

Expectation Series - Introduction

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September 24, 2018

<http://ccdatacenter.org/documents/ExpectationSeries.pdf>

Purpose

Climate change is the central issue of our time. It is a "wicked", multifaceted problem that has the potential to cause the collapse of our civilization and possibility result in the extinction of our species. This "Expectation Series" is an attempt to outline what we might expect from some of the major "climate factors", thereby providing a resource that can be used to "jog" one's memory of what to expect and why. Most of the "articles" are simply "bullet points" with detailed references, allowing the reader to quickly understand the basis of an "expectation". The articles should be viewed as a "work in process" as I will be revising them frequently as new material becomes available. Comments, suggestions, and corrections can be forwarded to me at bruce@chesdata.com.

Background

Many recent articles suggest (and I concur) that the IPCC (and other scientific organizations) are very conservative in their estimates for the expected temperature increase as the models used for their reports assume minimal natural emissions and likely underestimate climate sensitivity. But since most environmental organizations use the IPCC CO2 budget estimates for temperature increases of 1.5 °C and 2.0°C, the "general belief" is that we can "solve" climate change without sacrificing much by simply making slight changes to our lifestyles and by giving the politicians the "political will" to force our civilization to replace the consumption of fossil fuels with renewable energy in the next 30-60 years. Unfortunately the required changes are both more significant and costlier than most people realize.

Our climate strategy for the next 20-30 years will likely remain pretty much the same as it is today - work hard to mitigate greenhouse gas emissions where it makes economic sense and fund R&D to reduce carbon dioxide removal costs. In other words, let the "free market" determine how much CO2 is emitted or captured, with governments providing some incentives to reduce emissions (e.g., tax credits for renewables and carbon capture, renewable portfolio standards, carbon taxes, carbon caps, electric vehicle mandates, CAFE standards, power plant emission regulations, etc.). The problem is that it is likely too late to mitigate our way out of catastrophic climate change because (1) climate sensitivity is likely much higher than the models expect; (2) cumulative natural emissions will likely be in the 100-200 GTC range by 2100, and (3) non-CO2 radiative forcing will be very difficult to reduce to the levels expected by the models. As a result, a "mitigation only" approach would likely result in a temperature increase of 3 °C to 5 °C by 2100.

In order to meet the 2015 Paris Climate Agreement (which aims to keep "the global average temperature increase to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels") significant quantities of CO2 will almost certainly need to be removed from the atmosphere by either mechanical or biological means. And by anticipating that future generations will pay for CO2 removal, it then becomes possible to have emission scenarios that result in any temperature increase from 1°C to 2°C by "simply" removing the required amount of CO2. But many people see CO2 removal as a "moral hazard": by anticipating CO2 removal in the future we will skimp on mitigation now, and if CO2 removal does not work as planned (i.e., is too expensive) the result will be catastrophic climate change. Unfortunately, we are at the point where we must accept the moral hazard and plan for significant CO2 removal. But a major stumbling block to CO2 removal is its cost - although we are rich enough to be able to *afford* the necessary costs (likely several trillion dollars per year in the next 10-30 years) it is unlikely that politicians will be willing to raise taxes enough to actually *pay* for the necessary costs. And a possible "Catch 22" is that if carbon dioxide removal is to be affordable, costs might need to come down so much that it would make economic sense to emit CO2 now and remove CO2 later. And another problem is determining who pays to remove the CO2: 1) the U.S. (with 4% of world's population) is responsible for 25% of cumulative CO2 emissions; 2) India and China (with 35% of world's population) are responsible for about 8% of cumulative CO2 emissions; 3) India and China would like to emulate our life style; 4) how can we deny them what we have achieved? 5) shouldn't the U.S. (and other OECD countries) pay most of the CO2 removal costs?

Expectations

By 2030 the temperature increase is apt to be about 1.5°C and there might be no sea ice in the Arctic in September. Some climate scientists are worried that this might cause a really serious release of methane from the sub-sea methyl hydrates in parts of the Arctic, resulting in a temperatures to spike of 1-3°C in a few years. My guess is that, even without a "methane burp", between 2030 and 2040 the changes in the Arctic will drive changes to weather patterns that could easily disrupt food production (and a "methane burp" would simply make that happen sooner). This might cause famines in many parts of the world, disrupt global trade, and perhaps cause multiple advanced societies to collapse. And this likely a question of "When" and not "If". In other words, we are very likely already headed towards a "hothouse" Earth because we are not willing to make the sacrifices needed to stop global warming. So the only way to avoid a "hothouse Earth" is to employ some sort of solar radiation management in the coming decades.

The " Expectation Series" currently contains the following articles:

Climate Factors the Determine the Expected Temperature Increase		
1	Anthropogenic CO2 Emissions	Global CO2 emissions from fossil fuels will likely remain the same through 2050 at about 10 GTC/year and atmospheric CO2 could reach 480 PPM by 2050
2	Natural Emissions	Cumulative emissions through 2100 from natural feedbacks will likely be in the range of 120-200 GTC (not including methane from methyl hydrates).
3	Methane	"Global warming triggered by the massive release of carbon dioxide [from permafrost] may be catastrophic, but the release of methane from [methyl]hydrate may be apocalyptic".
4	Global Warming Feedbacks	The reaction of clouds to a warming atmosphere has been one of the major sources of uncertainty in estimating exactly how much the world will heat up from the accumulation of greenhouse gases
5	CO2 Uptake	If we can limit net emissions to about 250 GTC, the ocean and biosphere will absorb all of the emitted CO2 and atmospheric CO2 will eventually return to the current level
6	Climate Sensitivity	Recently it has been demonstrated that the models that best capture current conditions have a mean value of 3.7°C compared to 3.1°C by the raw model projections
Temperature Increase		
7	Temperature Increase	Likely increases: 1.5°C by 2030; 2.0°C by 2050; 4-5°C by 2100
CO2 Emission Budgets		
8	CO2 Emissions Budget - Alternative Analysis	We essentially have exhausted the CO2 budget for 1.5°C and 2.0°C
Carbon Dioxide Removal Costs		
9	CDR Costs	"Even if climate geoengineering techniques [,which includes carbon dioxide removal,]were ever actively pursued, and eventually worked as envisioned on global scales, they would very unlikely be implementable prior to the second half of the century".
10	CDR Costs - U.S.	Using Hansen's \$450/tC as a rough estimate , we, in the U.S., should be spending about \$1,900 per person per year (about \$700 billion total) for the next 30-50 years to capture and sequester carbon
Other Consequences of Global Warming and CO2 Emissions		
11	Climate Change	It is quite possible that global warming will cause significant shifts in the Earth's entire atmospheric circulation patterns, which might lead to massive crop failures in the US.
12	Sea Level Rise	We could have between one and two meters of sea level rise by 2100
13	Ocean Acidification	Oceans could lose up to \$1 trillion in annual value by 2100 due to acidification