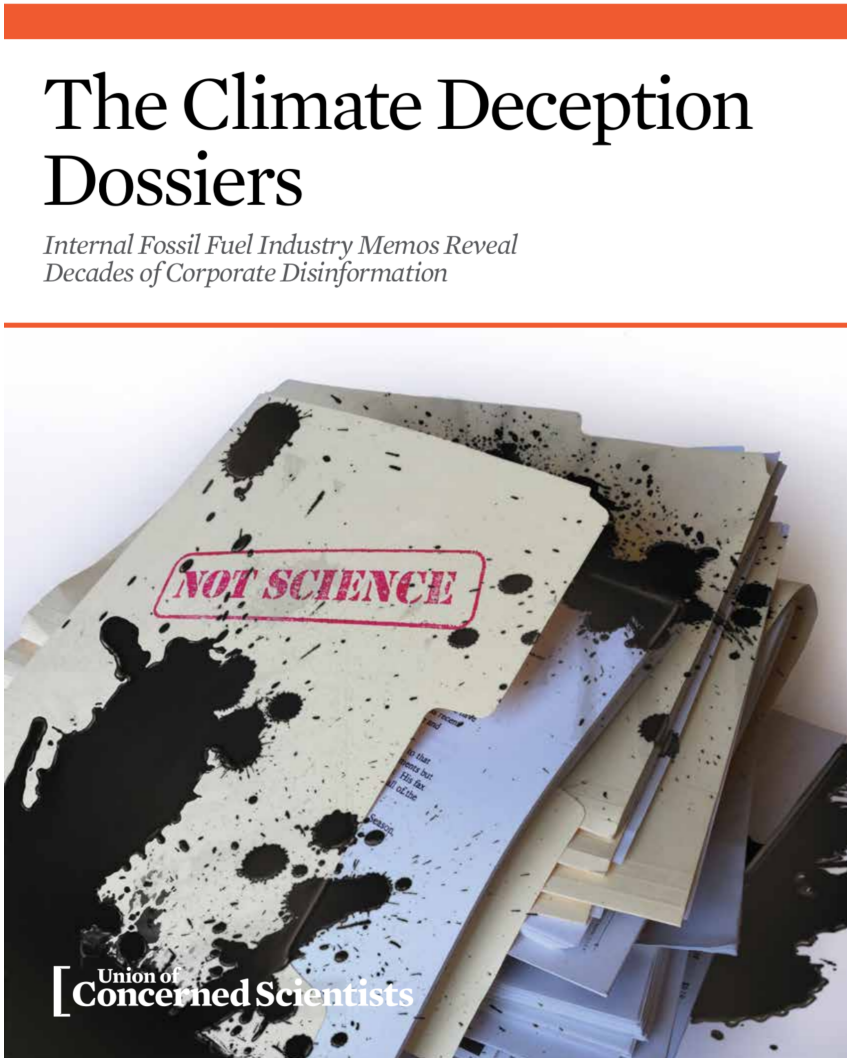
LIES $\Rightarrow$ CONFUSION $\Rightarrow$ INACTION

Much Documentation of Climate Lies Exists



Still More Documentation of Lies

theguardian

Greenpeace exposes sceptics hired to cast doubt on climate science

Sting operation uncovers two prominent climate sceptics available for hire by the hour to write reports on the benefits of rising CO2 levels and coal

The findings by Greenpeace show how paid-for information challenging the consensus on climate science can appear in the public domain without funding sources being revealed. Photograph: Michael Williamson/Getty Images

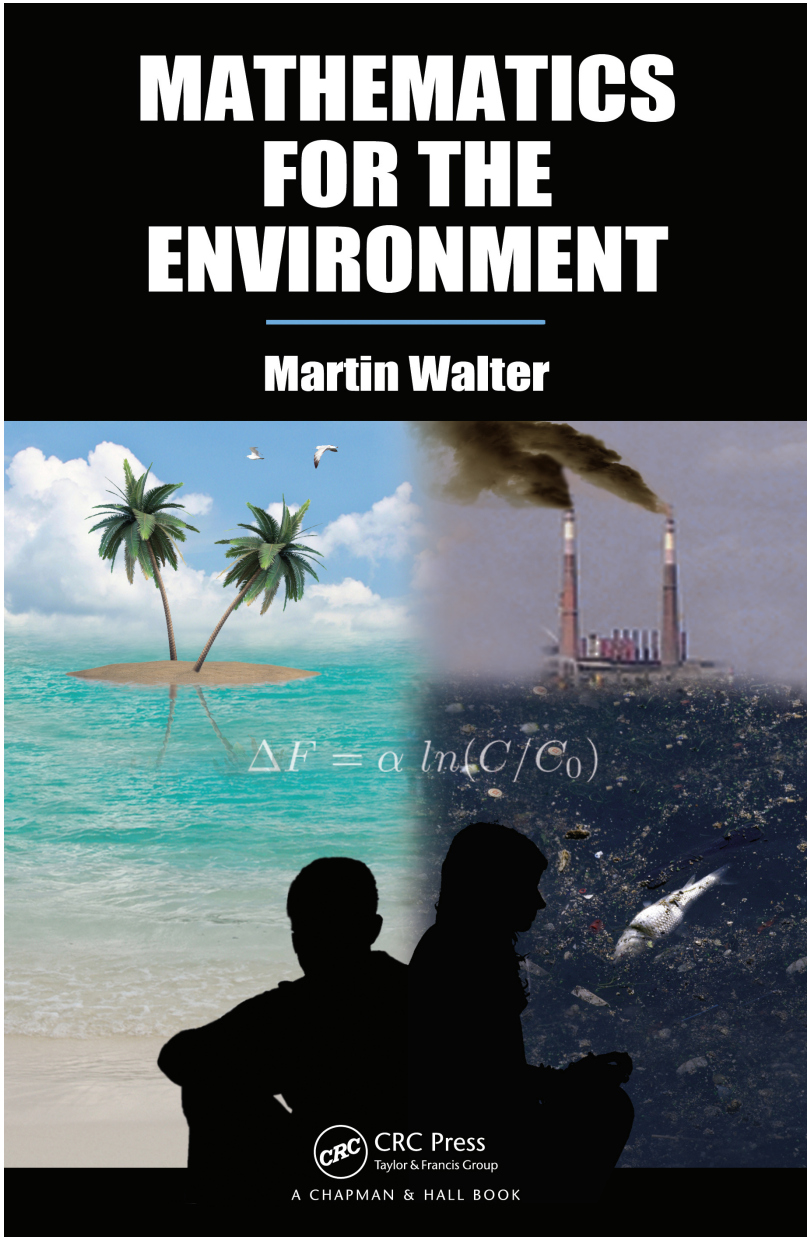
Suzanne Goldenberg US environment correspondent

Tuesday 8 December 2015 15.37 EST

An undercover sting by Greenpeace has revealed that two prominent climate sceptics were available for hire by the hour to write reports casting doubt on the dangers posed by global warming.

Posing as consultants to fossil fuel companies, Greenpeace approached professors at leading US universities to commission reports touting the benefits of rising carbon

The Book: 19 Years in the Making



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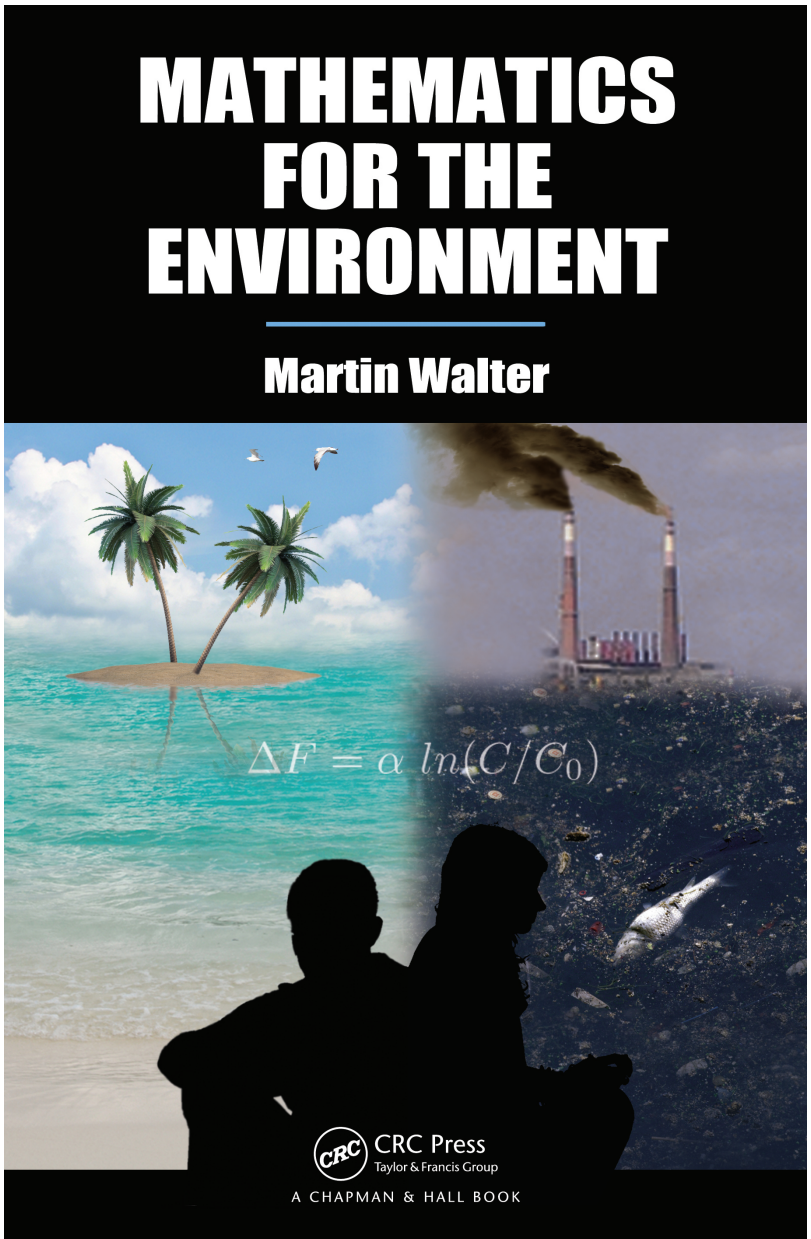

Let Us Teach

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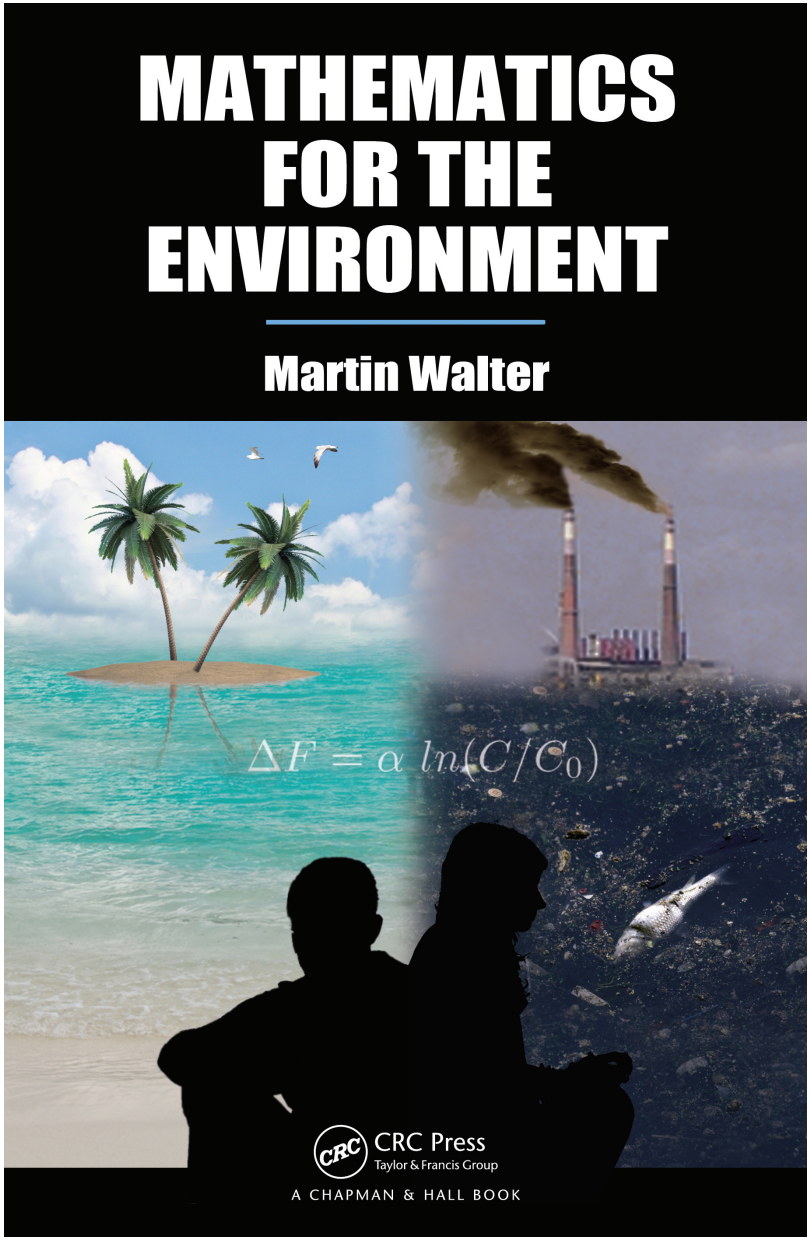
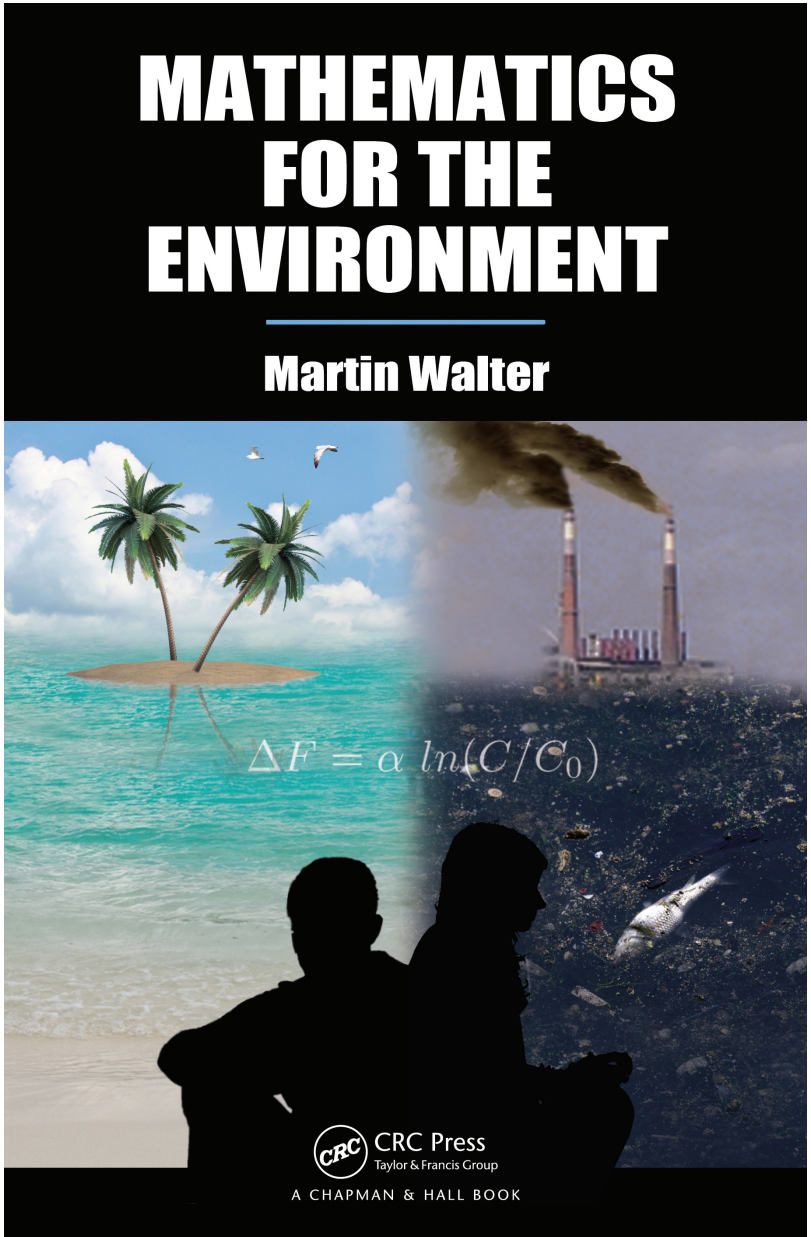


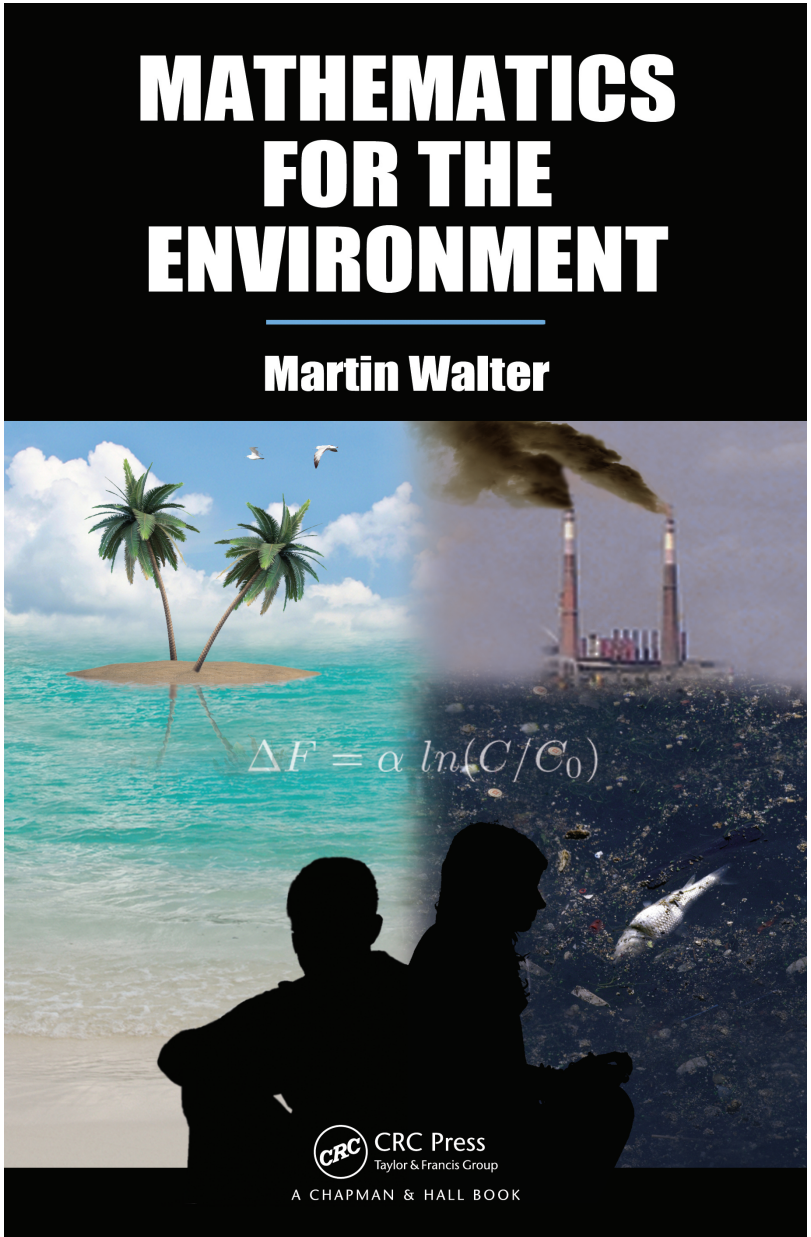
Let Us Teach As If

The Book: 19 Years in the Making



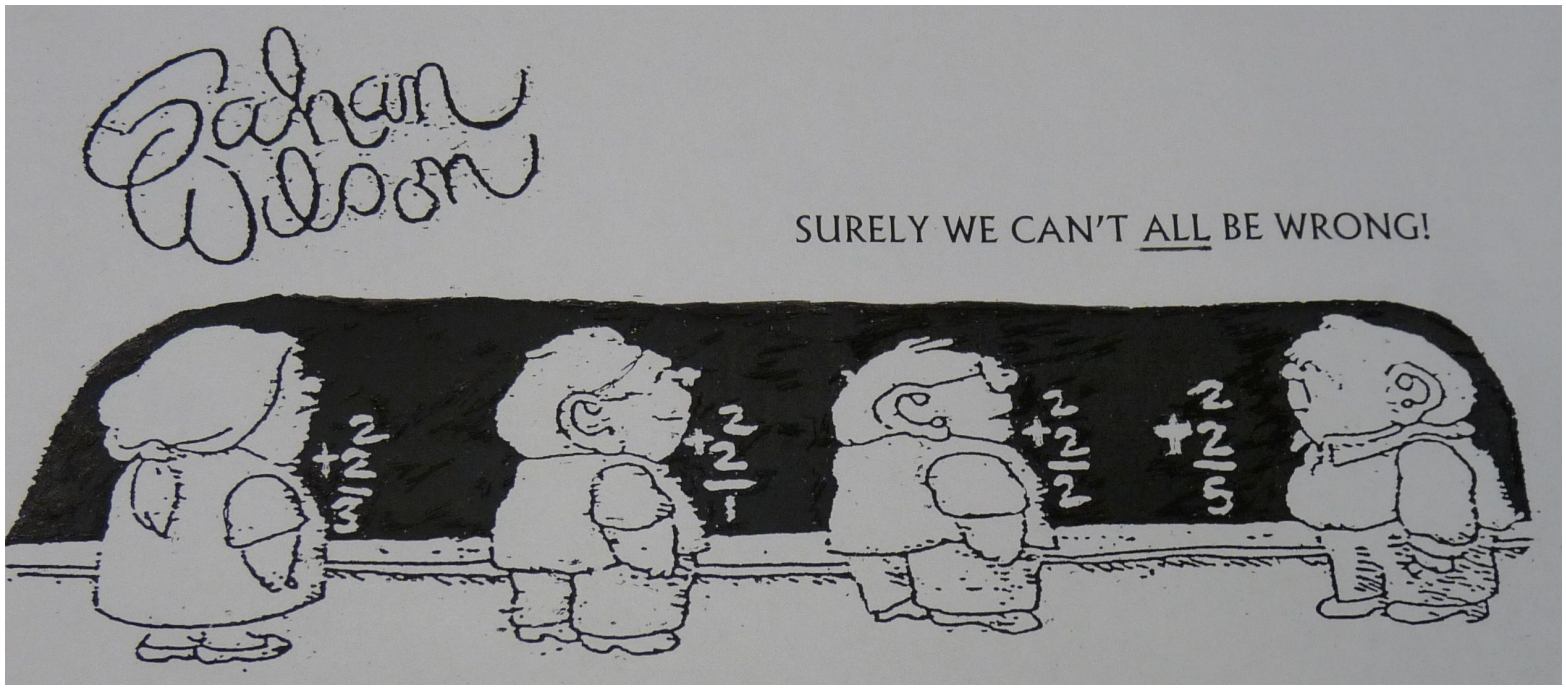
Let Us Teach
As If
OUR SURVIVAL MATTERS

The Book: 19 Years in the Making



Let Us Teach
As If
OUR SURVIVAL MATTERS
Specially Mathematics!

Humility is Required



More Facts Everyone Should Know About the Science of GLOBAL WARMING

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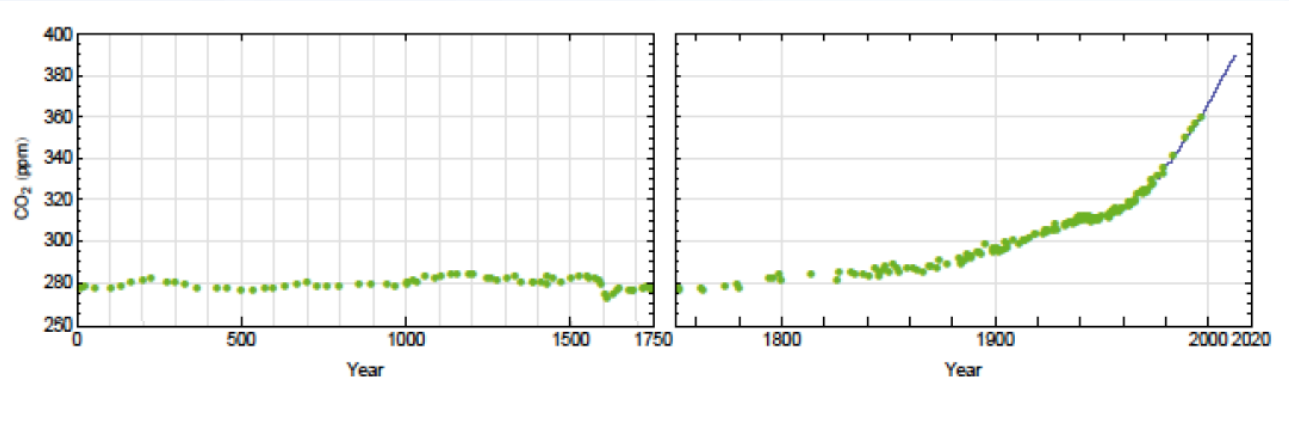
From the National Center for Atmospheric Research USA (Thanks to Dr. J. T. Kiehl)

From the National Center for Atmospheric Research USA

Observations Show an Increase in Atmospheric Carbon Dioxide

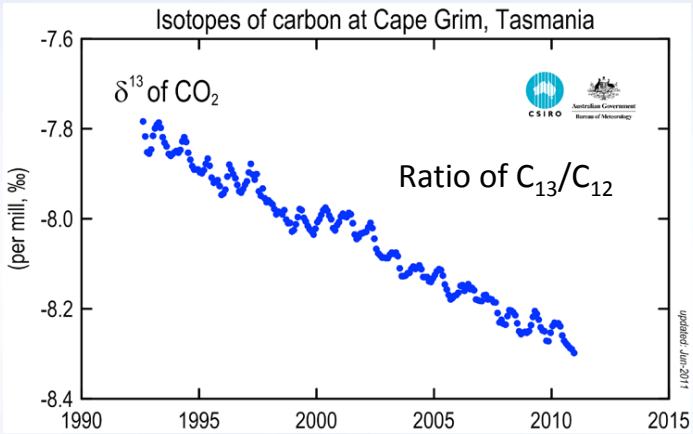


IPCC-AR5

From the National Center for Atmospheric Research USA

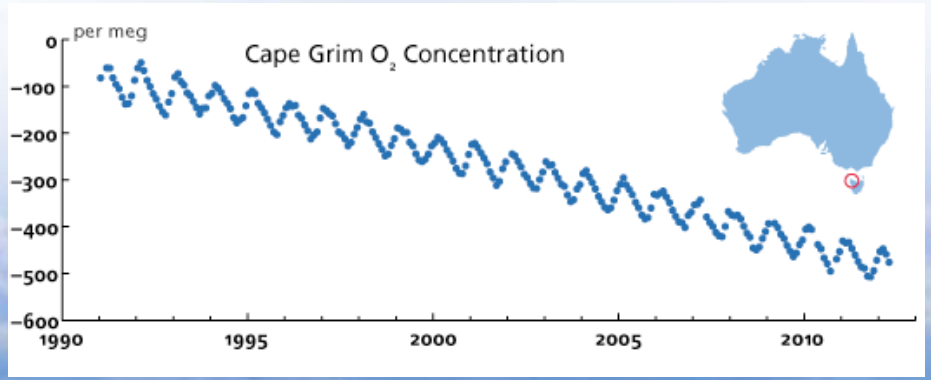
This CO_2 Increase is Due to Human Activity

Isotopic Signature



Ratio of C_{13}/C_{12}

Combustion

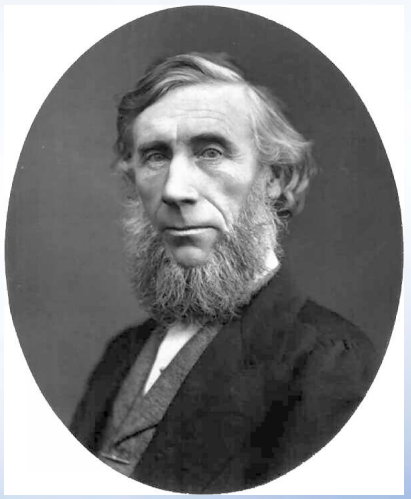


IPCC-AR5

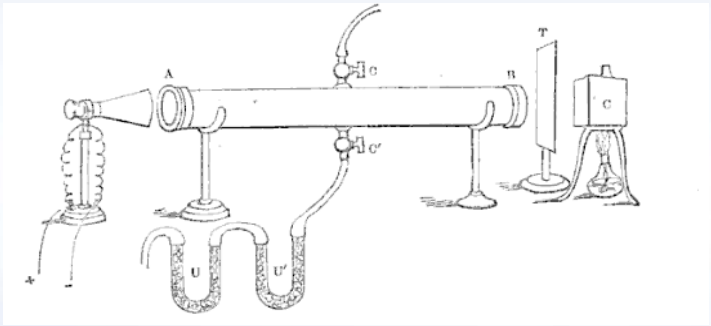
From the National Center for Atmospheric Research USA

CO_2 is an Efficient Greenhouse Gas

Laboratory Measurements by John Tyndall in the 1850s



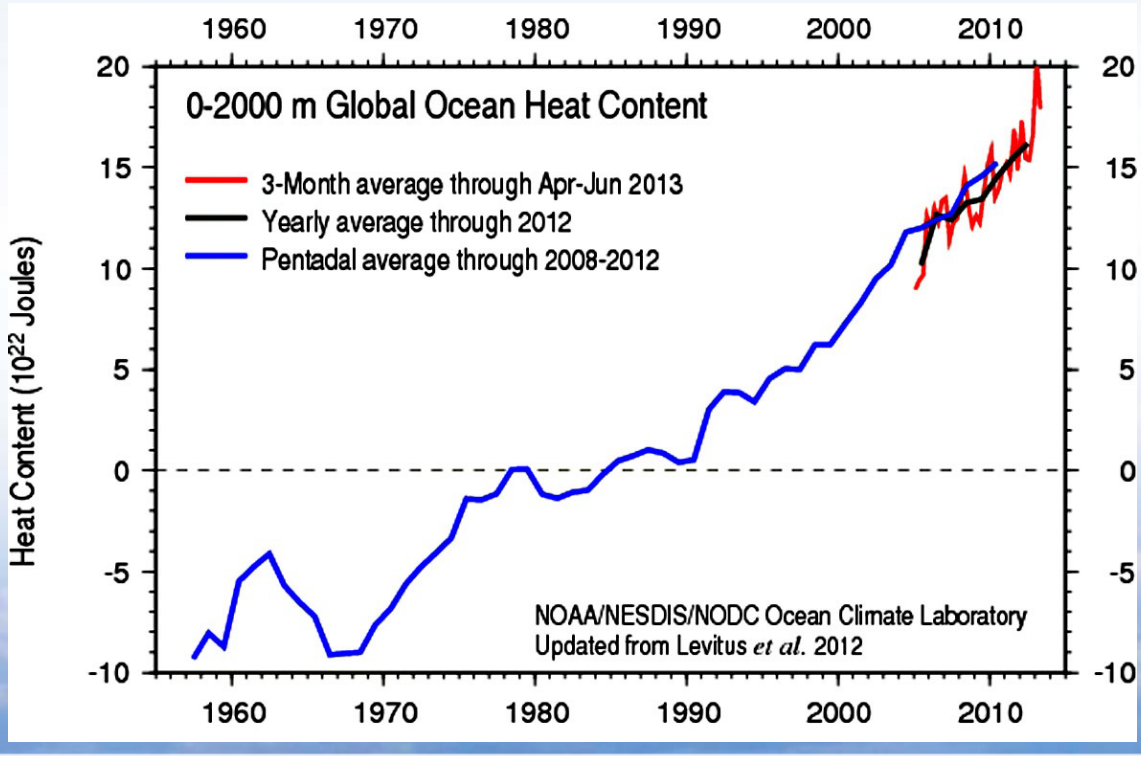
John Tyndall



The bearing of this experiment upon the action of planetary atmospheres is obvious ... the atmosphere admits of the entrance of the solar heat, but checks its exit; and the result is a tendency to accumulate heat at the surface of the planet (Tyndall, 1859a).

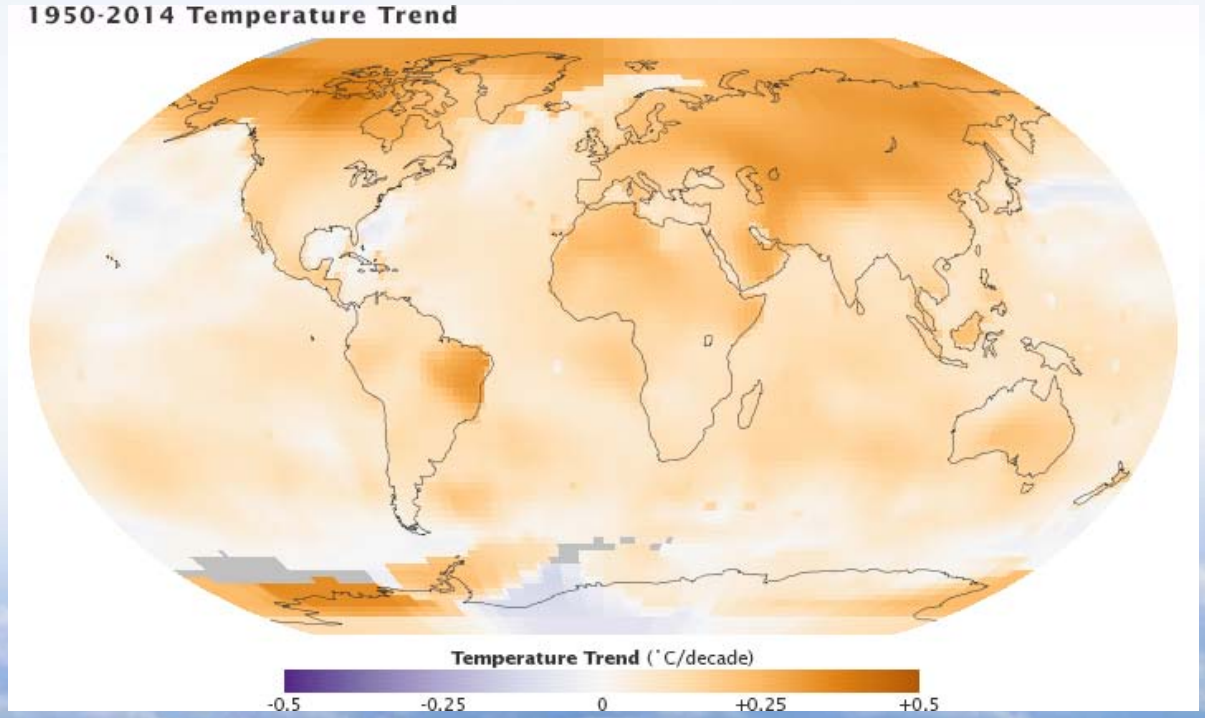
From the National Center for Atmospheric Research USA

Increasing atmospheric CO_2 leads to a stronger greenhouse effect, which traps more energy in the climate system



From the National Center for Atmospheric Research USA

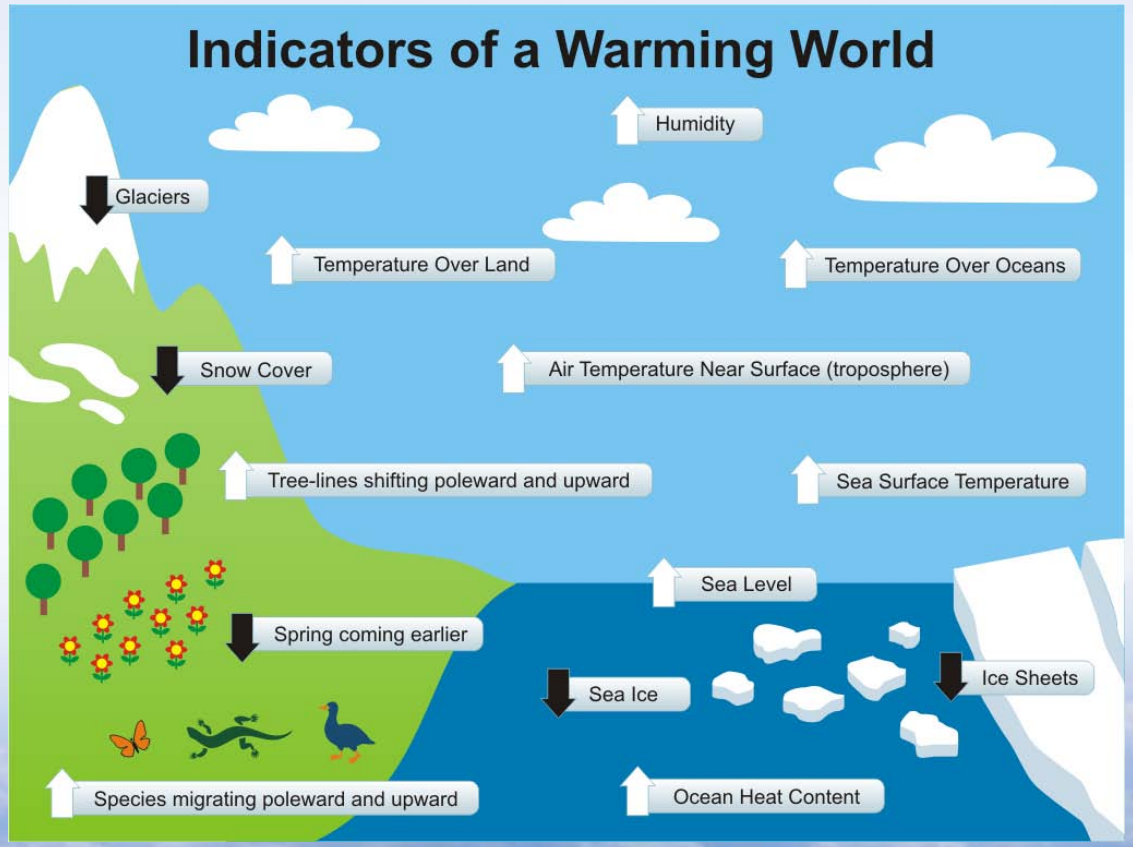
According to the law of conservation of energy, the trapped greenhouse energy must warm Earth



http://www.giss.nasa.gov

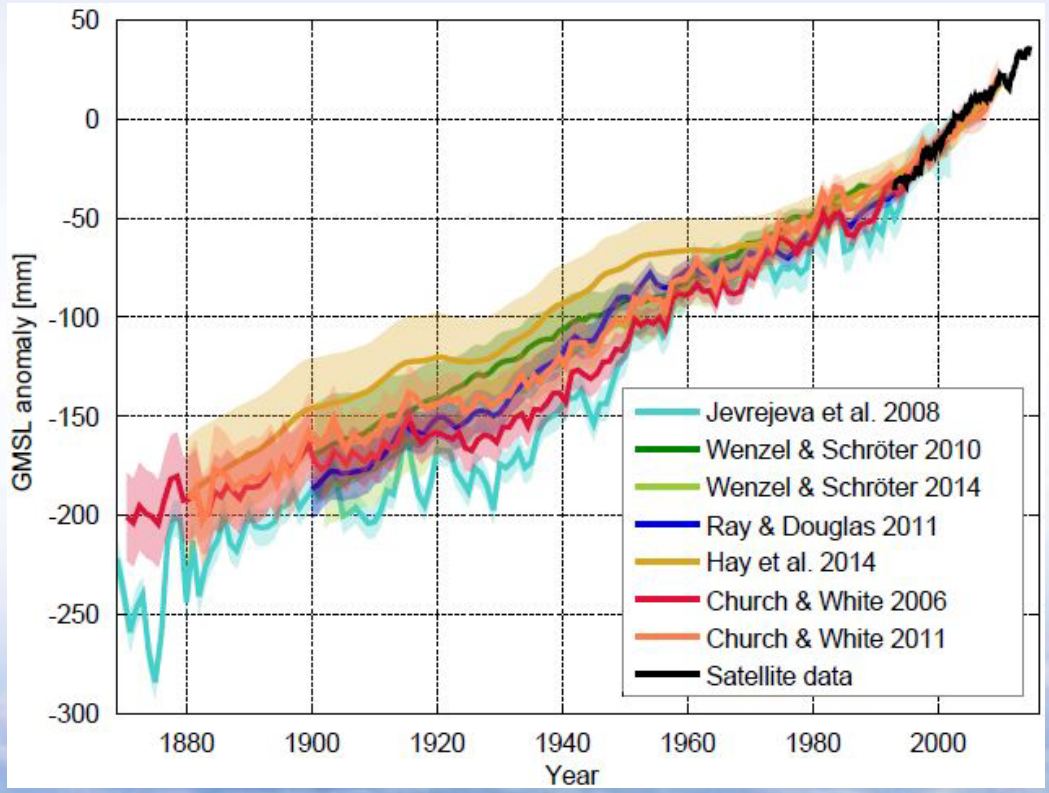
From the National Center for Atmospheric Research USA

It's Not Just Temperature



From the National Center for Atmospheric Research USA

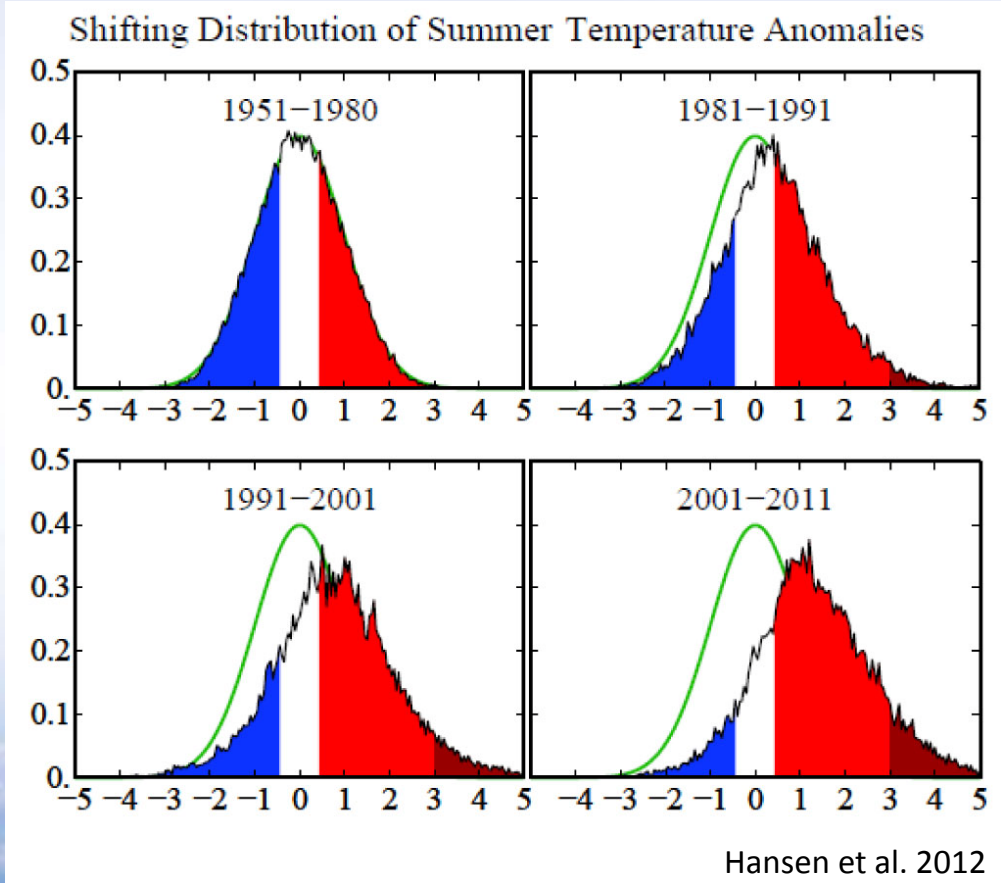
Sea Level Rise



Hays et al. 2015

From the National Center for Atmospheric Research USA

Shift in Temperature Extremes



Earthquakes and Weatherquakes: Mathematics and Climate Change

Martin E. Walter

In memory of Roger Gallet

In 1824 the French mathematician Jean Baptiste Joseph Fourier (1768–1830) in order to describe certain observations, created the term "greenhouse effect", [7, 8]. In modern language this effect occurs when visible spectrum sunlight passes through an enclosure-creating barrier, such as glass or an atmosphere, and the enclosure heats up because the barrier absorbs/emits infrared spectrum radiation or otherwise traps heat. This paper is one (small) mathematical step on the journey that Fourier began. Our main goal is to describe a plausible model wherein the proportion of extreme weather events, such as tornados, among all weather events, can be expected to increase as the concentrations of greenhouse gases, such as carbon dioxide, increase in the atmosphere.

In 1896 Swedish scientist Svante August Arrhenius (1859–1927), 1903 Nobel Prize winner in chemistry, was aware that atmospheric concentrations of CO_2 (and other gases) had an effect on ground level temperatures; and he formulated a "greenhouse law for CO_2", [1]. Were Arrhenius alive, the motivations for his study and the precise values of physical constants used in his models might change, but his greenhouse law remains intact today. From a reference published about 102 years after [1], namely, page 2718 of [14], we see Arrhenius's greenhouse law for CO_2 stated as:

(Greenhouse Law for CO_2) $\quad \Delta F = \alpha \, ln(C/C_0),$

Martin E. Walter is professor of mathematics at the University of Colorado. His email address is walter@euclid.colorado.edu.

where C is CO_2 concentration measured in parts per million by volume (ppmv); C_0 denotes a baseline or unperturbed concentration of CO_2, and ΔF is the radiative forcing, measured in Watts per square meter, $\frac{W}{m^2}$. The Intergovernmental Panel on Climate Change (IPCC) assigns to the constant α the value 6.3; [14] assigns the value 5.35. Radiative forcing is directly related to a corresponding (global average) temperature, by definition radiative forcing is the change in the balance between radiation coming into the atmosphere and radiation going out. A positive radiative forcing tends on average to warm the surface of the Earth, and negative forcing tends on average to cool the surface. (We will not go into the details of the quantitative relationship between radiative forcing and global average temperature.)

Qualitatively his CO_2 thesis, which Arrhenius was the first to articulate, says: *increasing emissions of* CO_2 *leads to global warming.* Arrhenius predicted that doubling CO_2 concentrations would result in a global average temperature rise of 5 to 6 deg C. In 2007 the IPCC calculated a 2 to 4.5 deg C rise. This is fairly good agreement given that more than a century of technology separates the two sets of numbers.

For the record, cf. [2], preindustrial concentrations of CO_2 are estimated to have been about 280 ppmv. From [2], page 43, we see a table of global, average annual CO_2 concentrations from 1960 when it was 316.91 ppmv to 2006 when it was approximately 381.84 ppmv. In this table the function of CO_2 concentration versus time is essentially an increasing function from 1960 to the present (neglecting the annual fluctuation). We

More Tornados – More Huricanes – More ?

Thus our axiom, that nature has no preferred size (or scale) for earthquakes, implies that earthquakes are geometrically distributed if the number of earthquakes is plotted versus magnitude, i.e., the logarithm of intensity.

I close this section by mentioning that there is a wide variety of natural phenomena described by power laws [3, 15].

Weatherquakes and Global Warming

Climate is, by definition, weather statistics. Thus one might suppose that any number of mathematical tools might be applicable to the study of climate and weather. Dr. Roger Gallet, our friend and a scientist with the National Oceanic and Atmospheric Administration (NOAA) many years ago initiated a sophisticated statistical analysis of weather events using every tool of which we were aware and more, including, for example, Gumbel's work, [11]. He was trying to demonstrate what we refer to as *Gallet's Conjecture*, viz., that the proportion of extreme weather events among all weather events increases as the atmosphere (troposphere) becomes warmer. Our colleague, Dr. Holley briefly joined the effort to statistically verify Gallet's Conjecture. About the time it was becoming evident to us that the results would likely not be definitive, sadly, Dr. Gallet became ill and passed away. Add to this the fact that we were familiar with the now famous work of Jerzy Neyman on the statistics of smoking and health from the last century, and how in the early years it was ignored/attacked by some—with some success since exact mechanisms by which cigarettes impacted health were not then well understood. Any analogous statistical analysis of weather events by this author would likely be greeted with even less enthusiasm. Finally we were (are) of the opinion that should Gallet's Conjecture become statistically, obviously, unassailable, it might be too late to do anything about it. Thus we were motivated to bypass statistics and look for a fundamental mechanism and/or principle (or principles) that would imply the truth of Gallet's Conjecture.

Since power laws appear in such a wide variety of natural phenomena, [3, 15], we investigated the possibility that a power law might find a place in the study of weather events.

We shall use the terms "weatherquake" and "weather event" interchangeably. We can ask: What is the distribution of the number of weather events as a function of event intensity, or as a function of the logarithm of event intensity? It would be easy to wave our hands and say that because weather events are influenced by many small and seemingly unrelated random effects the distribution of weather events should approximate the normal distribution. Of course, we could have made the same hand-waving argument about earthquakes, which we have seen are distributed geometrically when plotted as a function of the logarithm of event intensity. Ultimately this question is to be answered by empirical observation of weatherquakes, some of which has been done; cf. [4].

The alert reader will have noticed that we have not given a precise definition of weatherquake other than a tautological one. Neither have we given a definition of intensity of a weatherquake or how to go about measuring same. These considerations are actually part of our weatherquake hypothesis.

The Weatherquake Hypothesis

There exists a definition of *weatherquake* and there exists a definition of *intensity of weatherquake* such that nature has no preferred size (or scale) of intensity of weatherquake. Significant nonempty classes of such weatherquakes exist.

Although some statistical measures of hurricanes, for example, are not analogous to that of earthquakes, [6], we have found no arguments supporting the negation of the weatherquake hypothesis, i.e., that there is a reasonable definition of weatherquakes or their intensity such that nature prefers some intensities more than others. Furthermore, one could disprove the weatherquake hypothesis by showing that our conclusion about extreme weatherquakes (in the next section) implied by the weatherquake hypothesis is false. However, empirical evidence thus far is tending to confirm, not contradict, this conclusion [9, 10, 4].

From the point of view of pure mathematics we could remain silent on any proposed definitions of weatherquakes and their intensities, but we owe the reader some discussion of these topics. Thus virtually no one who has been in the presence of a tornado would deny that such is a weatherquake—same for a hurricane. These and some other classes of weatherquake follow power laws [4]. The data tell us that two different classes of weatherquake can (and often do) follow different power laws. This does not affect the conclusion(s) in the next section. In fact, hurricanes switch from one power law to another at eighty-five knots, which coincides with the formation of the hurricane eye.

Thus we claim that the collection of classes of weatherquakes to which the weatherquake hypothesis/power laws apply is not only nonvacuous but socially and scientifically significant. For historical reasons the Saffir-Simpson hurricane wind scale and the Fujita scale of tornado intensity were developed independently and are not directly comparable. There is even a third class of wind weatherquakes varying from light breezes to

A THEOREM

high-velocity wind storms (unidirectional) that appear to obey a power law, [4]. Certain collections of precipitation weatherquakes are likely candidates for satisfying the weatherquake hypothesis, and so on. One possibly universal method of defining weatherquakes and measuring their intensity could be this: observe a peak in power, i.e., a peak in energy flow per unit time, in a volume of atmosphere over a given geographical area in a given interval of time. A number of interesting theoretical investigations will suggest themselves to the interested reader—such as comparisons of local maxima of power in subintervals of an interval of time with the maximum over the entire interval, or comparing the total energy of a weatherquake to its peak power, and so on. One must keep in mind, however, practical limitations of the type and number of observations likely to be actually made in the field. We are confident that the weatherquake hypothesis is satisfied, but we do not know the entire collection of weather events to which it applies.

Not everything that happens in the atmosphere is a weatherquake, just as not every activity of the earth's crust is an earthquake. I mention tectonic plate movements, "slow earthquakes", and pyroclastic flows as examples of things that happen (and are often associated with earthquakes) but that are not always in themselves regarded as earthquakes. The same is true of the atmosphere.

The important thing is this: for events in the earth's crust, respectively the earth's atmosphere, there is a significant class, respectively a collection of classes, of quakes to which power laws apply. To these classes the pure mathematics of the next section applies. The model is so simple that little room is left to escape certain conclusions. For a bit more discussion see [4, 19]. We thus proceed to our main conclusion.

Implications of the Weatherquake Hypothesis for Extreme Events

Following the same arguments used in the case of the Gutenberg-Richter law, we see that the weatherquake hypothesis implies (restricting to one type of weatherquake at a time if necessary) that a power law gives the number of weatherquakes as a function of the intensity of said weatherquakes. Also, from the same mathematical argument used in the case of earthquakes, it follows that the number of weatherquakes (of a given type that follow a given power law) plotted versus the magnitude of weatherquake, i.e., logarithm of intensity of weatherquake, is a geometric distribution. Let's suppose that this geometric distribution is $N_p[x] = \beta\, p^x$, with $0 < p < 1$, where it is easily seen that $\beta = -\ln p$ if $\int_0^\infty N_p[x]\, dx = 1$, i.e., we have a probability distribution. We are abusing terminology slightly because probabilists refer to this N_p as the probability density function of an exponential random variable if we write $N_p[x] = (-\ln p\ )e^{(\ln p\ )x}$, with $x \geq 0$. Below we will use the term *expectation* of N_p, i.e., $E[N_p]$, as probabilists do, namely, $E[N_p] = \int_0^\infty x\, \beta\, p^x dx$.

Thus $N_p[x]$ is the number, actually the number normalized, of weatherquakes of magnitude x, where x is the logarithm of weatherquake intensity. If we define extreme weatherquakes to be those of magnitude $x \geq a$, then $T_p[a] = \int_a^\infty N_p[x]\, dx$ is a measure of the amount of "effort" nature puts into extreme weatherquakes. (This measure can be considered an understated measure, since the horizontal axis, i.e., magnitude, is a logarithm of weatherquake intensity; and the logarithm of intensity increases far more slowly than actual intensity.) The $T_p[a]$ we refer to as the "tail past a" of our distribution. In a real life situation, a is a numerical value indicating a magnitude of weatherquake that no one denies is extreme.

The proof of the theorem below is elementary and is left as an exercise for the reader.

Theorem 1. *Given $0 < p < 1$ and the normalized, geometric probability distribution $N_p[x] = (-\ln p)\ p^x$, with $x \geq 0$, the expectation $E[N_p]$ satisfies*

$$E[N_p] = \frac{-1}{\ln p}$$

. The "tail past a" of N_p, $T_p[a] = -\ln p \int_a^\infty p^x dx$, satisfies

$$T_p[a] = p^a.$$

If $0 < p < q < 1$, then we have the following formula for the fractional increase in the expectation of N_q relative to the expectation of N_p:

$$\frac{E[N_q] - E[N_p]}{E[N_p]} = \frac{\ln p}{\ln q} - 1.$$

We have the following formula for the fractional increase in $T_q[a]$ over $T_p[a]$:

$$\frac{T_q[a] - T_p[a]}{T_p[a]} = \left(\frac{q}{p}\right)^a - 1.$$

Let's interpret the above theorem in the context of weatherquakes. If we start with an atmosphere satisfying N_p and then warm it up, i.e., add thermal energy, by the weatherquake hypothesis we should then have an atmosphere satisfying N_q for some q, $0 < q < 1$. Thus there are three choices, $q = p$, $q < p$, or $p < q$. Because we would expect that $E[N_p] < E[N_q]$, this implies that $p < q$.

Now one way to look at this is via the median, i.e., given p, for what value of a is $T_p[a] = \frac{1}{2}$? From Theorem 1 we see that $a = ln\,.5/\ln p$. Thus as p increases monotonically in the open interval from 0 to 1, a increases monotonically from 0 to ∞. Thus as p increases nature puts half of its total "effort" into weatherquakes of increasing magnitude.

A Modest Increase
in Global Average Temperature
Implies an Immodest Increase
in Extreme Weather Events

Where did HALF the CO_2 Go?

Where did HALF the CO_2 Go?

Where did HALF the CO_2 Go?

How acidic?

Where did HALF the CO_2 Go?

How acidic? What is pH?

Where did HALF the CO_2 Go?

How acidic? What is pH? (MATHEMATICS)

Acid Ocean Damage Sooner Than Expected

Extensive dissolution of live pteropods in the Southern Ocean

Acid Ocean Damage Sooner Than Expected

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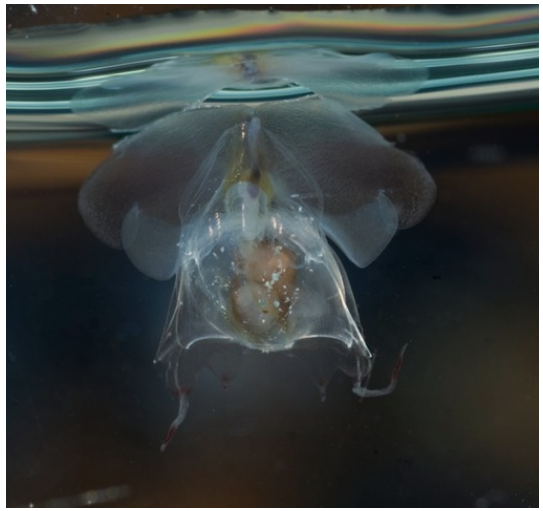
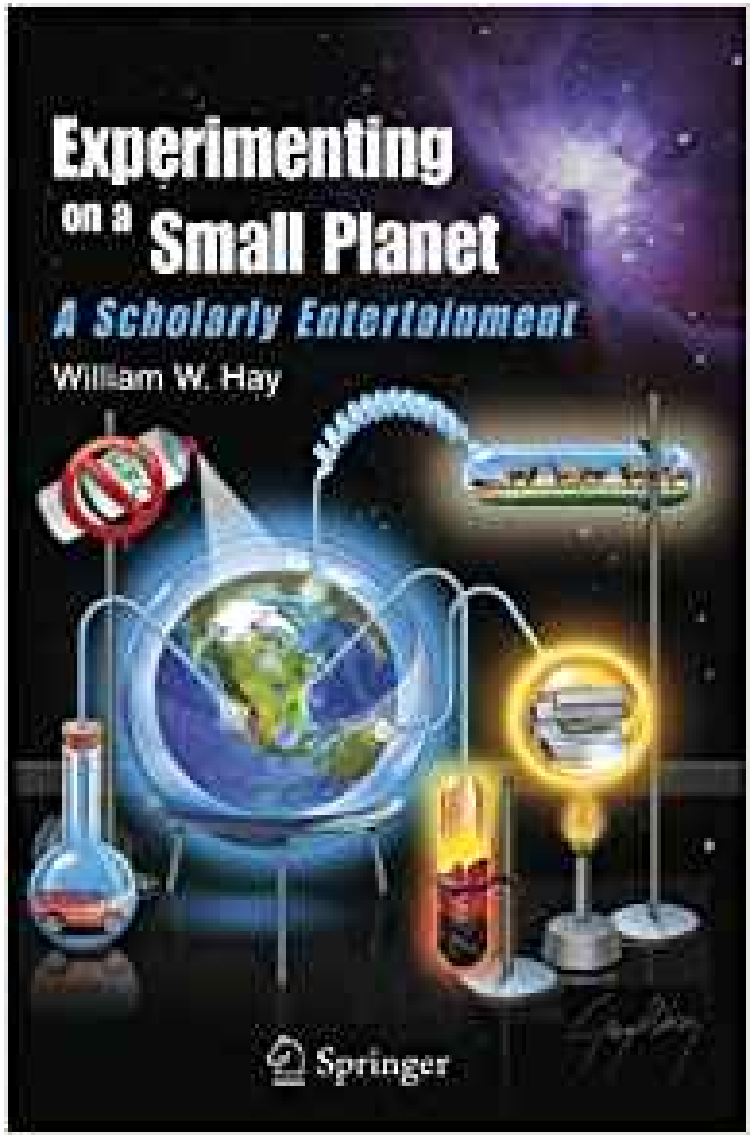


N. Bednarek, G. A. Tarling
D. C. E. Bakker, S. Fielding
E. M. Jones, H. J. Venables
P. Ward, A. Kuzirian
B. Lz, R. A. Feely, E. J. Murphy

Nature Geoscience
Volume: 5, Pages: 881 to 885
Published 25 November 2012

Experimenting on a Small Planet

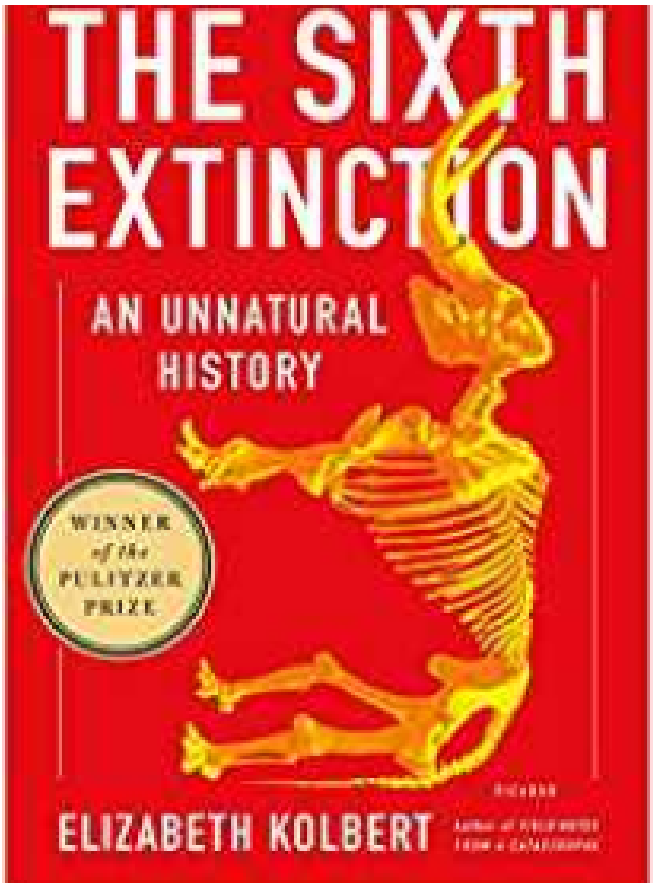


Just One of Many Problems: Sea Level Rise

"The last time Earth's atmosphere had a concentration of 400 ppm(v) CO_2 was during the Pliocene period about 3 million years ago during which time sea level was about 25 meters (80 feet) higher than it is today."
(Kerry Emanuel: http://eaps4.mit.edu/faculty/Emanuel)

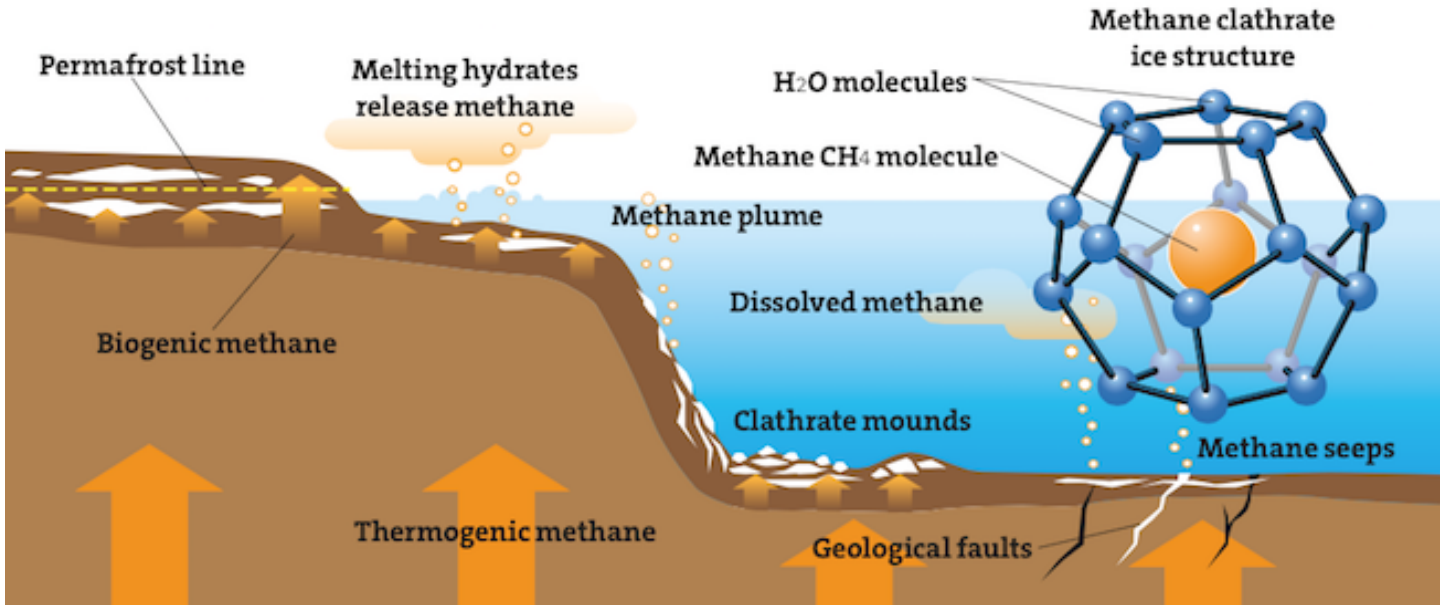
CLIMATE MOMENTUM

We Are in the Middle of The Sixth Great Extinction: It is Being Caused by Humans



One Candidate for Complete Collapse of Human Civilization Within 8 to 20 Years

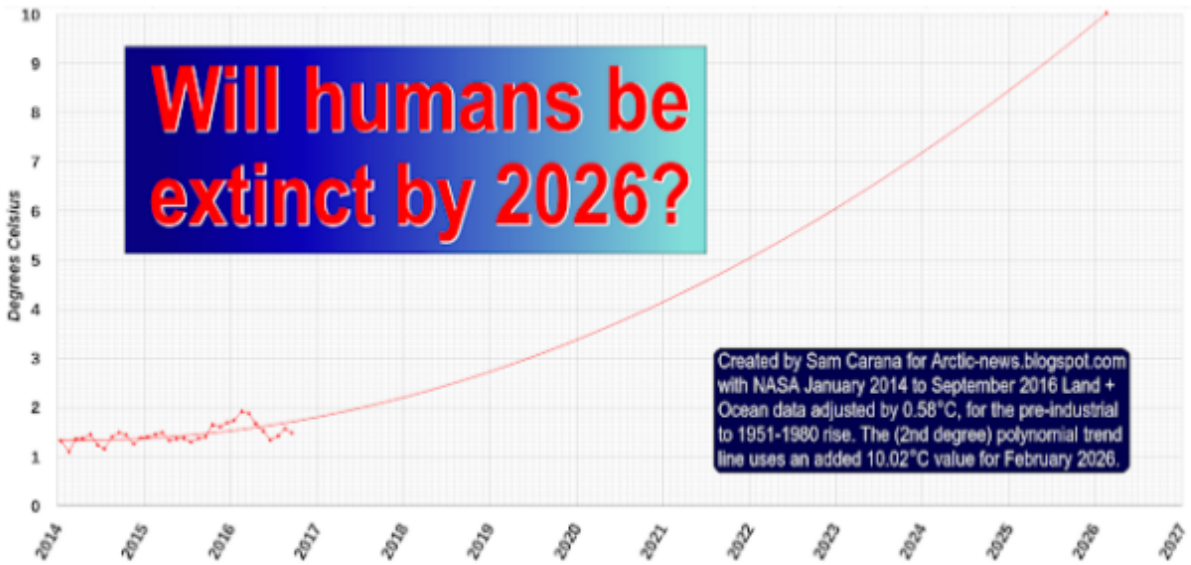
Sea Floor Clathrates



Extinction?
arctic-news.blogspot.com

Extinction

Will humans be extinct by 2026?



In the Arctic, vast amounts of carbon are stored in soils that are now still largely frozen. As temperatures continue to rise and soils thaw, much of this carbon will be converted by microbes into carbon dioxide or methane, adding further greenhouse gases to the atmosphere.