Cover Page

Title: Our first anthroponomic task: Remove the IR pea soup

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This paper is a non-peer reviewed preprint submitted to EarthArXiv. It has not yet been submitted to a journal in part because I am unsure of how one gracefully points out to a foreign journal that it has been dragged into U.S. politics in the form of a published paper that has all the earmarks of deliberate politically motivated disinformation (see section 4), and I feel a need for feedback.

OUR 1ST ANTHROPONOMIC TASK: REMOVE THE INFRARED PEA SOUP

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Abstract. **Some underappreciated aspects of the climate. [Idealization]: Earth has a partially IR-opaque 5-km-deep tropospheric layer whose (slowly rising) top radiates waste heat to space at the -18°C Stefan-Boltzmann temperature and below which the temperature increases 33°C by adiabatic compression. Fossil-fuel CO_2 has deepened this layer by 308 m and added 2°C of Anthropogenic Global Warming. [Hypothesis]: The final Vostok glaciation was aborted anthropogenically (it was the "Little Ice Age"): we are in *terra incognita* because [Fact] the 800,000 years of ice-core and sea-floor climate-proxy data describe a world whose mobile CO_2 inventory was 300 ppm, largely irrelevant to a world with $>$424 ppm. [Fact]: The climate-disinformation policy of the far right promotes "quantum saturation" to claim that global warming is ignorable. Such saturation of CO_2 may occur in spectrophotometer tubes, but not in the free atmosphere. Warming will increase as long as we emit CO_2. [Fact]: The threat is existential, the necessary fix is to return the atmospheric burden of CO_2 to 300$\pm$20 ppm, and there are helpful things we should have been doing for 50 years.**

E-mail address: DrFerrenMacIntyre@proton.me - [PeaSoup18.5-2023.0729-17:25].

1. MIDDLE SCHOOL REVISITED

For much of the U.S. public, AGW (*Anthropogenic* Global Warming) is a hoax (psychological projection) or a tempest in a teapot (insufficient background). "There is still no peer-reviewed study [supporting] the hypothesis that human-produced CO_2 emissions are causing AGW", wrote a Quoran, "updating" me. However, if middle-school science taught us that the sun warms the Earth, it was remiss if it did not mention the four following facts:

1.1. **Energy conservation.** After correction for albedo (reflected energy), the Stefan-Bolzmann equation provides the steady-state radiation temperature of a (fast-rotating blackbody) planet with an O_2-N_2 atmosphere (or no atmosphere). It has been used by astrophysicists since the 1880s. **The SB temperature of the sun-warmed Earth is a chilly 255°K or -18°C (0°F). The sun needs help!**

1.2. ***Ordinary* Global Warming.** The **OGW** help is provided by water vapor and the 300 ppm of *Vostok* CO_2 intercepting outgoing IR (infrared) radiation (which oxygen and nitrogen cannot do). This was discovered by an American housewife using kitchen supplies, sunshine, and a thermometer, in a peer-reviewed paper [1] in 1856 (even though — as a mere woman — she was not allowed to present the paper herself). Tyndall (1863) [2] usually gets the credit.

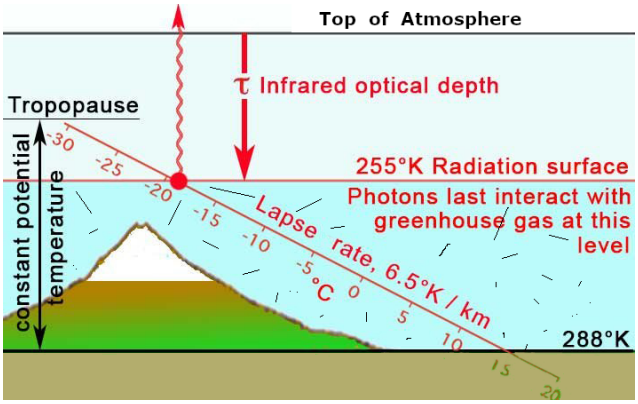
1.3. **The *U.S. Standard Atmosphere*.** This publication defines the ground temperature as a comfortable 15°C or 288°K. A 15° ground obviously cannot be the Earth's astrophysical –18°C Radiation Surface, or ERS — which is found at the atmospheric level where the ambient temperature is -18°C. This is an altitude of some 5 km, and **the 33° of OGW comes from adiabatic compression below this level**, as sketched in Fig. 1. (On 2023.0616 NASA released a realistic video animation showing our addition to the ERS as a turbulent yellowish split-pea-soup layer spreading southward with time. `https://svs.gsfc.nasa.gov/5110` .)

In Fig. 1, departing energy leaves the warm ground by conduction and convection (which we ignore, for the moment) and as radiation, whose paths are shown by short black lines. IR photons cannot escape until they reach the ERS, above which CO_2 density is low enough for them to escape to outer space.

CO_2 increase reduces the IR optical depth τ, lifting the ERS (and all the red lines) vertically. The "constant potential temperature" arrow defines the troposphere as adiabatic (no heat flow between air parcels) and the lapse-rate line shows the warming that accompanies adiabatic compression.

Short-wavelength daylight ($<4\mu$m) sunshine warms the ground directly: long-wavelength IR ($>4\mu$m) earthshine struggles to escape. The details are complex; suffice it to say here that the apparent paradox of cool downward radiation interacting with warmer CO_2 molecules below is handled by slight differences in radiant energy being balanced by compensating differences in kinetic energy (molecular velocity). It is total energy that is conserved. (Google "thermodynamic square" to see some of what we skip over — and that doesn't mention the molecular and optical

FIGURE 1. **Ordinary Global Warming.** The ERS is at the idealized horizontal tropospheric 255°K IR-radiation surface. Notice that the snow line is at the 0°C level on the Lapse-rate line. (Incidentally, the tropopause should be drawn higher, at -51° on the lapse-rate scale. This blunder is excusable as artistic license.)



details.) What is often called "downward radiation from the greenhouse effect" is here simply the random path of a photon (in Fig.1, the short black lines in the pea soup below the ERS). Much of the outgoing energy is carried by fast molecules after a photon absorption, quickly redistributed.

1.4. ***Anthropogenic* Global Warming. AGW** is provided by water vapor and the 124 ppm of *anthropogenic* CO_2 intercepting outgoing IR radiation, exactly like OGW. It is the same process, identical except in name, and (while helped by other "greenhouse gasses" — anything with more than 2 atoms in their molecules) not in the least mysterious. AGW is a 2°C increment on top of OGW, and what worries atmospsheric chemists is that **the only limit to the temperature rise that AGW can produce is the amount of buried carbon we can extract and burn**.

Most of us can agree that AGW is a threat — while disagreeing on the nature of the threat and the nature of the enemy. Is the threat to/of: Low-lying islands? Coastal cities? Flood plains? Coral reefs? Agriculture? Species diversity? Tropical diseases? Migrants? Hyperthermia (wet-bulb temperature)? Ocean circulation (Gulf Stream shut-down; anoxic deeps, H_2S)? Glaciers/Dry rivers (Colorado, Yangtze)? [Profits? Privilege? Capitalism?] Democracy? Civilization? Extinction? Each perception inspires its own defense, easily politicized, and at cross purposes to others. The simple truth is that the answer to all of those candidates is "Yes! (with different time scales)", which has resulted in 60 years of denial and dithering (so far). Some of the threats are existential. The bracketed triplet is the American far-right's and generates the counterclaim that Democracy is the real threat (to greed, interpreted as "freedom").

Because so many seem to lack a working grasp of the data, Fig. 2 shows what has happened and Fig. 3 what has driven ir.

FIGURE 2. **Frame-of-Reference Data.** 140 years of surface-temperature change over land and sea. We and our food crops respond to the over-land temperature. **1884 appears to be the low point of the last 11,700 years, and we take this as the notional end of the Holocene.** We and the plants now living in the Temperate Zone are comfortable in the unshaded 2° range.

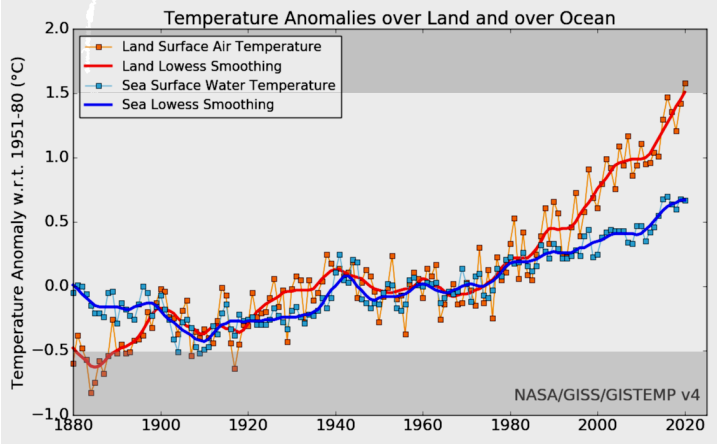
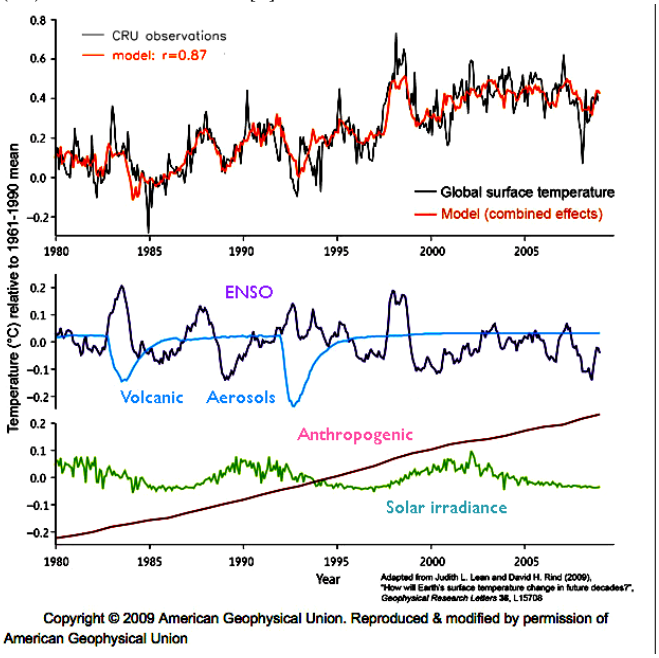


FIGURE 3. **"Climate is always changing".** Upper panel black line is original data. Lower panel separates the 4 principal drivers. Upper panel orange line is the reconstructed version explaining 76% (r^2) of the black line [4].



An unexpected problem is simple ignorance — in 2 unrelated forms. The first is Upton Sinclair's general truth: "It is difficult to get a man to understand something, when his salary depends on his not understanding it." This seems to lie behind the conservative inability to recognize the problems of the preceding paragraph.

The second form of ignorance is highly specific. The effort devoted to the polar ice cores gave us great insight into the climate of the last 800,000 years — but it is insight into a world now largely irrelevant. The Vostok world was defined by its mobile inventory of 300 ppm of CO_2, the peak atmospheric content reached during the interglacials between the glaciations. The current inventory is higher by 42% (124 ppm) and rising, and we know essentially nothing about how it will behave. The thawing permafrost of Siberia contains a lot of methane clathrate anxious to join the fun.

In the Vostok world interglacials were sharp peaks, climbing as northern insolation melted ice, falling as burgeoning forests recaptured CO_2. Ruddiman [3] noticed that the finale of the Vostok data was flat-topped and fundamentally different from the 3 previous sharply pointed peaks. He suggested a prehistoric Anthropocene in explanation, with human farming and land clearance leading to CO_2 emission 8000 years ago, followeed by methane from rice paddies at 5000.

In response to the need for a world-wide marker for a new epoch, atomic-bomb-testing debris will probably date the official Anthropocene ca. 1950 CE. For the purposes of this paper, we note that about 1880, the British Navy realized that ruling the seas required understanding weather and started collecting world-wide data. The fortuitous result is that Fig. 2 records the beginning of world thermometric temperature data — and also allows us to pick the capture of its minimum in 1884 as an arbitrary date for the end of the Holocene and the "Vostok world". Since that moment (coincidentally infamous as the elbow of Mann's hockey stick [5]) we have unwittingly been on our own. In an epoch that is truly Anthropocene [6] we have messed with the climate and it is ours to live with — and fix if we can. **The Anthropo*cene* is necessarily anthropo*nomic*: actively managed by mere humans.** None of this new responsibility meshes well with the traditional skill sets of current economists or politicians!

1.5. **An exemplary number.** One number we have tried many times to deduce is "climate sensitivity", meaning the temperature rise for doubling CO_2, with calculations which range from 0.5°C to nearly 10°. The problem is real because the number depends upon the time span considered. The perturbed world returns to steady state at different speeds for different processes, so there is no correct answer. One difficulty is that water vapor is numerically more important than CO_2 (but without the CO_2 the water vapor would all freeze out on Antarctica). A useful approach for human time scales is to halve the observed Antarctic numbers for use elsewhere. This seems to work pretty well [7]. The current authority on climate sensitivity is a 92-page Bayesian analysis whose abstract has a "Plain-Language Summary" concluding, "We remain unable to rule out that the sensitivity could be above 4.5°C per doubling of carbon dioxide level" [8].

2. PEA SOUP

2.1. **Simplicity Is Good.** When dealing with something that can't be seen and takes decades to be noticed, it helps to have an analog that is visible, with an intuitive mental image which is understandable to the non-scientist. I suggest that exactly this is offered by a historical experience that shares many of the attributes of CO_2 itself. John Evelyn described it in 1661 [9], Hermann Melville called it the "London pea-souper", and we can use it to build an "80% model" that explains 80% of AGW while safely ignoring 80% of its complexity. (The hidden assumption here is that 150 years of study enable atmospheric physicists to identify the most significant aspects of their subject matter.) Simplicity is important because, as Goody [10] put it, "the promise of very large computers is illusory if the purpose is understanding as opposed to elaborate bookkeeping".

Pea soupers included soot and sulfur dioxide, which corroded lungs but were easy to remove. Their third major pollutant was CO_2 itself. Invisible and odoroless, nobody noticed it, and it is much harder to remove. Figure 4 is a contemporary soot+automotive-smog pea souper. To make clear where the model does not match reality, pea soup needs an iinversion, while CO_2's mole fraction is everywhere 424 ppm (as of 2023-0525). Pea soupers result from local conditions: CO_2 is truly global.

Anyone can find a data set on the web to support any pet theory, The best I have found to show what is happening (Figure 2) and why it is happening (Figure 3) are the work of thousands of independent workers making routine measurements, published by the world's 3 best cimate labs. If you want to argue with this data, please adduce material of comparable depth and reputation in support of your claim. Flat contradictions, childhood recollections, and accusations of scientific misbehavior are not data.

2.2. **Why the 80% Model?** It is the nature of models to increase in complexity with time. There are some 50 digital climate models of moderate complexity, and apparently they are best run as committees, to get a majority vote on some particular event. Nonethess, a simple, understandable model that works well may be more useful than a complex, impenetrable model that works better. I submit that the 33° of OGW is neither mysterious nor subtle, and that the 1-2° of AGW is part of the same process. The difficulty appears to be the remarkable reluctance of the Holocene to end quickly and decisively, in the manner of its interglacial predecessors. This speaks to an equally remarkable sensitivity of glaciation initiation. Table 1 [p 23] summarizes the major facts covered by the 80% model, with short explanations of cause and consequence.

[Table 1 near here]

Although OGW and its temperature have been undertood since the late 1800s, they are seldom mentioned on social media. This is because under the rubric of free speech we tolerate falsehood from commercial and political sources on the grounds that everyone undertands them as harmless exaggerations. Then we allow

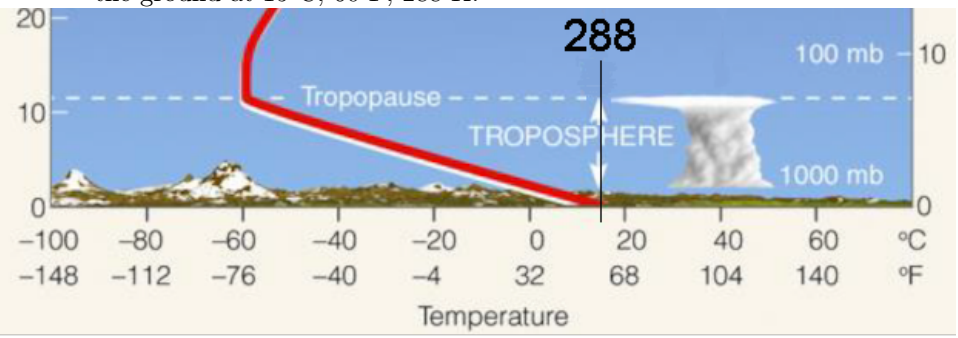
FIGURE 4. Contemporary pea souper over Almaty, Kazakhstan. Except for color and the smog's sharp upper surface (flattened by a temperature inversion), this represents what the bottom of the atmosphere might look like if we could see in the infrared. It certainly makes real the concept of atmospheric layers! (White ground fog might be a better choice for color, but it lacks the implicit malignance of smog and pea soup.) (Photo: Igors Jefimovs/Wikimedia Commons.)

the dozens of right-wing propaganda factories to call themselves "research institutes". The deliberate Stalinesque campaign of *"dezinformatsiya"* and its process of spreading confusion has moved to the internet to spread all kinds of distrust, of U.S. policies and politicians, and of climate and any other science. This paper closes with an example of the subtlest relevant current approach, so you can see this policy in action.

With .its focus on the obvious, the 80% model can help one ignore disinformative web pages that argue about the emissivity of the earth and the grayness of its blackbody, the variation of its albedo and the shape of IR absorption lines, the depth of the carbonate compensation level in the Atlantic and the disintegration of polar ice shelves, the ozone hole and UV reactions in the stratosphere, the AMOC and the PDO, cosmic rays and cloud nuclei, the size distribution of cloud droplets,the slow growth of the sun's core, and the thousand and one other details that are available for argument. These are mostly real, interesting and sometimes important problems, but the questions they raise are secondary and *do not need resolving before we can act* intelligently on the available knowledge. The basic idea of the model has long been well known, it agrees with international climate labs, introduces no errors, and any 6th grader who has been to the Dead Sea, Death Valley, or even the Coachella Valley Music and Arts Festival (all hot and below sea level) will understand it experientially. The troposhere is fundamentally simple: my Scoutmaster recommended Kraght's *Meteorology for Ship and Aircraft Operation* [11] as preparation for the Boy Scout Weather merit badge.

[Figure 5 near here]

FIGURE 5. In the 80% model, the troposphere of the *U.S. Standard Atmosphere* is the only part of the atmosphere relevant to climate warming. Historically, the lapse-rate line was anchored to the ground at 15°C, 60°F, 288°K.

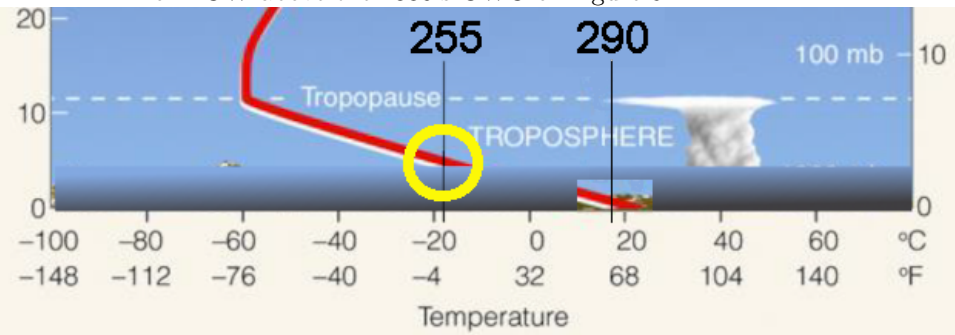


2.3. **Global Warming by Fiat.** 15°C was long accepted as a useful estimate of temperate-zone surface temperature before becoming the official baseline of the *U. S. Standard Atmosphere* in 1962. In the troposphere, the Standard Atmosphere's temperature decreases vertically at -6.5°C/km – the lapse rate (dT/dz), and the red line in Figs 5 and 6 – corresponding to the average moisture content. The actual lapse rate is a function of humidity [12] and can vary with height. (The temperature may vary 30° on either side of the ideal line 1% of the time [13].) There is no way for an air "parcel" (an ounce, a mole, or a cubic foot) of air in radiative equilibrium with its neighbors to change its energy, so it is at constant potential temperature (it returns to a given temperature at a given altitude), its atmospheric motion is adiabatic (no heat crosses its boundary) and $p^{(1-\gamma)}T^{\gamma} = constant$, where γ (the ratio of specific heats) is 1.4 for N_2 and O_2. This would curve the lapse rate except that a moderate humidity linearizes it over the 210-310°K-range [14]. Cloud base is about 1500 m; the tropopause stops the growth of cumulonimbus incus clouds; stratospheric winds disperse frozen tops of thunderstorms into characteristic "anvils"; all these effects are shown in Fig 5.

The 80% model defines the ERS as the altitude where the lapse-rate line crosses our SB temperature of -18°C (0°F, 255°K, Fig 6). This is the steady-state temperature of a rotating blackbody planet, given the temperature of and distance to our sun and the 30% fraction of energy reflected. While the SB temperature has increased as the sun's helium core has expanded over the last 4 bilion years, in 1880 and 2030, the SB temperature remains 255°K (barring changes in albedo).

The troubling 1.5°C AGW increase that we think of as all of global warming is exactly the same process as this defined baseline OGW – a fact that should eliminate some of the wilder short-term "explanations" found on the web. The best way to characterize AGW is as "more of the same". If you have a pet theory of global warming, test it by asking yourself if it could reliably have supplied $\sim 33°$ of warming for 3 billion years.

FIGURE 6. Behaviorally, the lapse-rate line is anchored at the top of the pea soup, where it crosses the 255°K (0°F, -18°C) SB temperature. Below this point lies IR-opaque pea soup, in a simple analog of the condition of the atmosphere. This intersection defines the Effective Radiation Surface of the Earth. By adding CO_2 we have raised the lapse-rate line vertically (maintaining its slope) and moved its ground intersection $\sim 2°$ to the right. That's our $\sim 2°$ of AGW above the 1880's OWG of Figure 5.



[Figure 6 near here]

Below cloud base, most outgoing radiation is intercepted and re-distributed by water vapor, rather than CO_2. But cloud base is far below the ERS, leaving CO_2 as the "control knob" of global warming [15]. The 80% approach to the ERS uses the formal lapse rate, whence $33°/(6.5°/\text{km}) = 5077$ m, halfway to the tropopause when the Standard Atmosphere was defined.

The important point is the **adiabatic temperature rise** throughout the troposphere: "a thermodynamic change of state of a system such that no heat or mass is transferred across the boundaries of the system. In an adiabatic process, expansion always results in cooling, and compression in warming" [16]. **Global warming needs no extra heat.** When we add CO_2 it mixes uniformly and globally with the atmosphere. The top of the pea soup rises everywhere, defining the altitude at which the CO_2 density is low enough for half of the -18°C photons to escape to space directly.

The infrared view of the Earth from space sees the top of the pea soup as a relatively constant -18°C (±3°, perhaps) whatever the ground temperature may be. (I do not have an image which shows this, but there was a web page whose wallpaper was just such a quasi-uniform satellite view of the North Atlantic Quadrant of the Earth – with isotherms and a half-a-dozen cold blue spots for the frozen tops of Atlantic storms. It had sufficient detail that a back-of-the-envelope integration of its mean temperature was indeed 255°K.)

Colloquially, ***global warming is just an unfamiliar way of saying that "snow lives on mountain tops"*** – a process that most of us accept as natural and generally true without feeling a need to invoke conspiracies. This is arguably

the simplest and most straightforward explanation of global warming yet suggested – and it has been understood for a century: I make no claim of originality, only a plea for common sense! It also lets us estimate the height of the ERS from future injections of CO_2, because on average 47% stays in the atmosphere [17], with the remainder going into trees and the ocean.

Take-home concepts – Ordinary Global Warming is:
1) **Not new:** it is a gas-thermodynamic process that made life on Earth possible;
2) **Large:** it has always been above 20°C;
3) **Long term:** its time constants are those of geological epochs and ocean overturning;
4) **Cumulative:** AGW will get worse as we postpone action.

3. THE ROAD NOT TAKEN

3.1. **Notation.** Let me expand our notation. The first formal definitions [18] (for the sake of field geologists) divide a single axis into:
•**Glacials:** "episodes during which extensive glaciers developed."
•**Interglacials:** "episodes during which the climate was incompatible with the wide extent of glaciers".
s Those looking at computer screens find it useful to divide a seconnd axis also:
•**T-Rises:** short episodes (10 kyr) of rapid temperature rise;
•**T-Falls:** long episodes (100 kyr) of slowly falling temperature.

A byproduct of the need to understand the sequence from human activity to global change to climate warming was the recovery of polar ice cores [20]. These cores have given us an invaluable 800,000-year record of annual values of a long list of measured and inferred climate parameters described in a confusing wealth of original research papers. These papers were analyzed by the IPCC (Intergovernmental Panel on Climate Change — a child of the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) — every 6 or 7 years, in an effort to make the research accessible to non-scientists. The resulting series of multi-volume reports, known as FAR (1990), SAR (1995), TAR (2001), and then AR4 (2007), AR5 (2013), and AR6 (2023) have an intentionally conservative and calming bias. Only in 2005 did they get around to discussing *Carbon dioxide capture and storage* — 40 years late by my accounting. Given the comsition of the IPCC, it is no surprise that they overlooked biological possibilities here.

The value of these reports is — I submit — greater to geologists and students of the past, than to politicians and planners for the future, because they are unwittingly descriptive of a world now lost. The "Vostok world" was defined by a mobile inventory of 300 ppm of CO_2. The current world of 425 ppm (as of mid-2023) has already broken the "Vostok cycle" of glacials and intergacials that the IPCC reports describe, and we should be wary of extrapolating from them to the future.

We may take the $3\frac{1}{2}$ most recent glaciation cycles as definitive of the "Vostok period" when "atmospheric and climate properties oscillated between stable bounds" [19], these being $\leq$ 300 ppm of CO_2 during warm interglacials and $\approx$ 180 ppm at

the coldest part of the long glacial. Incidentally, the common 300-ppm peak of the interglacials indicates that the "steady volcanic leakage of CO_2" over the 800,000 year record is small enough to be considered background noise by the 80% model.

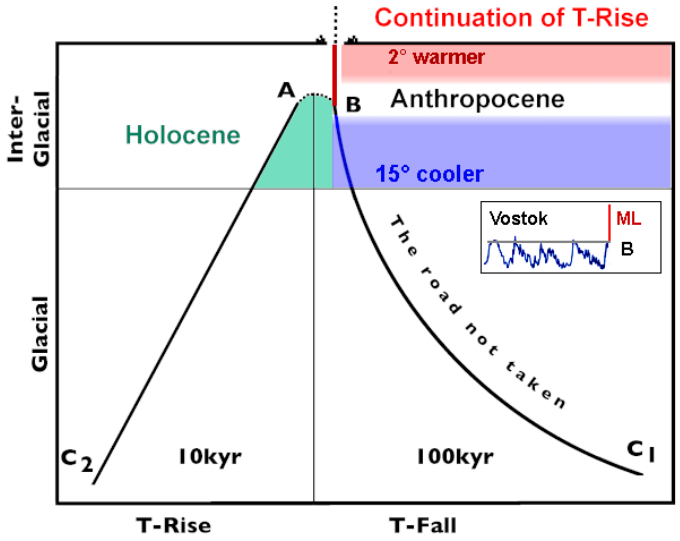
The major hypotheses for the cold-storage of the CO_2 whose movement determined the Vostok cycle were thalassochemical (changes in alkalinity of polar waters) [21], biological (soil carbon and trees buried by advancing ice) [22], and methane clathrates [23] in tundra and on Arctic shelves. In the apparent absence of a bookkeeping paper examining relative quantities for these reservoirs, we should be aware that there are unquantified amounts of stored CO_2 in ocean and tundra that will be released as the climate warms.

There is a growing realization that "the end of the peak interglacial conditions [is] the initial stage of the subsequent glaciation and thus also ... the glacial inception" [24, §7.3]. The simultaneous end of a T-rise and beginning of a T-fall minimizes the influence of Croll-Milankovitch [25,26] astrophysics on the inception of a new ice age. Given the known reluctance of climate cycles to match astrophysical cycles, it is a considerable improvement to automate T-Falls and leave the starting of T-Rises as Milankovitch's principal chore. Perhaps this is what Wunsch was getting at when he noted that Milankovitch could account for <20% of climate forcing [27].

An example of what can happen in today's post-Vostok world is the failure of Antarctic ice-shelf growth [28]. It used to be that in cold winters, Antarctic Circumpolar Water, highly oxygenated from its wind-blown circuit, would freeze onto the edge or bottom of an ice shelf. Ice formation leaves the salt behind, creating an oxygen-rich, dense, salty, water mass which sinks to become Antarctic Bottom Water, AABW, which spreads out to ventilate most of the sea floor below 4 km with its life-giving oxygen. No ice-shelf growth means no AABW, followed eventually by anoxic deeps. Sulfur bacteria survive, getting their oxygen from sulfates and leaving behind toxic sulfide. Recent work [29] suggests that volcanic CO_2, warm oceans, and diminished vertical circulation were sufficient to eliminate many marine species in the Permian-Triasic extinction, killing them off before reaching the concentration of H_2S required to kill the land dwellers. The best way to avoid this happening again was to have started toward zero-carbon in 1965 (when the Keeling Curve [30] showed us what was happening) and planned ahead: smaller families, public transport, better middle-school science, thorium reactors, etc. There was no dearth of useful ideas, no lack of professionals who understood what was happening — and no dearth of Big Carbon CEOs who fully realized the threat to their profits and had no qualms about lying to the public. The U.S. needs a codicil to the First Amendment whch requires advertizing hyperbole to be identified as such, so that pseudo-scientific propaganda papers from e.g., the Heartland Institute, carry required warnings that they are not to be taken seriously.

Much of the confusion surrounding climate warming comes from an unprecedented event that made the Holocene an interglacial unlike all its predecesors, which started cooling immediately after their peak. Early farming ventures in northern Europe [3] apparently prevented this quick descent for the Holocene, extending it for 11.7 millennia. By now we "should be" well into the downslope of the most

FIGURE 7. **Ice-Age Coordinate plot,** with cartoon of the last (aborted) Vostok cycle. We are at B, which appears twice. In the inset it joins 400,000 years of Vostok ice-core data (blue) to 70 years of Mauna Loa data (red). The near-vertical "Continuation of T-Rise" in red and dotted black is the global-warming path we are on. "The road not taken" is the long glaciation typical of the Vostok cycle that we avoided, and the white "Anthropocene" band is the CO_2/temperature path we need to stay on to preserve civilization and its contentments !



recent Vostok cycle and be facing ice storms and failed crops. The fact that we are not having this problem also indicates that the ice-core record ("Vostok" for short) describes a world now vanished.

Figure 7 began as an afterthought showing simple crossed axes adding a dimension to glaciation, and a cartoon of a Vostok Peak. The details volunteered. The low points $C_{1,2}$ are incidental to the discussion, and might represent a balance between slow photosynthsesis at low CO_2 while waiting for an astrophysical opportunity. C_2 was flat for at least 7 kyr waiting for a trigger [31], and must have been a boring and uncomfortable period for our ancestors. The trigger was almost certainly greater insolation at 65°N releasing CO_2 from sea and tundra half a millennium earlier, despite the IPCC's unfortunate comment prematurely absolving Big Carbon: "it is unlikely that CO_2 variations have triggered the end of glacial periods. Antarctic temperature started to rise several centuries before atmospheric CO_2 during past glacial terminations" [32]. This lag is simply the result of northern insolation taking a long time to affect the southern hemisphere.

The rapid T-Rise of Figure 7 "officially" [31] extends from 21 ka to 9 ka. By point A, all of the easily accessible sequestered mobile CO_2 inventory is back in

the atmosphere. The gap to point B allows for oscillations in the balance between, e.g., outgassing/oxidation of the last resistant carbon within reach and the growth/extent of young forests. 7.5 ka was a minor temperature peak; 2000 years ago, the temperature started down more markedly [33] and Point B would represent the triumph of photosynthesis over decay. Young forests started turning atmospheric CO_2 back into vegetation, and as CO_2 dropped, so did temperature, but very slowly.

4. The Little Ice Age

About 900 CE the descent increased and by 1500 Europe was into the Little Ice Age. As noted above, this is already long for an interglacial, but no-one knew this in the 19th century. In 1884 — my choice, the lowest over-land temperature in Figure 2 — and to everyone's relief, the temperature started back up. Then, as now, the common explanation was the misconception, "Climate is always changing". (Check the web for "Köppen climate classification" to see why this is a misconsception. What changes all the time is weather.) But this time it *was* the climate. The questions are: How?, and Why?.

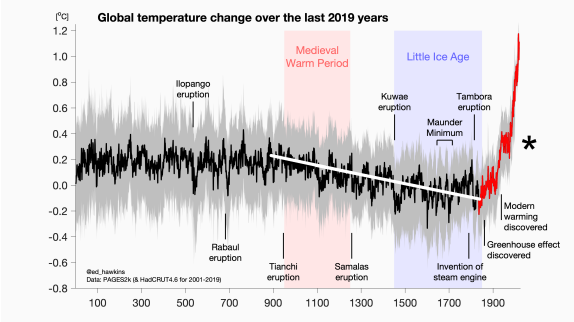
Since 1884, we have not been in the Vostok world. We have not been in the Holocene. We are in *terra incognita*, with working name "Anthropocene". In this world the mobile inventory of CO_2 is 42% higher than Vostok's, at 424 ppm (as of 2023.0600), and has exerted only a small fraction of its potential influence because of the heat capacity and thermal lag of the ocean. The only things we can be sure of are that **we have little idea of what lies ahead and no guidance from the ice cores, and we aren't going to like the results.**

However, there is an under-appreciated possibility here. Nothing in the ice-core data indicates anything special about the last Vostok interglacial – except that the 11 kyrs of the Holocene should have been followed by a normal T-fall. **Some may recall that as late as 1978, perceptive glaciologists were worrying about the return of the ice [34].** Long before we had the Vostok data, there were some who felt that interglacials were not the stable state that Genesis prematurely taught the West to expect. They knew that glacials and interglacials alternated, perhaps automatically, without a visible driver. Clues thicken with the millennial temperature decline from 900 to 1884 CE, the episode that in 1939 François Matthes named "the Little Ice Age" (LIA). California's Sierra Nevada impressed him by the freshness of its morraines, and he apparently introduced the name in his report [35]. The Medieval Warm Period, not yet recognized as a local North Atlantic fluctuation, confused the issue considerably.)

Figure 8 emphasizes the dominance of CO_2 in climate, with neither abundant vulcanism, nor serious solar inactivity (the Maunder minimum), nor the intrusion of warm Atlantic water into the north (the Medieval Warm period) having noticeable effect. *The Atlantic Monthly* called Figure 8 "the most controversial graph in science" [37], but since the blade continues to grow we can hope it will eventually look real even to concrete thinkers and hard-right conservatives. Similar but shorter rapid changes in CO_2 beginning in 1850 are seen in the WAIS core from Western

Antarctica [38], which has contributed to the dismissal of the LIA as uninteresting. The noise to the left of the asterisk is the last gasp of the last glaciation, including 5 failed attempts to drop below -0.25°C (1961-1980 reference).

FIGURE 8. **The Blade of Mann's Hockey Stick** [5] appears to continue the T-rise that preceded the Holocene, with its handle being part of the T-Fall that followed the last Vostok peak. (The Blade is also shown in red at point B in Figure 7.) Annotations by Ed Hawkins [36]; white line, red blade/T-Rise, and asterisk by author.



If the T-rise that ended in the Holocene stopped 11,700 years ago because it ran out of mobile inventory (rather than for astrophyical reasons), the restart of the T-rise by the hockey stick's blade would seem to be attributable to "new" CO_2 from coal at the begining of the Industrial Revolution. This indicates that the T-rise will grow as long as we feed it CO_2. But then what? Although dT/dCO_2 comparisons beween Europe and Antarctica have been uncertain, Hansen et al. [7] get a good match to European conditions by dividing the Antarctic Dome C temperature changes by 2, with a bit of time adjustment for snow consolidation.

The system must be delicately poised if a T-fall could be reversed by the CO_2 added in the 2 centuries between the invention of the steam engine and the asterisk oscillation of Figure 8 as Britain switched from wood to coal. (Unfortunately, British coal-production records from this period are often found "within the body of a document and are not obvious from the description in the catalogue", according to *The National Archives* [39] thus making such a check a major research project.) Still, this reversal reinforces the idea that earlier T-rises were terminated by running out of trapped CO_2 rather than by insolation cycles or oceanic processes. YouTube videos of flames from ice fields and pingo blowouts in the tundra show that methane clathrates which might be part of the mobile inventory are still available at 424 ppm, but they are, if not "new" resources, at least untapped by the previous highs of the Vostok series. They would have remained locked in permafrost had the Little Ice Age descent not been interrupted.

Table 2 collects a preliminary list of papers relevant to the idea that the LIA belongs in the Vostok series. If this hypothesis has any merit, it emphasizes the "control-knob" aspect of CO_2 and the extravagant influence of "new" CO_2 on the

system. It may have been a coincidence that British coal mining occurred just when the Vostok cycle was in its most sensitive state, akin to the rash of "fine-tuning" coincidences of astrophysics. The binary nature of the Anthropocene's extinction-level threats – with a narrow track between depopulation by cold and depopulation by heat – suggests that our species' childhood is over. Adult abstract thinkers are responsible for any steps toward survival. The immediate focus is global warming and hence atmospheric CO_2. We want the latter to be near 300 ppm to keep the former near 33°, which is a major technological enterprise. More to the point, it requires such a large politicoeconomic adjustment that implementing it seems unlikely without also addressing the delicate sociopolitical issues of population [50, 51], governance [52], and economics [53, 54] — and this at a time when the world's democracies are already in trouble.

4.1. **The Meaning of Anthropocene.** It should be clear to any *competent* politician that the corolllary to the definition is that "human choice" has been overtaken by sheer necessity if we want civilization to continue. **The Anthropo*cene* is necessarily anthropo*nomic*: actively managed by mere humans.** An impartial obsever might notice that as a species, we offer little indication of readiness for such responsibility.

TABLE 1. (Part of) The Confused History of the LIA (Little Ice Age) Really Table 2.

DATE	**REF**	**EVENT**
900	Figure 8	Putative start of LIA during interglacial
1823	40 Hestmark	Traces of the ice age are everywhere
1856	1,41 Foote	Carbon dioxide and water vapor trap heat in the atmosphere
1875	25 Croll	Astronomical forcing of ice age
1884	Figs. 1, 8	Notional end of LIA and Holocene
1901-09	42 Penck	Recognition of repetitive ice ages
1939	33 Matthes	Identification of Little Ice Age in California's Sierra Nevada
1941	26 Milankovich	*Kanon der Erdbestrahlung und seine Anwendung auf Insolation*
1955	17 Keeling	First accurate measurement of ambient CO_2
1969	26 Milankovitch	U.S. edition of *Canon of Insolation*
1976	13 GPO	Define U.S. Standard Atmosphere
1978	43 Schneider	*In Search of the Coming Ice Age (20-min video)*
1987	66 Barnola	Analysis of CO_2 in Vostok core
1988	44 Berger	Milankovitch theory predicts imminent 15 kyr of cold and colder
1994	45 Hughes	No *global* "Medieval Warm Period"
1998	46 Hunter-Anderson	Surprisingly, the LIA was noticed on Rapa Nui
1999	5 Mann	Hockey stick (restart of T-rise from 300-ppm base)
2004	27 Wunsch	Milankovitch supplies $< 20\%$ of climate forcing
2005	47 Matthews	LIA was worldwide, but timing is uncertain
2021	48 Lapointe	LIA was triggered prematurely by intrusion of Atlantic water
2023	49 Kaufman	Cooling began 2000 years ago, driven by insolation; reversed at end of LIA
2023	Here	**The LIA was the aborted final T-fall of the Vostok series**

4.2. **Adult Responsibility.** If we were serious about survival, we would take "Anthropocene" literally. Ready or not, we — mere humans — are patently responsible

for maintenance and operation of our planetary home. It seems that some feel that **economics** (from the Greek for "*managing* the household") is the principal discipline required to run the world successfully. The results suggest something about carts and horses, and that **ecology** (Gk for "*studying* the [planetary] household") was a necessary first step. Similarly, the assumption that a creator divinity would be benevolent is an assumption biased by cultural develoment during the long friendy Holocene. The Anthropocene is likely to show us a far sterner face. Was Creation as intentional as fine tuning suggests? Are we just lab rats in a large experiment hoping to find a culture — shaped by descent with (random) modification and survival of the (temporarily) fittest — that could avoid competitive extinction ?

The response of an intelligent species to planetary warming might be to stop neighborly wars as the easy and logical first step toward "zero carbon", and devote the energy and resources so freed to the real problem facing us. On the other hand, perhaps that is a parochial Western outlook: both Russia and China would be happy to see Siberia thawed and dried and its untapped resources made accessible. But even that view requires that enouogh civilization survives to be worth gloating over, and there is no guarantee of that.

Next best might be legislation prohibiting the sale of fossil carbon to any concern that cannot capture 90% of the resulting CO_2 for permanent (underground?) storage by, say, 2030. Fortunately, we know how to capture CO_2 from coal-fired boilers [55] making this a problem we can solve by throwing legislation, research, and C-level salaries at it. This is worth doing because roughly $1/3$ of CO_2 emissions are concentrated at electricity-generating sites – think of a continuous freight train of gondola cars running from coal mine to generator.

Interim help is offered by a perennial grass *Panicum virginianis* (switchgrass) that sequesters 100 tons carbon per acre while increasing biodiversity [56]. This makes temperate grasslands about equal to tropical rainforests at capturing carbon. The chemistry remains obscure, but a 1996 discovery [57] little noticed even by soil scientists, was a third irregular biopolymer known as **glomeralin**, which may yet become as important to us as cellulose (polysugar) and lignin (polyphenol, and the most abundant, renewable source of aromatics on Earth) because like them it is produced by photosynthesis. It also provides nitrogen to soil and gives it the structure needed to hold water and for proper aeration, movement of plant roots, and stability to resist erosion. It is produced by symbiotic arbuscular mycorrhizal fungi (Glomerales) acting as root hairs for plants, and makes up nearly $1/3$ of soil carbon, particularly in the deep black chernozems of Ukrainia, the pampas, the prairies, or generically, steppes. These are our most productive nd indestructible soils, but even they have been depleted of soil carbon.

Figure 8 tells us that the most important question currently before the human race is this: Can we get our act together before global warming makes civilization impossible? If we want "a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current 385 [now 424] ppm" [6]. I suggest that we need to aim for 300 ppm. The recipe for a Goldilocks world under

today's other conditions is simply stated, if hard to achieve: **return the atmosphere to 300±20 ppm of CO_2 and keep it there**. Our first priority should be learning to turn the climate-control knob. This is not easy, and it will require politicians whose staff can translate *Nature* and *Science* into politically viable suggestions.

5. PAPER MILL OR DISINFORMATION IN A RESPECTABLE JOURNAL?

5.1. **Relevance.** It is one thing for politicians to lie to us. After all, it is a job requirement (Diplomat: "an honest gentleman sent abroad to lie for the good of his country", Sir Henry Wotton, 1604) — but it loses its utility if recognized. It is another thing entirely for party propaganda arms to publish biased pseudoscience (e.g., an economics paper supporting the trickle-down hypothesis. We have 50 years of data to refute it) — but because the "experiments" behind the data were constructed to satisfy a precoonceived notion, their evalutive worth is compromised. It might be useful if legisation announced numerical goals, with failure to meet them guiding their immediate replacement. However, the one form of propaganda we should not tolerate is scientific disinformation in a peer-reviewed journal. (Misinformation is sometimes unvoidable; Disinformation — intentional lying — is intolerable.) We can do better! The immediate target of my wrath is a paper directly relevant to global warming. We begin with a brief historical review.

5.2. **122 Years Ago.** In 1896 Svante Arrhenius showed that atmospheric CO_2 was responsible for warming the Earth [58]. In 1900, spectrophotometrist Knut Ångström (son of the eponymous Ångström) tried to persuade Arrhenius that his paper overlooked a familiar problem of spectroscopy and that CO_2 could not be responsible for global warming, because at its recorded concentration it would already be "saturated" and unable to further affect solar radiation.

This was wrong for 2 reasons. Trivialy, CO_2 meassuments were by unreliable wet chemistry until Dave Keeling's careful work [17] in mid century[1]. They were notoriously inaccurate (experimenters exhaled upon their reactants) and the true concentation was not known. The result was that Knut was simply ignored.

The secod reason is more important. A spectrophotometer measures the concentration of CO_2 by detecting missing photons from a probe beam. These are removed by conversion to internal bond-wagging energy in susceptible molecules (i.e, 3 or more atoms per molecule, with fequency dependent upon molecular structure). The natural lifetime of such an excitation is on the order of a second — during which period an air molecule would have been hit 5 billion times by other molecules. The usual result is instant reconversion of internal energy into kinetic energy shared by neighboring molecules.

(The objection of the second law — that heat does not flow from cold to hot, so CO_2 above cannot warm the earth below — is statistical and here manifested by (1) density: more photons are fired upward than downward, so energy moves

[1]Disclosure: I was hired by SIO to be Keeling's postdoc in 1965.

upward; and (2) kinetic spread: a slowly moving molecule may absorb a photon that raises its total energy above the mean energy of its neighbors, but this also increases its chance of firing a photon to cool off. Heat, or energy in motion, thus spends nearly all its time as molecular motion rather than as photons.

If an excited molecule in a spectrophotometer tube re-emits a photon, it will not, in general, be aimed at the detector, but at the enclosing tube, thus permanently lost. This works well for low concentrations of photoactive gas, but when half of the molecules are excited, they begins to decay by Einsteinian stimulated emission (not absorbing the probing photons, but emitting one in synchrony and producing a quasi-logarithmic flattening of the concentration curve). This cannot happen in the free atmosphere. where an emitted photon goes its own way in a random direction until it hits another CO_2. Eventually it reaches the top of the pea soup and escapes.

The question of saturation faded away by common consent. (At least I have not found a definitive paper explaining saturation from Knut's day.) However, the politicization of global warming seems to have resurrected it as another potential Big Lie.

5.3. ***Errors Revisited.*** Despite Swiss Re's estimate of global warming costing the world $23 trillion annually by midcentury [59], half of the U.S. Senate refuses on principle to "believe in" global warming, and wants to be reassured that we can let the hoax run its course, after which the stockmarket will rebound. A recent paper [60] shows in mathematical detail how we can do that, ostensibly putting dentures in Knut's argument. Its arithmetic may be valid; its logic is not. it was published in an ostensibly peer-reviewed journal from Singapore, and it is available from 8 reliable reprint sites including Harvard and Researchgate (most papers are content with one such site). The paper pretends that CO_2 poses no threat because saturation sets in near 300 ppm, with a maximum ΔT of 0.5°C at 600 ppm. This is deliberate disinformation. In the free atmosphere there are no tube walls to absorb the photon energy, collisions will return electrons to the ground state, and there are always ground-state molecules higher in the atmosphere. Anyone competent to write the paper would be aware of this.

If that paper were correct, it would mean that Arrhenius had been wrong for a century with no one noticing; that the thousand IPCC reviewers had been hoodwinked; and that the hundreds of international scientists who did the research reviewed by IPCC were uniformly incompetent or suborned. It appears to have been published to provide a peer-reviewed reference to cast doubt on the research of us "hoaxers". The result of well funded groups [61] spreading deliberate lies about climate change and global heating is that "[H]uman life on earth may be on the way to extinction, in the most horrible way" [62].

On that note, remember that Venus, whose dense atmosphere is 96.5% CO_2 with highly reflective clouds of SO_2 and a calculated SB temperature of 220°K but a surface temperature that destroys landing probes, estimated as 730°K (457°C, 854°F) from a rather thicker pea soup, with a global warming of 510°C [63]. The Parker Solar Probe recently took pictures of the surface through gaps in the clouds

— and it is a red-hot 450°C [62]. As Pierrehumbert says [64] with respect to saturation: "Hot as Venus is, it would become still hotter if one added CO_2 to its atmosphere".

6. BIBLIOGRAPHY

Dear Reader, the bibliography is a hand-assembled mess. I lack access to a working departmental system. Any chance I can hook up with yours long enough to get 66 references into common format?

The notation "&Na" replaces "et. al." and indicates N additional authors. In a bibliography, the author and date are for identification, so one name, the year, and the title are usually adequate. A computer may need to time the saved version of a paper to the nanosecond) but the librarian and the search routines find the year sufficient. For a societal acknowledgement of scientific contribution and personal worth, please read the original paper, which may have 273 authors. In dual reference numbers (e.g.: 49-1) the first number is a recent line number where the call to the reference can be found. These may not be up to date.)

49-1) E Foote. "XXXI. On the Heat in the Sun's Rays". Am J Sci Arts S.2. 1856:22;6 377-383.
https://static1.squarespace.com/static/5a2614102278e77e59a04f26/t/5aa1c3cf419202b500c3b388/1520550865302/foote_circumstances-affecting-heat-suns-rays_1856.pdf
(One reason Tyndall gets all the credit is that Eunice presented her work in 2 papers. The other one, numbered XXX and immediately preceding XXXI in the journal, is a totally confused account because it evidently never occurred to her that glass might be relatively opaque to "heat rays". One suspects that a discerning editor persuaded her to divide an original continuous paper.)

49-2) Tyndall, John (1861). "The Bakerian Lecture: On the Absorption and Radiation of Heat by Gases and Vapours, and on the Physical Connexion of Radiation, Absorption, and Conduction. Phil Tran Roy Socof London 151 (1861), pp. 1-36.
https://www.jstor.org/stable/108724

70-3) Ruddiman, W. F.: 2003, 'The anthropocene greenhouse era began thousands of years ago', Clim. Change 61, 261–293. Ruddiman 2005, The earlly athropogenichypothei a year later. Climatic Change 69: 427–434
https://link.springer.com/article/10.1023/B:CLIM.0000004577.17928.fa
https://www.uvm.edu/~pbierman/classes/gradsem/2008/ruddiman_2005.pdf

75-4) JL Lean, DH Rind. (2009) How will Earth's surface temperature change in future decades. Geophysical Research Letters 36:15;
https://doi.org/10.1029/2009GL038932

79-5) ME Mann, RS Bradley, MK Hughes. Northern Hemisphere Temperatures During the Past Millennium: Inferences, Uncertainties, and Limitations. Geo-phys. Res Lett 1999:26;6 750-762.
http://www.geo.umass.edu/faculty/bradley/mann1999.pdf

79-6) PI Crutzen, EF Stoermer: 2000, 'The "Anthropocene" ', IGBP Newsletter 41, 12.

82-7) J Hansen &9a. Target Atmospheric CO_2: Where Should Humanity Aim? The Open Atmospheric Science Journal, 2008, 2, 217-231.
https://openatmosphericsciencejournal.com/contents/volumes/V2/TOASCJ-2-217/TOASCJ-2-217.pdf

82-8) SC Sherwood &17a. (2020)An Assessment of Earth's Climate Sensitivity Using Multiple Lines of Evidence. Reviews of Geophysics 58;4 e2019RG000678
https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2019RG000678

87-9) JE Evelyn. (1661) Fumifugium. London; W. Godbld for G. Bedel, and TM Collins.
https://www.gethistories.com/p/life-in-the-smoke-1661

87-10) RM Goody, YL Yung. Thermal Radiation Theoeretical Basis. 2nd ed. Oxford.
https://www.abebooks.com/9780195102918/Atmospheric-Radiation-Theoretical-Basis-Goody-0195102916/plp

107-11) PE Kraght (1942) Meteorology for Ship and Aircraft Operation. Cornell Maritime Press. https://www.abebooks.com/first-edition/Meteorology-Ship-Aircraft-Operation-Kraght-Peter/1769423323/bd

110-12) NE Daidzic. On Atmospheric Lapse Rates. I J Aviation Aeronautics Aerospace, 2019:6;4. This is a case where for convenience a constant, 6.5, conventionally stands in for half-a-dozen formulas, some quite complex.
https://commons.erau.edu/ijaaa/vol6/iss4/2/

110-13) U.S. Standard Atmosphere. Government Printing Office. 1976.
https://www.engineeringtoolbox.com/standar-atmosphere-d_604.html

111-14] D. Koll, T. Cronin. Earth's outgoing longwave radiation is linear due to H2O greenhouse effect. Proc Natl Acad Sci 2018:115;41, 10293-10298.
https://doi.org/10.1073/pnas.1809868115

123-15) AA Lacis &3a. Atmospheric CO2: Principal Control Knob Governing Earth's Temperature. Science 2010:330;356, DOI: 10.1126/science.1190653
https://www.researchgate.net/publication/47429333_Atmospheric_CO2_Principal_Control_Knob_Governing_Earth%27s_Temperature

15-16) UNFCCC Glossary, "adiabatic process"
https://unfccc.int/resource/cd_roms/na1/ghg_inventories/english/8_glossary/Glossary.htm

136-17) CD Keeling. The concentration and isotopic abundance of carbon dioxide in the atmosphere. Tellus 1960:12;2 200-203. DOI: 10.3402/tellusa.v12i2.9366

http://www.rescuethatfrog.com/wp-content/uploads/2017/01/Keeling-1960.pdf.
https://gml.noaa.gov/webdata/ccgg/trends/co2_data_mlo.pdf.
https://scrippsco2.ucsd.edu/history_legacy/charles_david_keeling_biography.html

147-18) Code of Stratigraphic Nomenclature, Bulletin of the American Association of Petroleum Geologists, 1961:45; 645-665.
https://paos.colorado.edu/~fasullo/1060/resources/glacial.glossary.html
https://pubs.geoscienceworld.org/aapgbull/article-abstract/45/5/645/34842/Code-of-Stratigraphic-Nomenclature?redirectedFrom=fulltext

155-19) C Genthon &7a. Vostok ice core: response to CO_2 and orbital forcing changes over the last climatic cycle. *Nature* 1987:329, 414-418.
https://www.nature.com/articles/329414a0

157-20) E Jansen, J Overpeck &14a. 2007 Science Basis, Working Group I, 4th Assessment Report, IPCC. Cambridge University Press.
https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-spm-1.pdf

162-21) WS Broeker, TH Peng. The role of $CaCO_3$ compensation in the glacial to interglacial atmospoheric CO_2.
https://www.whoi.edu/cms/files/broecker87gbc_69163.pdf

162-22) Zeng. Glacial-Interglacial Atmospheric CO_2 Change. The Glacial Burial Hypothesis. Adc. Atmos. Sci. 2003:20;6,693-677.
https://www2.atmos.umd,edu/~zeng/papers/Zeng03_glacialC.pdf

162-23) GJ MacDonald. Role of methane clathrates in past and future climates. Climate Change 1990:16, 247-281.
https://link.springer.com/article/10.1007/bf00144504

164-24) PAGES. Interglacials of the last 800,000 years.Rev. Geophysics 2016:54 162-219. doi:10:1002/2015RG000482.
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015RG000482

164-25) J Croll. (1875) Climate and time in their geological relations: a theory of the secular changes of the earth's climate. Daldy Isbister, 577 pp.
https://www.gutenberg.org/ebooks/62693

164-26) M Milankovitch. Kanon der Erdbestrahlung und seine Anwendung auf des Eiszeitenproblem Special Publication 132, Section of Mathematical and Natural Sciences, 33 p. 633, 1941. Belgrade: Royal Serbian Academy of Sciences (Canon of Insolation and the Ice Age Problem) (trans. Israel385 Program for the US Department of Commerce and the National Science Foundation, Washington 11 DC, 1969).
https://www.semanticscholar.org/paper/ICE-AGES-(MILANKOVITCH-THEORY)-Loutre/295bb27fafd030489e04d9c770436f13b458af0a

164-27) C Wunsch. 2004. Quantitative estimate of the Milankovitch-forced contribution to observed Quaternary climate change. Quaternary Science Reviews 23;9-10, 1001-1012
https://www.whoi.edu/cms/files/wunsch04qsr_54723.pdf

166-28) HD Pritchard &5a. Antarctic ice-sheet loss driven by basal melting of ice shelves. 504 | Nature 2012:484,502-512.
https://www.nature.com/articles/nature10968

166-29)JL Penn &3a. Temperature-dependent hypoxia explains biogeography and severity of end-Permian marine mass extinction. Science 2018:362;6419, —
https://www.science.org/doi/10.1126/science.aat1327

168-30) The Keeling Curve. https://keelingcurve.ucsd.edu

170-31) R. F. Ivanovic &8a. Transient climate simulations of the deglaciation 21–9 thousand years before present; PMIP4 Core experiment design and boundary conditions. Geosci. Model Dev. Discuss., 8, 9045–9102, 2015
https://gmd.copernicus.org/articles/9/2563/2016/gmd-9-2563-2016.html

170-32) AR4: IPCC, 2007: Climate Change 2007 - The Physical Science Basis Contribution of Working Group I to the Fourth Assessment Report of the IPCC (ISBN 978 0521 88009-1 Hardback; 978 0521 70596-7 [Solomon, S.&xxa.] Paperback) https://www.ipcc.ch/report/ar4/wg1/

184-33) DS Kaufman &31a. Recent warming reverses long-term arctic cooling. Science 2009 Sep 4;325(5945):1236-9. doi: 10.1126/science.1173983.
https://www.researchgate.net/publication/279338822_Recent_Warming_Reverses_Long-Term_Arctic_Cooling

191-34) G Miller, C Langway, J Hayes, S Schneider. In Search of the Coming Ice Age. (22-minute video 1978.)
https://www.youtube.com/watch?v=q_TAPaVBmb0

191-35) FE Matthes. Report of the Committee on Glaciers, Transactions of the American Geophysical Union, 1939:20; 518-523.
https://doi.org/10.1029/TR020i004p00518 Paywalled.

200-36) E Hawkins (National Centre for Atmospheric Science, University of Reading.
https://www.antarcticglaciers.org/glaciers-and-climate/climate-change

196-37) C Mooney. The Hockey Stick: The Most Controversial Chart in Science, Explained. The Atlantic Monthly, 2015.0510.
https://www.theatlantic.com/technology/archive/2013/05/the-hockey-stick-the-most-controversial-chart-in-science-explained/275753/

196-38)J Ahn &7a. Atmospheric CO2 over the last 1000 years: A high-resolution record from the West Antarcti Ice Sheet (WAIS) Divide ice core. Global Biogeochemica Cycles 2012:26; GB2027, doi:10.1029/2011GB004247.
https://publications.csiro.au/rpr/pub?list=BRO&pid=csiro:EP122616

208-39) National Archives
https://www.nationalarchives.gov.uk/help-with-your-research/research-guides/mines-mining/#4-records-before-1850
Fortunately, there appear to be 16 academic institutions within walking distance.

T1-40) G Hestmark. 2018 (January): Jens Esmark's mountain glacier traverse 1823, the key to his discovery of Ice Ages. Boreas 2018:8;47, 1-10
https://doi.org/10.1111/bor.12260.ISSN0300-9483

T1-41) R Jackson (2019) Eunice Foote, John Tyndall and a question of priority. Notes and records. R Soc J Hist Sci.
https://doi.org/10.1098/rsnr.2018.0066

T1-42) A Penck, E Brückner. (1901-1909). Die Alpen im Eiszeitalter (3 Vols.). Leipzig: Tauchnitz.
https://opac.geologie.ac.at/ais312/dokumente/Penck_1909_Eiszeitalter_Bd_1.pdf

T1-43) G Miller, C Langway, J Hayes, S Schneider. In Search of the Coming Ice Age. (22-minute video 1978.)
https://www.youtube.com/watch?v=q_TAPaVBmb0

T1-44) A Berger. *Milankovitch, the father of paleoclimate modelling* Climate of the Past Discussions, Georges Lemaître Center for Earth and Climate Research, Earth and Life Institute, Université catholique de Louvain, Louvain-la-Neuve, 1348, Belgium
https://doi.org/10.5194/cp-2021-9

T1-45) MK Hughes, HF Diaz. Was there a 'medieval warm period', and if so, where and when?. Climatic Change 26, 109–142 (1994).
https://doi.org/10.1007/BF01092410

T1-46) RL Hunter-Anderson. "Human Vs. Climatic Impacts at Rapa Nui, Did the People Really Cut Down All Those Trees?," in *Easter Island in Pacific Context; South. Seas Symposium: Proceedings of the Fourth International Conference on Easter Island and East Polynesia*, ed. Christopher M. Stevenson, Georgia Lee, and F.J. Morin (Los Osos, CA: The Easter Island Foundation, 1998).
https://www.academia.edu/9338114/Human_vs_Climatic_Impacts_at_Rapa_Nui_or_Did_the_People_Really_Cut_Down_All_those_Trees

T1-47) JA Matthews, KR Brian. The 'Little Ice Age': re-evaluation of an evolving concept. Geogr. Ann., 2005:87A;1, 17-36.
https://www.geo.umass.edu/climate/papers2/Matthews_05.pdf https://cdiac.

ess-dive.lbl.gov/trends/co2/vostok.html

T1-48) F Lapointe, RS Bradley. Little Ice Age abruptly triggered by intrusion of Atlantic waters into the Nordic Seas. Science Advances. 2021:75;1, https://onlinelibrary.wiley.com/doi/abs/10.1111/j.0435-3676.2005.00242.x

T1-49) DS Kaufman &31a. Recent warming reverses long-term arctic cooling. Science 2009 Sep 4;325(5945):1236-9. doi: 10.1126/science.1173983. https://www.researchgate.net/publication/279338822_Recent_Warming_Reverses_Long-Term_Arctic_Cooling

~~238/50) G Herrington. Update to limits to growth: Comparing the World3 model with empirical data. J Industrial Ecology 2021:25;3,614-626. https://doi.org/10.1111/jiec.13084~~
~~238/51) J Pomeroy. An age-old question : the global impact of demographic change. HSBC Bank plc, London, 2015 https://www.worldcat.org/formats-editions/951154623~~
~~238/52) S Bowles, H Gintis. A Cooperative Species: Human Reciprocity and Its Evolution. (2013, Princeton). https://press.princeton.edu/books/paperback/9780691158167/a-cooperative-species~~

~~238/53) R Morrison. We Build the Road as We Travel: Mondragon, A Cooperative Social System. (Beech River Books, 1997) ISBN 10: 0-9658903-0-9 ISBN 13: 978-0-9658903-0-4 https://www.beechriverbooks.com/id21.html~~
~~238/54) TM Hanna. 2013 Mondragón and the System Problem. https://geo.coop/story/mondragon-and-system-problem~~

252-55) Towards Zero Emissions: CCS in Power Plants Using Higher Capture Rates or Biomass. EAGHG Technical Report2019-02 March 2019. http://documents.ieaghg.org/index.php/s/CLIZIvBI6OdMFnf

254-56) TR Hestrin, MR Lee, B Whitaker, J Pett-Ridge. The Switchgrass Microbiome: A Review of Structure, Function, and Taxonomic Distribution. Phytobiomes Journal 2020:1;8, 14-21. https://doi.org/10.1094/PBIOMES-04-20-0029-FI

254-57) SF Wright, A Upadhyaya. Extraction of an abundant and unusual protein from soil and comparison with hyphal protein of arbuscular mycorrhizal fungi. Soil Science 1996:161;9, 575-586. https://journals.lww.com/soilsci/Abstract/1996/09000/EXTRACTION_OF_AN_ABUNDANTANDUNUSUALPROTEIN

264-58) S Arrhenius. On the influence of carbonic acid in the air upon the temperature of the ground. Phil. Mag. S. 5 1896:41;251, 237-276. https://doi.org/10.1080/14786449608620846

273-59) C Flavelle. Climate Change Could Cut World Economy by $23 Trillion in 2050, Insurance Giant Warns.
https://www.nytimes.com/2021/04/22/climate/climate-change-economy.html

273-60) D Schildknecht. Saturation of the Infrared Absorption by Carbon Dioxide in the Atmosphere. Internat J Modern Physics B 2020:34;30 205-293.
https://arxiv.org/pdf/2004.00708.pdf This paper describes what happens in enclosed tubes at high concentration of target molecules and photons. The atmosphere is deep enough so that there is always unsaturated gas above the top of the pea soup.

275-61) C McGreal. How the fossil-fuel industry contributed to the climate crisis and lied to the American public.
https://www.theguardian.com/environment/2021/jun/30/climate-crimes-oil-and-gas-environment

275-62) Spratt, D., Dunlop, I. 2019, "Existential climate-related security risk: A scenario approach" (Breakthrough - National Centre for Climate Restoration, Melbourne).
https://arnhemspeil.nl/nap/dok/2019-06-07-bt-paper-on-existential-climate-related-security-risk.pdf

277-63) BE Wood &15a. Parker Solar Probe Imaging of the Night Side of Venus. Geophys. Rev. Lett. 49,3-e2021GL096302
https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021GL096302

277-64) B Angliss. Venus's climate V: How scientists know Venus's surface temperature is a result of greenhouse heating
https://scholarsandrogues.com/2011/05/06/venus-climate-v-co2-heating/
http://people.atmos.ucla.edu/liou/Lecture/Lecture_3.pdf

277-65) RT Pierrehumbert. Infrared radiation and planetary temperature. Physics Today 30 Jan 2011, 30-38.
https://geosci.uchicago.edu/"rtp1/papers/PhysTodayRT2011.pdf

T1-66) Barnola, J.M., D. Raynaud, Y. S. Korotkevich, and C. Lorius. 1987. Vostok ice core provides 160,000-year record of atmospheric CO2. Nature 329:408-14.
https://www.nature.com/articles/329408a0

Plass, .G. N. 1953. The carbon dioxide theory of climatic change. Bulletin of the American Meteorological Society 34:80.

7. Table 2

TABLE 2. **THE 80% THEORY OF GOBAL WARMING**

	OBSERVATION	EXPLANATION
1	Stefan-Bolzmann astrophysics says Earth receives 5800K (visible) energy from the sun and reradiates it to space as IR at 255K (–18°C, 0°F).	Energy is conserved here — but a 0°F sun-warmed Earth would be a chilly place, so something else is going on! **The sun needs help.**
2	The *U.S. Standard Atmosphere:* in 1976 the Earth's mean ground temperature was a comfortable 288K (15°C, 60°F).	The "something else" is OGW (Ordinary Global Warming). It kept water liquid and made Earth life possible for 3 billion years.
3	$\Delta T_{gw} = (288 - 255)K = 33$°C or 60°F of OGW, much larger than the AGW that the scientifically challenged far-right claims is neither happening nor possible.	CO_2 density low enough for 50% of the 15μm IR to escape sets the -18°C level. Surface heat works its way up here by convection and an intermittent random radiation walk.
4	OGW means that the ground surface *cannot* be the ERS (Earth's Radiating Surface). See: `https://svs.gsfc.nasa.gov/5110`	When it isn't 10-m radiation steps, it is kinetic energy, whose temperature is that of adiabatic compression, decreasing linearly as it rises.
	This was known about OGW (33°C of ORDINARY Global Warming) in 1890.	
5	The *USStdAtm* defines a mean-humidity lapse rate (dT/dz) — rate of temperature change with altitude — to be –6.5°C/km.	The height of the –18°C level of the lapse rate is set by CO_2, and its height determines the ground temperature.
6	This in turn defines the ERS to be 33°C/(6.5°C/km) = 5.077km, half way to the tropopause, without visible structure. .	With 2° of AGW, the height today is 35/6.5= 5.385 km. This is the mean of a fuzzy gradient, which can rise at least to the tropopause.
7	No Carboniferous protist found a way to eat cellulose or lignin, so a vast amount of CO_2 was stored as coal and oil, 300 million years ago.	This was a fortuitous bit of fine tuning which granted us a comfortable Holocene. Abrahamic religions credit this to a benevolent deity.
8	But we dug it up and burnt it and built a civilization around it before we recognized it as a poisoned gift. And dumped it back in the atmosphere as CO_2 without a second thought.	The troposphere is relatively simple: **Adiabatic compression (no heat added) is always warming.** (Cf. diesel engines, tire pumps, and katabatic winds.) $p^{(1-\gamma)}T^{\gamma} = constant, \gamma = 1.4$.
	This got us 2°C of AGW (ANTHROPOGENIC Global Warming) — so far.	
9	This matters because there is no effective limit to AGW. Our 424 ppm is 141% of Vostok's 300 ppm, which might get us to 141% of the 33° of OGW in decades. Or centuries.	141% of OGW's 33°C would add 46°C to the -18°C sunshine, for 13°C of AGW and a ground temperature of 28°C or 82°F — if we stopped adding CO_2 today.
10	The final Vostok glaciation — 900 CE to 1884 (the Little Ice Age) — was dramatically reversed by early Industrial CO_2 (Mann's Hockey Stick).	The ice cores tell us a great deal about a 300-ppm world — but very little about a 424-ppm world. We are in *terra incognita*, full of surprises.
11	Climatologists suggest that 4°C of AGW is sufficient to make 90% of the land uninhabitable. People die en masse when the wet-bulb temperature of the humid tropics exceeds body temperature.	There is no "quantum saturation" in the free atmosphere (only in spectrophotometer tubes. On Venus, SB says 220K, but a 96% CO_2 atmosphere gets 510K of OGW for a red-hot surface at 730K.

The root of the problem: "Everything touched by the far right dies." Umair Haque