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Viewpoint

Does CO_2 really drive global warming?

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I don't believe that it does.

To the contrary, in applying the IFF test – if-and-only-if or necessary-and-sufficient – the outcome would appear to be exactly the reverse. Rather than the rising levels of CO_2 driving up the temperature, the logical conclusion is that it is the rising temperature that is driving up the CO_2 level. Of course, this raises a raft of questions, but all are answerable nevertheless. What is particularly critical is distinguishing between the observed phenomenon, or the "what", from the governing mechanism, or the "why". Confusion between these two would appear to be the source of much of the noise in the Global Warming debate.

In applying the *IFF* test we can start with the clear correlation between the global CO_2 profile and the corresponding temperature signature. There is now in the literature a 400,000 year sequence clearly showing, as a phenomenon, that both go up – and down – together (1). The correlation is clear and accepted. But the causation, the mechanism, is something else: Which is driving which?

Logically, there are four possible explanations, but only two need serious consideration unless they both fail.

- Case 1: CO_2 drives the temperature as is currently mostly frequently asserted;

and

- Case 2: Temperature drives the CO_2 levels.

Both appear at first to be possible, but both then generate crucial origin and supplementary questions. For Case 1, the origin question is: What, independently, is the source of the CO_2, that is then rising and falling, and which then, somehow, is presumed to drive the temperature up and down. For Case (2) it is: What is the driver for the temperature changes; and if this then drives the CO_2, then where does the CO_2 come from? For Case 2, the questions are answerable; but for Case 1 they are not.

Consider Case 2. This directly introduces the global warming behavior. Is global warming, a separate and independent phenomenon, in progress? The answer, as I heard it in geology class 50 years ago, was "yes", and I have seen nothing since then to contradict that position. To the contrary, as further support, there is now documentation (that was only fragmentary 50 years ago) of an 850,000 year global-temperature sequence, showing that the temperature is oscillating with a period of 100,000 years, and with an amplitude that has risen, in that time, from about 5 deg-F at the start to about 10 deg-F "today" (meaning the latest 100,000 year period) (2). We are currently in a rise that started 25,000 years ago and, reasonably, can be expected to peak "very shortly".

On the shorter time scales of 1000 years and 100 years, further temperature oscillations are to be seen, but of much smaller amplitude, down to 1 deg-F and 0.5 deg-F in those two cases. Nevertheless, the overall trend is clearly up, even through the Little Ice Age (~1350 – 1700 AD) following the Medieval Warm Period. So the global warming phenomenon is here, with a very long history, and we are in it. But what is the Driver?

Arctic Ocean Model

The postulated Driver, or mechanism, developed some 30 years ago to account for the "million-year" temperature oscillations, is best known as the "Arctic Ocean" model (2). According to this model, the temperature variations are driven by an oscillating ice cap on the northern polar regions; and the crucial element in conceptual formulation of this mechanism was the realization that such a massive ice cap could not have developed, and then continued to expand through that development, unless there was a major source of moisture close by, to supply, maintain, and extend the cap. The only possible moisture source was then identified as the Arctic Ocean which, therefore, had to be open – not frozen over – during the development of the ice ages. And it then closed again, stopping the moisture supply, by freezing over during the warming retreats.

So the model we now have is that if the Arctic Ocean is frozen over, as is the case today, the existing ice cap is not being replenished and must shrink, as it is doing today. As it does so, the earth can then absorb more of the sun's radiation and therefore will heat up – global warming – as it is doing today, so long as the Arctic Ocean is closed. When it is warm enough for the Ocean to open, which the oceanographic (and media) reports say is evidently happening right now, then the Ice Cap can start to reform.

As it expands, the ice increasingly reflects the incoming (shorter-wave) radiation from the sun so that the atmosphere cools. But then, the expanding ice cap reduces the (longer-wave) radiative loss from the Earth, acting as an insulator, so that the earth below cools more slowly and can keep the ocean open although the ice cap is expanding. This generates "out-of-sync" oscillations between atmosphere and earth. The Arctic Ocean "trip" behavior at the temperature extremes, allowing essentially discontinuous change in direction of the temperature, is identified as a bifurcation system with potential for analysis as such. The suggested trip times for the change are interesting: They were originally estimated at about 500 years, then reduced to 50 years and, as the most recent, down to 5 years. So, if the Ocean is opening right now, we could possibly start to see the temperature reversal under way in about 10 years.

What we have here is a Sufficient mechanistic explanation for the dominant temperature fluctuations and, particularly, for the current global warming rise – without the need for CO_2 as a driver. Given that pattern, the observed CO_2 variations then follow, as a driven outcome, mainly as the result of change in dynamic equilibrium between the CO_2 concentration in the atmosphere and its solution in the sea. The numbers are instructive. The 1995 IPCC data on the carbon balance show ~ 90 Gigatons of carbon in annual quasi-equilibrium exchange between sea and atmosphere, and back again; and an additional 60 Gigatons exchange between vegetation and atmosphere giving a total of ~ 150 Gt (4). This interpretation of the sea as the major source is also in-line with the famous Mauna Loa CO_2 profile for the last 40 years showing the consistent season-dependent variation of 5 or 6 ppm, up and down, through the year – when the average global rise is only 1 ppm per year.

This oscillation is attributed in the literature to seasonal growing behavior on the "Mainland" (5), which is mostly China, > 2000 miles away; but no such profile with that amplitude is known to have been reported at any mainland location. Also, the amplitude would have to fall due to turbulent diffusive exchange during transport over the 2000 miles from the

Mainland to Hawaii, but again there is lack of evidence for such behavior. The fluctuation can, however, be explained simply from study of solution equilibria of CO_2 in water as due to emission of CO_2 from and return to the sea round Hawaii governed by a +/-10 deg-F seasonal variation in the sea temperature.

Man's impact

The next matter is the impact by man from fossil fuel combustion. Returning to the IPCC data and putting a rational variation as noise of about 5 Gt on those numbers, this float is then of the order of the further – almost trivial (< 5%) – annual contribution of 5-6 Gt from combustion of fossil fuels. This means that fossil fuel combustion can not be expected to have any significant influence on the system unless, to introduce the next point of focus, the radiative balance is at some extreme or bifurcation point that can be tripped by "small" concentration changes in the radiation absorbing-emitting gases in the atmosphere. Can that include CO_2?

This now starts to address the Necessity or "only-if" elements of the problem. The question focuses on whether CO_2 in the atmosphere can be a dominant, or "only-if" radiative-balance gas; and the answer to that is rather clearly "no". The full detailed support for that statement takes the argument into some largely esoteric areas of radiative behavior, including analytical solution of the Schuster-Schwartzchild Integral Equation of Transfer that governs radiative exchange (5-7); but the outcome is clear.

The central point is that the major absorbing gas in the atmosphere is water, not CO_2, and although CO_2 is also the only other significant atmospheric absorbing gas, it is still only a minor contributor on account of its relatively low concentration. The radiative absorption "cross-sections" for water and CO_2 are so similar that their relative influence depends primarily on their relative concentrations. Indeed, although water is actually stronger, for many engineering calculations, the concentrations of the two gases are added, and the mixture is treated as a single gas.

In the atmosphere, the molar concentration of CO_2 is in the range 350 to 400 ppm. Water, on the other hand, has a very large variation but, using the "60/60" [60% RH at 60 deg-F] value as an average, then from the standard American Society of Heating, Refrigerating, and Air-Conditioning Engineers Psychrometric Chart, the weight ratio of water to dry air is ~ 0.0065, or roughly 10,500 ppm on a molar basis. Compared with CO_2, this puts water, on average, at 25-30 times the (molar) concentration of the CO_2; but it can range from a 1:1 ratio to > 100:1.

Even closer focus on this is given by solution of the Schuster-Schwartzchild Equation of Transfer applied to the U.S. Standard Atmosphere profiles for the variation of air temperature, pressure, and density with height (8). The results show that the average absorption coefficient obtained for the atmosphere closely corresponds to that for the 5.6 to 7.6 μm water radiation band, with the water concentration in the range 60 to 80% RH which is on-target for atmospheric conditions. The absorption coefficient is, correspondingly, one to two orders of magnitude higher than the coefficient values for the CO_2 bands at a concentration of 400 ppm. This would seem to eliminate CO2 and thus provide a closure on that argument.

This overall position can be summarized by saying that water accounts, on average, for >95% of the radiative absorption. And because of the variation in the absorption due to the variation in the water, then anything CO_2 might do in the future by increase in its concentration, water will already have done. The common objection to that argument is that the wide fluctuations in the water make an averaging (for some reason) impermissible. Yet such averaging is applied without objection to global temperatures where the actual temperature variation across the Earth from poles to equator is roughly −100 deg-F to +100 deg-F; and a change in the average of ±1°F is considered major and significant. If this averaging procedure can be applied to the atmospheric temperature, it can be applied to the atmospheric water content, and if it is denied for water it must, likewise, be denied for the temperature – and then we don't have an identified problem!

What the evidence shows

So what we have on the best current evidence is that:

- global temperatures are currently rising;
- the rise is part of a nearly million-year oscillation with the current rise beginning some 25,000 years ago;
- that the trip or bifurcation behavior at the temperature extremes are attributable to the "opening" and "closing" of the Arctic Ocean;
- that there is no need to invoke CO_2 as the source of the current temperature rise;
- that the dominant source and sink for CO_2 is the ocean, accounting for about two-thirds of the exchange, with vegetation as the major secondary source and sink;
- that if CO_2 were the temperature-oscillation driver, no mechanism – other than the separately-driven temperature (which would then be a circular argument) – has been proposed to account independently for the CO_2 rise, and fall, over the 400,000 year period;
- that the CO_2 contribution to atmosphere from combustion is inside the statistical noise of the major sea and vegetation exchanges so a priori it can not be expected to be statistically significant
- that water – as gas not condensate or cloud – is the major radiative absorbing/emitting gas (averaging 95%) in the atmosphere, not CO_2;
- that extraction of the radiation absorption coefficients identifies water as the primary absorber in the 5.6 to 7.6 μm water band in the 60 to 80% RH range; and
- that the absorption coefficients for the CO_2 bands at the 400 ppm concentration are one to two orders of magnitude too small to be significant even if the CO_2 concentration was doubled.

The outcome is that the global warming advocate's conclusion on the role of CO_2 evidently has it back to front: It's the temperature that is driving the CO_2. If there are flaws in these propositions, I'm listening; but if there are objections, let's have them with the numbers.

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