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Our **weather systems, for example are in *dynamic balance***; for example, a developing storm reaches a limit defined by the physics, thermodynamics, and the topography, so that storms never continue to develop and expand out of control, say to cover half the Earth. Nature is such that the development and decay effectively balance each other out so that things always return to that equilibrium (or average) state, and things look the same as before.

On the other hand, we have **explosive volcanoes, which are in *metastable balance***. For metastable processes, a system goes into an increasing or decreasing trend, and in order to restore an equilibrium state, the system reaches a *tipping point* where nature must lurch it forward suddenly to restore equilibrium. The process of Mt St. Helens volcano is one such example; magma built up beneath the volcano for many weeks before, reaching a tipping point and then exploded suddenly without warning. The explosion destroyed every single plant, animal, and some 60 foolish human beings (who had been warned to stay away) for up to 20 km or so around. One can argue that after several decades the land and ecosystems more or less returned to what they were, but the system, the volcano never looks the same afterward, with some 500 m being removed from the top of the mountain. That’s the nature of a metastable system. Earthquakes are also metastable systems.

I mention metastable equilibrium because when we inspect the trends in atmospheric CO2 and global mean temperatures from the Antarctic and Greenland ice cores, you find that CO2 was actually in dynamic balance, albeit long-term with a cycle of about 100,000 years where atmospheric CO2 was always maintained between about 185 to 300 ppm. Global mean temperatures had approximately the same 100,000-year cycle, with glaciation taking place every 100,000 years. We are presently in the interglacial period and should have been soon headed back into the usual glacial cooling for about 80,000 years to maximum, then with deglaciation occurring over about 20,000 years. Both CO2 and global temperatures were in this dynamic equilibrium for at least the last 800,000 years; that is, until we started on our industrial revolution, so that in just the last 100 years or so (virtually instantaneous on the glacial timescale), humans have caused CO2 to move from *dynamic equilibrium* into *metastable*, with CO2 now standing at 423 ppm at this date, way out of balance and still increasing rapidly.

The question is, will global mean temperatures also go *metastable* and will both reach a tipping point? The answer is ‘probably’, although it is difficult to predict with climate models because this process is *stochastic* or random. One critical thing here is to try and predict what the time ***lag*** is between CO2 and global temperatures. Various research suggests several decades to a century, but the true answer becomes somewhat of a guessing game, partly because atmospheric CO2 is still rising at an exponential rate. Equally uncertain is how much will the global mean temperature increase, and over how long a period. Best guess is that the current level of CO2 has the potential for a temperature rise of 3-5 °C, and possibly within a decade or two. If so, that would have quite dramatic impacts on our climate and all forms of human systems and activity. When would be the tipping point? Latest research suggests about the time that mean global temperature reaches 2 °C, which will be close to 2040 at current rates (I use temperature increases since 1910, about when industry started mass production of goods on assembly lines). That’s when the real excitement would start, and I seriously doubt that our social orders could endure the rapid changes. Weather impacts alone would cause serious disruptions in food supply, after which our standards of medical and educational systems would deteriorate rapidly, law and order would start breaking down, and so on. We’ve already seen some of these signs in the past decade. Those breakdowns would lead to the huge population decreases that some of you are suggesting.

Unfortunately, too many countries (including Canada) have bastardized the IPCC definition of ‘*net-zero emissions*’, which IPCC defines as reaching zero emissions. Most countries appear to have assumed that as long as we keep carbon emissions at or below a baseline value (2005 emissions 730 MT for Canada), that temperatures would level out and not rise further. How foolish, given that we reached this disruption in our climate when emissions were much lower! The ‘lag’ between CO2 and temperature increases is becomes highly important in this context, and we are already close to 1.5 °C warming, that 2 °C is uncomfortably close at hand.

There are two major problems to overcome here: 1) we need a rapid reduction in carbon emissions AND 2) some means to remove carbon already in the atmosphere. It should be obvious how we solve the first problem, for common sense would tell us to rapidly convert from fossil fuel energy over to renewable electric energy. Government, however, are too tied to the fossil fuel industry and continue to support them.

That aside, there remains the second problem of removing atmospheric CO2, from 420+ ppm down to about 300 ppm, and that’s not an easy task for we have yet to develop any technology to accomplish this. Governments plan to plant millions of tree seedlings to sequester excess carbon emissions, but simple calculations show that this won’t do anything close to either counter emissions or to reduce atmospheric CO2 in remaining time (less than 30 years) that we have to solve the problems. They also support DAC (direct atmospheric capture), but results to date are again insignificant compared with the scale of the problem. DAC won’t make even a dent in removing CO2, although that is the only technology we should continue improving until something better comes along. Then there is CCS (carbon capture and storage) devised and operated by the fossil fuel industry in one of the greatest deceptions ever perpetrated on governments, and they have all bought into it. CCS also cannot make any significant difference to total annual global emissions, for it would require some 40,000 complex and expensive facilities like the 30 or so that have been operational worldwide. The deception is that the fossil fuel industry turned this into a tool to increase oil/gas well efficiency, by piping captured CO2 below wells forcing more oil/gas to the surface. In other words, each CCS facility is really a CCU (carbon capture and utilization) facility to add to our global climate problem.

The world is in a very compromised position, where governments don’t have the balls to fight against fossil fuels and turn present oil/gas subsidies towards renewable energy and required infrastructure. We are far too close to a ‘tipping point’ in the climate (it’s possible that it’s already started), and our leaders are fiddling while Ottawa, Washington, London, etc. burn. Apocalypse may be just around the corner. We should be panicking right now (as Greta Thunberg suggested) to get everything done that we can possibly accomplish. We should be on a ‘war footing’ just as Seth Klein suggests in “*A Good War: Mobilizing Canada for the Climate Emergency*”, yet we still dither. I have to continue to hope that we will wake up this year, for otherwise I’m not leaving much of a legacy for my four great-grandchildren of 7 months to 4 years. But we should never lose hope and give up on efforts. Adaptation to a post-tipping point climate is not a viable means of survival.

Remaining hopeful, but not surprised if we get the worst outcome,

 *Geoff Strong*

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