Anthropogenic CO_2, Climate Change, and more important matters

Brian G. Sanderson

December 16, 2006

1 Disclosure

I'm a general-purpose scientist with some knowledge about fluid mechanics, computational methods, mathematics, and ecology. I have absolutely no fiscal interest in climate modelling or climate prediction. The following is a personal perspective on the great debate we are not really having about CO_2 and climate change.

2 Basic Scales

The mass of the atmosphere is about 5.137×10^{18} kg. A CO_2 concentration of one part per million by volume (ppmv) amounts to about 2.13×10^{12} kg of carbon in the atmosphere. In 1850 the atmosphere had 288 ppmv CO_2 and this has risen to 369.5 ppmv in 2000. The concentration of CO_2 is believed to have been fairly stable for thousands of years prior to 1850 with $C_{1850} = 613 \times 10^{12}$ kg of carbon in the atmosphere. By the year 2000, CO_2 in the atmosphere amounted to $C_{2000} = 787 \times 10^{12}$ kg of carbon.

Anthropogenic CO_2 emissions are believed to be about $E_A = 6.8 \times 10^{12}$ kg of carbon per year. Natural (not anthropogenic) CO_2 emissions are less well known, but are believed to be higher by a factor of about 30, ie $E_N = 30E_A$. Natural CO_2 emissions are, of course, offset by natural sinks.

A time scale for natural carbon cycling in the atmosphere is, therefore

$$T_C = \frac{C_{1850}}{E_N} = \frac{613 \times 10^{12}}{30 \times 6.8 \times 10^{12}} = 3 \text{ years} \tag{1}$$

Of course this is just the fast time scale, mostly associated with biological processes. There are also much longer time scales associated with volcanism and deep-ocean convection, for example.

3 Emissions and asphyxiation

It is interesting that anthropogenic emissions are only a thirtieth of natural emissions, yet they appear to have increased the amount of CO_2 by a factor of $369.5/288 = 1.2830$. Here are two ways of interpreting this observation. First, one might think that long time-scale processes will play the primary role compensating for the anthropogenic perturbation to emissions. Perhaps, but previously major climate shifts are believed to have happened on relatively short time scales and persisted for long times. Alternatively, we might ignore the long time-scale mechanisms and consider that the response of atmospheric CO_2 to anthropogenic forcing is indicative of the some nonlinear dynamic in the short time-scale mechanisms. We might write an equation for the amount of carbon C in the atmosphere

$$\frac{dC}{dt} = E_N + E_A - sC^b \tag{2}$$

where sC^b is the sink of carbon from the atmosphere. Note, the sink of carbon from the atmosphere is written as the amount of carbon in the atmosphere raised to an unknown power b. Providing $b > 0$, the sink increases as C increases — thereby partly offsetting any anthropogenic CO_2 emissions. If $b = 0$ then the sink has a fixed value s which was, presumably, finely tuned to E_N in order for the CO_2 in the atmosphere to have been stable for thousands of years before humans cranked up the E_A term. If $b < 0$, then the atmosphere is unstable in the sense that a small increase/decrease in CO_2 emissions will decrease/increase the sink term — thereby causing atmospheric CO_2 to climb/fall precipitously.

The value of b is important. The higher it is, the safer we are from polluting ourselves out of existence. Making a steady-state assumption, (2) gives

$$C_{1850} = \left(\frac{E_N}{s}\right)^{1/b} \tag{3}$$

before anthropogenic emissions, and

$$C_{2000} = \left(\frac{E_N + E_A}{s}\right)^{1/b} \tag{4}$$

with anthropogenic emissions in the year 2000. Dividing (4) by (3) gives

$$\frac{C_{2000}}{C_{1850}} = \left(\frac{E_N + E_A}{E_N}\right)^{1/b} \tag{5}$$

Taking the natural logarithm of (5) and rearranging gives the following equation for b

$$b = \frac{\ln\left(\frac{E_N+E_A}{E_N}\right)}{\ln\left(\frac{C_{2000}}{C_{1850}}\right)} = \frac{\ln(1 + 1/30)}{\ln 1.283} = 0.13 \tag{6}$$

So b is a small positive number. If anthropogenic emissions were to approach the natural emissions, then the CO_2 in the atmosphere would increase to 200 times the 1850 concentration. This amounts to CO_2 making up 6% of the atmosphere by volume — breathing would become hazardous, but plants would love it. It would be a bit like revenge for the oxygen pollution crisis 2.2 billion years ago. (That crisis produced atmospheric O_2 and wiped out a lot of bacteria species.)

4 CO_2 and temperature

Even our relatively modest year-2000 emissions have increased CO_2 in the atmosphere to 28% above pre-industrial levels. It seems that a 28% increase in CO_2 has resulted in a barely-measurable 1 Celsius increase in temperature. Why so little temperature increase for such a large increase in CO_2? The answer is simple — CO_2 is a relatively minor green-house gas compared to water vapour. Honest scientists/activists will always preface their predictions with the caveat that for CO_2 to cause major global warming it is necessary for there to be a positive feedback on water vapour. With a positive feedback, increasing CO_2 increases water vapour which increases temperature. At face value, the evidence for a positive feedback seems underwhelming.

Water vapour is very tricky stuff. Water can condense to become reflective clouds or reflective ice-sheets. These changes of phase make modelling water vapour much more difficult than modelling CO_2. Many criticisms can be legitimately levelled at climate modellers. My biggest beef is that before they start pronouncing the effects of small terms (ie CO_2), they should make damn sure the models can properly calculate the effects of big terms (sunlight, water, water vapour, and ice).

The modus operandi of climate modellers (at least back in the days when I last paid them any attention) was to fudge those big important terms with some article of faith and vary the CO_2 to see what happened. Personally, I believe it far more likely that instabilities associated with the three phases of H_2O are probably where we should be looking if we want to understand many (not all) of the previous climate changes. Then modellers would be in a proper position to start looking at interactions between CO_2 and H_2O. For now, I'd place my money on CO_2 varying as a passenger on the H_2O climate machine — prove me wrong!

5 Populate or breathe

While I am skeptical about anthropogenic CO_2 emissions causing global-warming, I'm uneasy about anthropogenic CO_2 emissions in general. There is just too much we don't know.

But what would we do about CO_2 emissions? There are those that advocate use of new technologies and economic devices such as 'carbon trading'. Personally, I see this stuff as window dressing. The real issue is human population. And reducing CO_2 emissions of an affluent citizen by 50% stands for nothing if we are to see the other 5 billion souls achieve the benefits of a modern lifestyle. Who could argue with such aspiration? Anyway, there are many other things that obviously limit human well-being (arable land, water supplies, food, materials for shelter, land fit for human habitation, pollution, resources to sustain economies, preserving some segment of the world for other species) — without having to draw tenuous relationships between CO_2 emissions and global temperature.

Consider the mass of 6 billion people presently on earth. At 70 kg per person, it is about

4.2×10^{11} kg. Now let us apply the 'every sperm is sacred' principle in which case this population doubles every 25 years. Then in 588 years, the mass of humanity will equal the mass of the atmosphere. Of course, this would never happen because humanity would run out of puff after a mere 125 years — atmospheric CO_2 would reach 6%.

6 From bleakness to utopia

I saw a website where it was suggested that colonization of space might be a safety valve for the population crisis. Scenes from 'Star Wars' of planets that are totally covered by huge cities that extend far into the atmosphere are just Hollywood!

Humans do not reproduce quickly compared to many other species. A dogma that made the most of our limited reproductive capacity was necessary for many thousands of years of human evolution and history. Application of this dogma in modern times will result in most people living in grinding poverty. Advances in knowledge and technology since the pre-Newtonian era have been spectacular — but have been squandered because the efficiencies gained have been largely lost on the burdens generated as we overpopulated this planet.

Abandoning outdated notions could bring humanity back into an ecological balance within ~ 4 generations. A technologically advanced civilization that has gained control of its population will have inordinate capacity for further advancement. In time, such a civilization might explore and populate the universe — though not from necessity.