

The Deep Past and Possible Future Climate – Part 1

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1. Introduction

I just finished reading a very complex book about a very disturbing event in Earth's deep past that may foretell our not-too-distant future. It is called the Paleocene–Eocene Thermal Maximum (PETM), and it occurred about 56-Million years ago.

As I'm writing this paper, I am reading the last parts of a second book that is quite different from the first one, but it also explores the title subject, albeit from a completely different perspective. The first book is Reference 1. I will not mention the second book in this post after this paragraph, and let readers see details in Part 2 of these twin posts.

In order to understand what the comparison is to our current situation; I need to provide a brief summary of what happened to cause the PETM. First there was a triggering-event (or events) that injected a small to medium pulse of greenhouse gas into Earth's atmosphere. This started triggering additional releases of greenhouse gasses from various GHG-reservoirs that avalanched into a major greenhouse gas release that resulted in major global warming.

Scientists have been aware of the PETM for many decades, but it required major detective work to piece together the chain of events that led to this event. The scope of the global warming that resulted (described in the bullets below).

- The Earth's surface air temperature increased by about 7°C in as little as 1,000 years at the start of the PETM, implying a sudden increase in greenhouse gas (GHG) levels;
- Ocean water also warmed by nearly as much, even deep-ocean water;
- Sea level rose marginally (perhaps as little as 5 meters, but the level was already 70 meters higher than today);
- Life on the continents and in the oceans was seriously impacted more in some places than in others, and
- The PETM lasted for 180,000 years.

One final comment: the current increases in GHG emissions by our species (*Homo sapiens*) is quite comparable to the triggering event that started the PETM, although the conditions at the end of the Paleocene were quite different from today. I'm sure my readers' big question is: could our GHG emissions trigger an event similar to the PETM. The answer is complex, but I will use this book as a guide, and try to give you some additional information, but the best source for this information is the book (referenced below with a link to the Amazon Site: the paperback is less than \$15).¹

2. Today and the End of the Paleocene

Note that most of the text below is from Chapter 7 of Reference 1.

¹ Steven Earle, PhD, "Runaway Climate, What the Geological Past can Tell Us about the coming Climate Change Catastrophe," © 2024 by Steven Earle, <https://www.amazon.com/Runaway-Climate-Geological-Coming-Catastrophe/dp/0865719896>

...might the ongoing anthropogenic climate change just be really miserable for everyone and deadly for millions of people, or does it have the potential to lead us into something much worse, a catastrophic runaway climate crisis like the PETM.

To investigate that, we need to assess how today's Earth is similar to that of the late Paleocene, and how it is different, and then consider the implications of those similarities and differences in determining our possible future climate trajectory.

2.1. Current Similarities

Although the Earth's plates are always moving (most at least a thousand kilometers since the Paleocene) the continental arrangement is not drastically different now from what it was then. As now, the Atlantic and Pacific Oceans were separated by North and South America on the one side and Eurasia and Africa on the other, although the Atlantic is now wider and the Pacific narrower. The significant concentration of land in the northern hemisphere was generally similar to what exists now, as was the total area of continental crust. Although the differences in continental positions are not that great, they have changed ocean currents, as we'll see below.

There were massive carbon reservoirs in permafrost, peat, wetlands, and vegetation in the late Paleocene, and methane hydrate² was stored within seafloor sediments. There was likely more permafrost carbon then, possibly more than twice as much, but less methane hydrate carbon.

The Paleocene Ocean was a sink for carbon from the atmosphere and the biosphere, just as it is now. As atmospheric carbon was stored in plants on land and in marine microorganisms in seas where it was gradually transferred to the deeper ocean.

2.2. Current Differences

2.2.1. Ice

The current existence of glacial ice on the continents and floating ice on the polar oceans has profound implications for our climate and our climate future and, for many of us, the land that we live on and the water that we drink. Although we are in an interglacial hiatus, we are still in a glacial age, and although most glacial ice and sea ice is far away from where most of us live, it still has significant implications for our current climate and huge implications for our climate future.

At present, glacial ice covers roughly 18 million square kilometers, or 12% of the Earth's land surface. Should it all melt, its total volume is enough to produce at least 65 meters of sea-level rise. It is important to recognize, however, that some of the glacial ice is as much as 4 kilometers thick; it won't melt overnight. Sea-level rise is already an issue for millions of people, but the full 65 meters of sea-level rise could not happen for several thousand years.

Sea ice is the ice floating on the ocean surface in polar regions. Its area varies from season to season, but it currently covers about 25 million square kilometers on average, or 7% of the Earth's ocean surface. The melting of floating sea ice does not have sea-level implications.

² Methane clathrate, also called methane hydrate, hydromethane, methane ice, fire ice, natural gas hydrate, or gas hydrate, is a solid clathrate compound (more specifically, a clathrate hydrate) in which a large amount of methane is trapped within a crystal structure of water, forming a solid similar to ice. Significant deposits of methane clathrate have been found under sediments on the ocean floors of the Earth. At just under 1,800 tonnes it is either the second or third largest natural sink for carbon in Earth's biosphere.

Several future climate implications of glacial and sea ice will come into play as the Earth continues to warm. Of course, the degree to which we allow it to warm over the next several decades-and the rate of that warming-will affect the outcomes. The main one is the change in albedo (reflectivity)³ of the land and sea surfaces that are currently covered in bright ice and snow, another is the release of a carbon that is stored in ice, and a third is the rise of sea level that is resulting from the melting of glacial ice on land.

The albedo effect of melting glacial ice and floating sea ice is a rapid and strongly positive climate feedback, one that did not exist during the Paleocene and Eocene. Ice covered with snow has an albedo of between 70% and 90%. The bare ground that is exposed when a glacier melts, has an albedo close to 30%, while the open water exposed when sea ice melts, has an albedo of less than 10%. A 2014 study showed a 3% decrease in the albedo of the Arctic Ocean region because of melting sea ice between 1980 to 2010. The authors concluded that the global warming that has resulted solely from this albedo change is equivalent to approximately one-quarter of the warming that is attributed to increased global CO₂ levels over the same period. That's only the Arctic region, and it's just sea ice (not glacial ice on land), so it's not difficult to see that the albedo change associated with melting ice is a significant one, and it's a factor that did not exist during the PETM. The ice-albedo feedback could make our glaciated world warm much faster than the unglaciated world of the early Eocene.

As shown in figure 7.1 below, the rate of Arctic sea-ice loss is alarmingly fast. In just 42 years, between 1980 and 2022, the volume of September ice decreased by 70%, while the volume of April ice decreased by 30%. (The minimum Arctic sea-ice cover is in September of each year; the maximum is in April). Based on these numbers, it is projected that the Arctic Ocean might be completely free of ice in September as early as 2035. The complete (year-round) loss of Arctic sea-ice will take longer, but it is likely to be essentially gone by the end of this century.

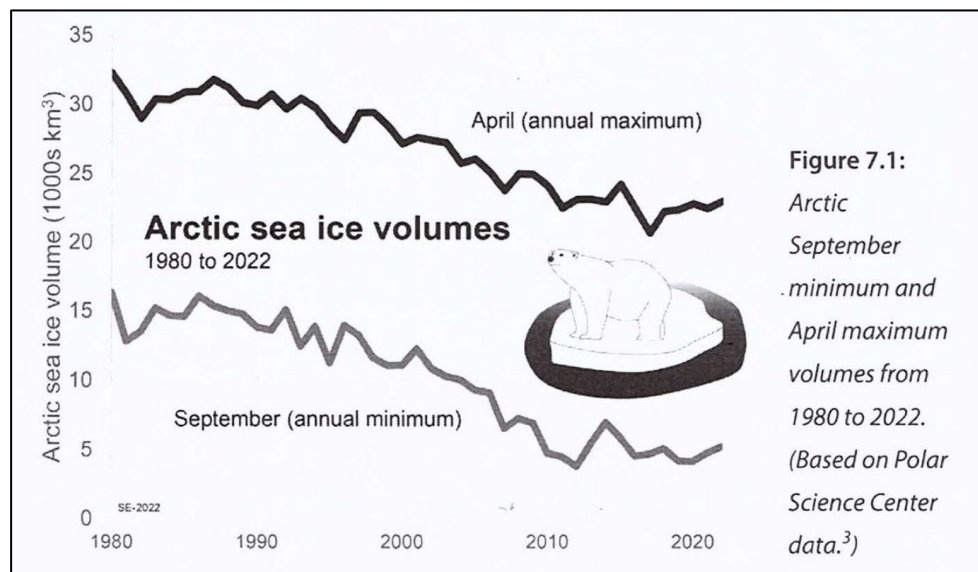


Figure 7.1:
Arctic
September
minimum and
April maximum
volumes from
1980 to 2022.
(Based on Polar
Science Center
data.³)

³ Albedo is the fraction of incident radiation (such as sunlight) that is reflected by a surface or body.

The extent of sea ice around Antarctica is similar to that in the Arctic Ocean, but its area has not been decreasing as quickly as in the Arctic mostly because the Antarctic region has not warmed as fast. In fact, there was a slow increase in Antarctic sea-ice extent from 1982 to 2014. That turned around in 2015, and although we don't yet know if the turnaround is just a blip, another record (Southern Hemisphere) summertime low was set in February of 2023, and an alarmingly strong record for wintertime low was set in September of the same year. There is little doubt that most of the Antarctic sea-ice will eventually melt as well. That melting will have an even greater ice-albedo feedback effect because the sea ice surrounding Antarctica is at generally lower latitudes than that in the Arctic. That means that there is more intense sun shining on the Antarctic sea-ice, so when that melts, the extra warming effect will be greater than for the Arctic.

Expect 1 to 2 meters of sea-level rise by the end of this century. That means that many places where people now live will be under water. Of course, this is just the beginning of anthropogenic sea-level rise. The IPCC reports that sea level is committed to rise for centuries because of the carbon that we have already emitted. It will reach between 2 and 6 meters (7 to 20 feet) if warming is limited to 2°C, and from 19 to 22 meters (62 to 72 feet) if warming is limited to 5°C. If we reach the magnitude of warming that was experienced during the PETM (around 7°C), almost all glacial ice will eventually melt (although that would take thousands of years), and sea-level rise will exceed 65 meters (213 feet). That rise didn't happen during the PETM because there was no glacial ice, but even if it had, the consequences would not have been dire because most organisms could have moved inland. Our problem is that much of our infrastructure and farmland is situated in areas that are less than 10 meters above current sea level.

Author's comment: I would like to suggest an exercise for my readers. Open up your favorite mapping software or web site, zoom out until you can see the whole continental U.S. (original 48 states). Then zoom into each of our three coasts (Atlantic, Pacific and Gulf). Count the number of major metropolitan areas on each of these coasts that are on the ocean-front and/or a major salt-water (tidally influenced) bay. I did this and counted the following:

Atlantic:

1. Boston
2. New York City
3. Miami

Gulf:

1. Tampa / St Petersburg
2. New Orleans
3. Houston

Pacific:

1. San Diego
2. Los Angeles
3. San Francisco Bay Area
4. Seattle

Above are 10 major US Port Cities, and by including non-contiguous states (Alaska and Hawaii) you could add two more (Anchorage⁴ and Honolulu) for 12, and all of them would lose most of their infrastructure with a 10-meter (33 foot) sea level rise.

Just you think a 10-meter sea level rise is completely off the table. I found a highly respected source that begs to differ. See the highlighted text on the next page.

*By 2100, we could see as little as 8 inches of additional sea level rise, or over 6 feet—based partly on how much we continue to pollute the climate, and partly on how the oceans respond to climate change that's already baked in.*⁵

Earth's sea level is rising as humanity warms the atmosphere and oceans by burning fossil fuels. Average sea level has risen by more than 20 centimeters (about 8 inches) since 1900, and it keeps rising faster, says Brent Minchew, an MIT geophysicist who studies glaciers and oceans.

However, he says, there is an enormous difference between the potential best- and worst-case scenarios for the future of sea level rise.

An important question is how much climate-warming greenhouse gas we continue to put in the atmosphere. In the rosiest possible future, global average sea level will rise another 20 to 50 centimeters (8 to 20 inches) by the year 2100. Minchew says the low end of that range would require humanity to achieve negative greenhouse gas emissions—in other words, not only stopping new emissions but also removing some excess greenhouse gases already in the atmosphere. The higher end, 50 cm, would occur if we did not meaningfully manage to cut our emissions, but still avoided a spike in sea levels from the collapse of major ice sheets or glaciers.

This range of sea level rise would not be cataclysmic, but it would be disruptive. Minchew says an extra 20 cm of rise would cause much more “nuisance flooding” for coastal communities, turning what used to be hundred-year floods into disasters that occur every couple of decades. Nations would need to invest vast sums in coastal infrastructure to keep floodwaters at bay, including new “green barriers” like wetlands and mangrove forests and “gray barriers” like seawalls.

*The worst-case scenario that includes the collapse of major ice sheets, however, is much worse. Minchew says the maximum projection for sea level rise by the end of the century reaches 2 meters, or 10 times higher than the 20-cm scenario and 4 times higher than the 50 cm scenario. What's especially daunting is that **halting greenhouse emissions may not be enough to stop this disastrous outcome.***

“Early-stage [sea level rise] was driven primarily by warming of the atmosphere due to increased CO₂,” he says. “But more and more, we see sea level rise being driven by different kinds of feedbacks within the system. Nowadays, the majority of sea level rise that we get both in Greenland and Antarctica is primarily driven by heat within the ocean—and that's not necessarily the ocean warming up directly because of ongoing climate change. It's more about shifting patterns of winds that are moving deep warm water around and causing it to come into contact with the glaciers.”

⁴ Note that, although Anchorage has less than 300,000 residents, the upper Cook Inlet around Anchorage is the most populated part of Alaska.

⁵ MIT Climate Portal, “What are the best- and worst-case scenarios for sea level rise?” June 12, 2024, <https://climate.mit.edu/ask-mit/what-are-best-and-worst-case-scenarios-sea-level-rise>

This ocean warming is especially important for Antarctica. Today, Greenland's melting glaciers are the biggest contributor to sea level rise. But it is the fate of Antarctica's ice, and particularly the West Antarctic Ice Sheet, that represents the tipping point between the best- and worst-case scenarios.

The eastern part of Antarctica contains most of its ice, but those ice sheets sit on stable ground. The West Antarctic Ice Sheet rests below sea level, which creates uncertainties about whether, and how quickly, it could slide into the ocean. "If we're going to get 2 meters of sea level rise by the end of the century, it has to come from West Antarctica," Minchew says. "Given everything that we know, it cannot come from anywhere else."

*Farther in the future, the differences between the best- and worst-case scenarios grow even starker. Unlike world temperatures, sea level rise responds slowly to climate change, and we can confidently expect that the oceans will keep rising long after we stop all our climate pollution. **By the year 2300, even with strong action to control climate change this century, we could plausibly see a meter or more of sea level rise; in the worst case, the seas could rise a staggering 10 meters (33 feet) or more.** Over the centuries, the chances of Antarctic ice sheets collapsing also rise. "On a long enough timeline, we lose virtually all ice on Earth," Minchew says. "Over geological timescales, it's rare to have ice sheets at the poles."*

Final author's comment: This is not my fight, nor is it any of my current readers, nor their children, nor even their grandchildren. But note that we need to start setting the stage for an eventual solution within the next few decades.

Specifically: There is still much about climate change that our best climatologists do not understand, including possible secondary effects resulting from positive feedback. See the post summarized and linked below

Accessory to Climate Change: *I've often commented in my papers that positive-feedback may be good in some circumstances (like with rock-guitar riffs), when it comes to climate change, it is generally bad.*

The primary drivers of climate change are greenhouse gasses (hereafter GHG), and the two most important GHG / drivers are carbon dioxide (CO₂) and methane (CH₄). Each of these compounds are generated by humans as well as Mother Nature. I've written about CO₂ often enough, to where you probably already know that it is primarily generated by burning things. The "things" are primarily organic compounds, whether these compounds are created and burned by humans (organic fuels like gasoline, diesel, natural gas and others). Nature also oxidizes organic materials to create CO₂ or CH₄, albeit mostly through slow oxidation verses fast-oxidation/burning.

And that's where we get to positive feedback. Much of the methane (CH₄, also called "Swamp Gas") production occurs in swamps and other wetlands. That is also where much of the positive feedback occurs through warming of these waters. In the paper linked below, I will shift to one of my favorite sources, and I will let you read the section for details. This paper also specifies how important a consideration reducing methane is.

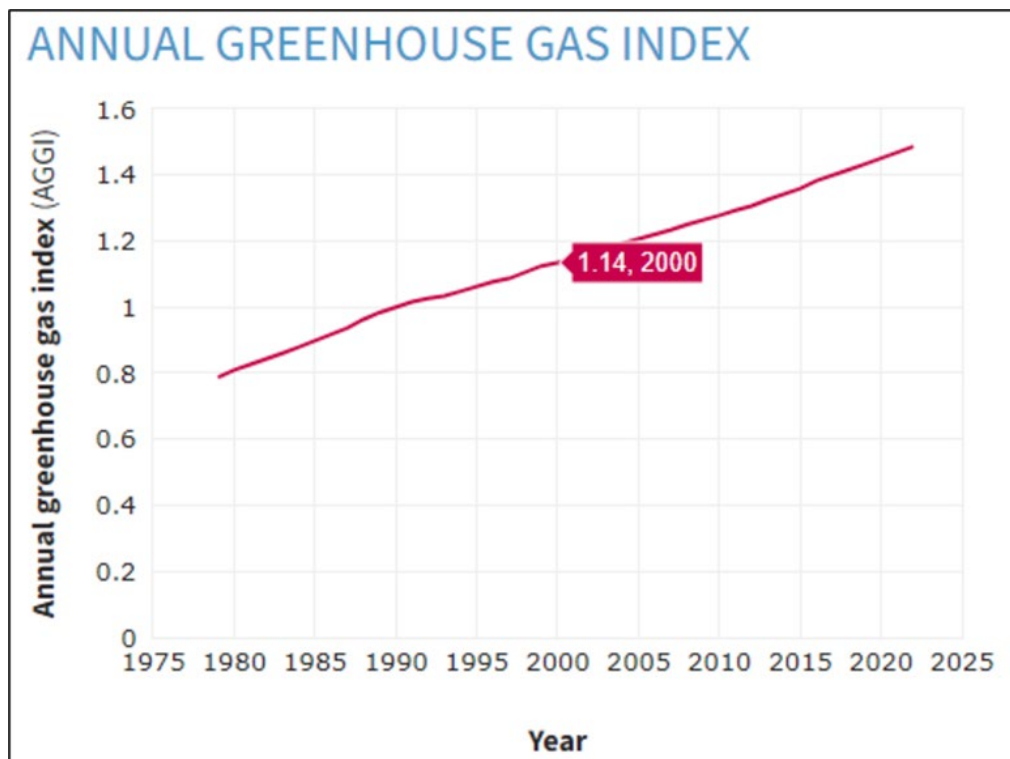
<https://www.energycentral.com/customer-engagement-experience/post/accessory-to-climate-change-wwSFZziUhlBZqPB>

Also, we need to purge our leadership of people that are climate change deniers. This will not be an easy battle, but we need all hands (and minds) on deck as soon as possible.

Everyone is entitled to their opinion, but when the opinion involves denying a natural climate-system is going off the rails, and where a large majority of climate-scientists agree the threat is likely to be real, the climate change deniers should keep their opinion to themselves.

See the text and chart below from a recent post by your author.

The chart below shows the Annual Greenhouse Gas Index (or AGGI), which is a measure of the global warming influence of all human-emitted greenhouse gases.⁶ The AGGI combines the warming influence of the main human-produced greenhouse gases and compares them to conditions in 1990. In 2023, the AGGI hit 1.51, indicating a 51 percent increase in the warming influence of greenhouse compared to 1990. You will note that the AGGI curve has continued to slowly bend upward since 1995 (increase its rate of increase).



⁶ <https://www.climate.gov/ghg/current-levels>