CLIMATE, WATER, CARBON DIOXIDE AND THE SUN

Jan Veizer
Ottawa - Carleton Geoscience Center, University of Ottawa
http://www.science.uottawa.ca/~veizer/default.html
the presentation may be downloaded from:
http://www.science.uottawa.ca/~pwickham/Veizer_New York_Mar 2009.ppt

Climate Change is widely anticipated to be the defining agenda for the new US administration. It is in this mindset that in December 2008 delegates from 189 nations at a conference in Poznan, Poland, charted a blueprint for the post-Kyoto world to be negotiated at a December 2009 meeting in Copenhagen. The resulting treaty will impact the wellbeing of humanity for decades or perhaps centuries to come. The deliberations of the world body are permeated by an almost universally held belief that the science of Climate Change is settled and it is only the social, economic and environmental agendas that should be the topic of deliberations. How valid is this widely held perception of science?

In 2008 Ann Henderson-Sellers released an essay based entirely on quotes from the lead authors of chapters in the Fourth Assessment Report of the Intergovernmental Panel for Climate Change (IPCC), the UN appointed body. It is a summary of their responses to an internal questionnaire initiated by the world's three leading climate science agencies (Global Climate Observing System Programme, World Climate Research Programme, International Geosphere-Biosphere Programme). The essay entitled "**The IPCC report: what the lead authors really think**" makes, among others, the following statements:

"Serious inadequacies in climate change prediction that are of real concern:

> • *Energy budget is really worrisome; we should have had 20 years of ERBE (Earth Radiation Budget Experiment) type data by now – this would have told us about cloud feedback* (… impact on Earth's energy budget; my commentary) *and climate sensitivity* (… to carbon dioxide, CO_2). *I'm worried that we'll never have a reliable long-term measurement. This combined with accurate ocean heat uptake data* (… climate modulation by oceans) *would really help constrain the big-picture climate change outcome, and then we can work on the details.*

Climate change research topics identified for immediate action:

> • *Bringing the carbon cycle models* (… essentially biology) *to a level comparable with the physical climate change models and fully incorporating them.*
>
> • *Reducing climate sensitivity" (…* to CO_2*)."*

The above is hardly the public spin painted by the media or the IPCC summary for policymakers, of "science being settled". It is instead an admission that the **climate models are** in reality **not about carbon dioxide, but about** some 1.6 Watts/m^2 (or 0.5%) "discrepancy" in **the poorly known planetary energy balance**. Note that at an average solar energy flux to the Earth of 342 Watts/m^2, the energy balance *models have an overall uncertainty* of at least +/- 6 Watts/m^2, *far more than the argued "discrepancy"*. Moreover, the issue is not whether there was an overall warming over the last century, there was, although it was not uniform and none was observed during the last decade. Geologic record provides us with an abundant evidence for such perpetual natural climate

variability, from ice caps reaching almost to the equator to palm trees and alligators in northern Canada.

Climate attribution to carbon dioxide:

Without our atmosphere the Earth would be a frozen ice ball at about -18°C. Natural greenhouse due to atmospheric blanket raises the temperature by about 33ºC and at least 2/3 of this warming is attributed to the greenhouse impact of water vapor. It is the **water vapor that is by far the most important greenhouse gas**. CO_2 and the other greenhouse gases play only a subordinate role in the overall temperature amplification: in nature as well as in the climate models ("positive water vapor feedback" in the IPCC terminology). However, the models treat the heat- and climate-generating global water cycle as "just being there" (steady state), relegating it to a passive agent in the climate system. Energy that is required to "drive" the water cycle, and generate more water vapor, must therefore come from somewhere else: the sun, anthropogenic greenhouse gases, other factors, or any combination of the above.

At first glance, the climate record of the past century does indeed resemble the trend in the solar output. However, because three decades of satellite data for solar heat flux (called "Total Solar Irradiance" or TSI) show only small variability it is claimed that TSI cannot explain the bulk of the energy imbalance. Solar output would therefore have to be somehow amplified in order to explain the entire magnitude of the centennial warming. The IPCC, arguing that because *no amplifier is known, and at the same time the atmospheric concentrations of carbon dioxide did increase from 280 to 370 ppm, it must be the anthropogenic greenhouse gases that are responsible for most of the energy imbalance*. Note that this is an **assumption**, an attribution by default**, not an actual** empirical or experimental **proof that carbon dioxide is the "driver"**. Such attribution is then taken as a fact and all subsequent complex model "calibrations" of climate sensitivity to CO_2 are made to fit this premise. Note also that because of the overwhelming importance of water vapor for the overall greenhouse, the models would produce similar outcomes whatever the source of additional energy into the water cycle. If an amplifier to solar output does exist, and empirical observations detailed below argue for its existence, the need to attribute the energy input to CO_2 would diminish accordingly.

The role of water in the fate of carbon:

How realistic is the basic model assumption that the tiny – biologically controlled - carbon cycle "drives" the climate via the passively responding huge water cycle? Restated in plain English: is it the tail wagging the dog or is it the other way around? Nature tells us that it is the other way around. Surely, the blossoming of plants in the spring is the outcome, not the cause, of warming sun and abundant rain.

Our atmosphere contains 730 billion tons of carbon as CO_2. Each year about 120 billion tons of carbon are cycled via plants on land and 90 via oceans. An equivalent of the entire atmospheric CO_2 amount is thus reprocessed via photosynthesis/respiration cycle of plants in just few years. Human emissions account for about 7 - 10 billion tons, or less than 5%, of the annual CO_2 flux. From the point of view of interaction of the water and carbon cycles it is important to realize that for every single unit of CO_2 that is sequestered by the plant from the atmosphere almost 1000 units of water must be lifted from the roots to the leaf canopy and eventually evaporated back into the air. It is this 1000:1 ratio, called "water utilization efficiency", that is ultimately responsible for the biofuels instigated food crises, because industrial productions of biofuels and food compete for the same limiting resources: water and solar energy.

The required huge energy source, about 78 Watts/m^2, that drives the water cycle – indispensable for both delivery of nutrients to the plant and as the coolant and reactant in photosynthesis - is clearly solar radiation (photons, particles of light). The *tiny carbon cycle in the photosynthesis/respiration loop is therefore piggy-backing on the huge water cycle,* instead of driving it. In short, it is the solar energy that drives the water cycle, generating warmer and wetter climate while at the same time invigorating the biological carbon cycle. The sun also warms the oceans that outgas their CO_2. **Atmospheric CO_2 is thus the product and not the cause of the climate**, as demonstrated by past records where temperature changes precede changes in atmospheric CO_2 concentrations and fluxes: ice cores, the 1991 Pinatubo volcanic eruption or seasonal oscillations are instructive examples.

The above makes it abundantly clear that biology is of prime importance to the understanding of the carbon cycle, yet - as the IPCC lead authors admit – the biological models are so rudimentary that they are of little utility to climate models. For example, we do not even know where about ¼ of anthropogenic CO_2 disappears ("missing carbon sink"). The ironic paradox of the IPCC scenario is the elevation of CO_2 to the status of principal climate "driver" while at the same time essentially ignoring the most important loop in the carbon cycle, biology.

Sun and its celestial amplification:

What might be the complementary source of energy that can account for the disputed 1.6 Watts/m^2, for mitigation of the CO_2 greenhouse effect, and for amplification of solar impact? The amount of solar energy reflected by the Earth is about 77 Watts/m^2, and the difference between cloudless and cloudy skies is about 28 Watts/m^2. **Clouds** *are a mirror, reflecting solar radiation back into space, and a change of but a few percent in cloudiness can* therefore *easily account for the disputed energy discrepancy*. In short, when the sun shines it is warm, and when it's cloudy, it is cold: a truly profound statement! Clouds, in and of themselves, are an integral part of the sun driven water cycle however formation of water droplets requires seeding (aerosols) and this is where solar amplification likely comes into play. Empirical and experimental results suggest that **cosmic rays** *hitting the atmosphere generate such initial seeds*, particularly over the oceans. While the actual mechanisms (coagulation, scavenging, electrical charges, UV impact) are presently debated, the correlations between cloudiness and cosmic ray flux have been published and the existing CLOUD program at CERN in Geneva, the biggest atom smasher in the world, should advance our understanding of the mechanism(s) involved.

The amplifying connection to the sun comes via its electromagnetic envelope, called the **heliosphere**, and a similar envelope around the Earth, the **magnetosphere**. These act as shields that screen the lethal cosmic rays from reaching our planet. Note that a less active sun is not only colder (lower TSI), but its heliospheric envelope shrinks, allowing more cosmic rays to reach our atmosphere and seed more clouds, and vice versa. A good analogy is perhaps the spectacle of polar lights, or the recurrence of magnetic storms, during solar flares. We are well aware of the reality of such short term phenomena called space weather. Yet, celestial phenomena on decadal and longer time scales, space climate, must also impact our atmosphere. Indeed satellite data for the last decade show a 25% shrinking of the heliosphere that is coincident with the halt, or even decline, in planetary temperature since 1998: a trend at odds with the ever rising levels of atmospheric carbon dioxide.

We also have *direct evidence* for the above scenario. Cosmic rays, when hitting the atmosphere, generate a cascade of so-called cosmogenic nuclides, such as carbon-14 or berylium-10, that then rain down to the earth's surface and can be measured in ice, trees, rocks and minerals. Cosmogenic nuclide records observed over the last 100 000, and particularly the last 10 000 years (the Holocene), correlate well with the highly variable climate trends. In contrast, the contemporary

Holocene concentrations of CO_2, measured in ice cores, were marooned around the low "preindustrial" levels of 280 ppm, with no resemblance to climate trends. Even if it were to be later shown that direct seeding of clouds by cosmic rays may not be the correct mechanism, and cosmic rays are therefore only an indirect measure of solar variability, the correlations of cosmogenic nuclides with climate argue that sun and its amplifying mechanism must play a dominant role in climate control.

The solar and greenhouse gas scenarios are complementary and not mutually exclusive concepts. It is only their relative importance that is open to debate. The issue is not the climate models themselves, which are as sophisticated as they can be given the present state of our knowledge. *The problem is the uncritical acceptance of the initial premise that only anthropogenic greenhouse gases can be the source of the disputed additional energy*. This mindset leads to an (un)conscious suppression of solar impact and an enhanced greenhouse gas attribution by default, likely by a factor of 3. The unspoken realization that this may indeed be the case can be the reason behind the lead author's call for "reducing climate sensitivity" to CO_2 in the models.

Implications for society:

From a societal point of view, the climate dispute involves not one but two agendas: environment and climate. The environmental agenda (pollution, waste, clean water and air, health issues) is clearly to be applauded, as is the political agenda of diversification of energy sources. The relevance of the climate agenda (mitigation and/or adaptation), however, depends on the outcome of an as yet open scientific debate, because carbon dioxide by itself is not a pollutant, but is in fact the basis of our food chain and thus of all life. Regardless of the eventual outcome of the climate debate, it is nevertheless legitimate to argue that atmospheric carbon dioxide levels are a convenient proxy for global industrial activity, hence planetary pollution, and can therefore serve as a quantitative yardstick for advancing the desired outcomes of environmental and political agendas. At the same time, a broader perspective of climate agenda, beyond the IPCC outlined scenario, is also desirable. Should the causative chain proposed here be substantiated – and observational data tend in that direction - certain activities, such as CO_2 sequestration, may prove an unnecessary drain on scarce resources that could be deployed elsewhere for the benefit of mankind.

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