Tipping points and climate change

From The Nature of Tipping Points Jerry McManus 29 March 2012

Few topics have been more liberally peppered with talk of tipping points than that of climate change. If you ask those people not in denial about global warming what the threshold for climate catastrophe is I suspect many will answer without hesitation "greenhouse gases" (GHG's), or perhaps "CO2". This is understandable, after all while climate science is certainly a complex topic it has been established that GHG's are the main drivers of global warming due to the well known and unambiguous physics of Earth's atmosphere. Thus, at least when it comes to public policy, it is relatively easy to get ones head around a key number like CO2 concentrations in parts per million.

Unfortunately, I believe this is a dangerous fallacy.

First, recall once again our definition of a tipping point: A small change that can have a large effect on the end state of a system. Due to our prodigious burning of hydrocarbons in the form of fossil fuels the amount of CO2 in the atmosphere is indeed growing exponentially, some would say super-exponentially, which is to say the rate of change is itself accelerating. But remember, a kink in a curve is not necessarily a tipping point. There really is no point at which we can say that adding one more part per million of CO2 will trigger climate catastrophe but below that level and, oh thank god, we are safe.

This is especially true when you consider the residence time of CO2 in the atmosphere which is measured in decades, if not centuries, due to the fact that the portion not absorbed by oceans or sequestered by buried vegetation is removed only by extremely slow geologic processes. The simple fact is, even if starting tomorrow all seven-billion-going-on-nine-billion people on Earth stopped emitting any CO2 whatsoever we would still suffer a de-stabilized climate and rising sea levels for decades to come due to the carbon we've already spewed into the atmosphere. This dynamic is greatly exacerbated by the extremely large thermal inertia of the world's oceans and icecaps. Put another way, we are probably only just now feeling the full effects of carbon that was emitted decades ago, with much worse to come. Such is the pernicious effects of very long feedback delays in a complex system.

The climate is a dynamic system that can be said to exist in an unstable equilibrium. This equilibrium is variable, the complex interactions of sun, sea, and atmosphere give rise to oscillations that are measured in decades and, in the case of ice ages and inter-glacials, millennia. Within that range however there has formed a kind of homeostasis that is conducive to life, a balance between the positive feedbacks that create reinforcing loops and the negative feedbacks which create regulating loops.

It is in this balance where the greatest danger of a tipping point can be found. Should any of the factors that contribute to positive feedbacks get too far out of bounds then this can tip the balance in favor of self-reinforcing behavior that, once started, can quickly take on a life of its own and overwhelm our capability to regulate it which will lead inexorably to accelerating or "runaway" climate change.

Melting permafrost. Dying forests. Acidic and anoxic oceans. Vanishing ice-cap albedo. These are just a few of the factors at the heart of global climate feedback loops, any one of which could be dangerous, but taken all together and greatly magnified by feedback delays measured in decades if not centuries then it becomes clear that the crisis we face completely dwarfs the problem of CO2 concentrations alone.

We are altering both the chemistry of the atmosphere and the composition of the biosphere at a rate orders of magnitude greater than that seen in the geologic past. At this point even cutting CO2 emissions to zero would be woefully inadequate, we would still need to take desperate measures in an attempt to restore the previous balance by putting in place global negative feedbacks. Reforestation, carbon sequestration, cloud seeding, all this and more while at the same time we power down and depopulate to levels last seen many decades ago. Unfortunately, given both the enormous challenge of such an undertaking compounded by the very long feedback delays in the climate system we would probably need to have started such a program many years ago. We may have already passed the tipping point of no return.

Conclusion

I hope this small excursion clears up some of the confusion surrounding the subject of tipping points. It's important first of all to understand what a tipping point actually is. Like others, I myself have often confused exponential growth as a tipping point when in truth it is really only a kink in a curve as seen from a sufficiently large perspective.

Next, it's important to understand the difference between direct and contextual tipping points. The example of the straw that broke the camels back is a direct tipping point, whereas the example of the forest fires is a contextual tipping point. Increasing the density of the forest by one more percent did not directly cause a firestorm, but it did cross a critical threshold where the chances of a firestorm greatly increased. Beyond that point all that was needed was a spark for catastrophe to follow, much like the subprime housing crisis was the spark that melted down the global financial system.

Finally, let us not become beguiled by talk of CO2 concentrations in the climate crisis. The real and present danger to countless future generations, if not all life on Earth, are positive feedbacks that are poised to cross a critical threshold (if they have not done so already), at which point they take on a life of their own and race away from our capability to damp them down and return the climate to the happy equilibrium we've enjoyed for these many millennia.