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Review

Human Interference with the Earth Has Abolished the Next Ice Age but Overdosing with Carbon Dioxide Emissions Could Have Catastrophic Consequences

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Abstract

Around 1600 AD the carbon dioxide content of the earth's atmosphere started to rise, even whilst according to the Milankovitch [1] astronomical theory of climate variation it was due to fall. On the natural earth the carbon dioxide count of the atmosphere is a delayed response and an enhancing feedback on the basic cause of the Milankovitch astronomical cycle, the intensity of the June sunshine. If the Milankovitch cycle had continued its natural course, the medevial cold period known as the little ice age. Human interference with the earth has abolished or delayed the next ice age but overdosing with carbon dioxide emissions could have catastrophic consequences.

Keywords

Ocean surface salinity; Climate change; Poleward movement of water vapour

1. The Milankovitch Astronomical Cycle

According to the Milankovitch theory of climate variation (1980)[2] as verified by Berger [3] the driving variable of the alternation between ice ages and interglacial periods is the June distance between earth and the sun. There are good basic physics reasons why observable variables in the process of climate change are likely to have a particular response lag structure. The June sunshine is the primary cause. This is because, with the exception of Antarctica. which is mostly under permanent ice cover in any case, there is much more land at high attitude in the Northern than in the Southern hemisphere, and that is where the high summer sunshine can cause snow and ice cover to melt away. The orbit of the earth around the sun is slightly elliptical, and over longer periods of time this minimum distance does not occur at the same time of the year. Currently January 3 is the day of minimum distance between the earth and the sun [4]. Accordingly, the next ice age is, as far as the natural course of events is concerned, overdue.

On the natural earth, the carbon dioxide content of the earth' atmosphere lagged after the temperature. Freezing out of sea water as ice in seasonably open sea area in cold climate zones causes the remaining sea water to sink to the bottom of the ocean, provided it is more salty than the deeper water below. That is by itself a mechanism which removes CO_2 from the atmosphere. In addition, upwelling of water from deeper parts of the oceans, which although containing only very small amounts of minerals nevertheless facilitates the growth of microscopically small plants, called alae, which like all plants convert carbon dioxide into biological tissue and Oxygen. The latter mechanism requires cold, oterwitse the sea will not freeze over.

Shackleton [5] provided information which confirms the Milankovitch model, whilst adding the carbon dioxide content of the earth's atmosphere as an enhancing variable and adding a response lag structure.

It is indeed reasonably well established that, even though carbon dioxide is a greenhouse gas, increases in the carbon dioxide content of the earth's atmosphere *lag behind* rises in temperature [6].

Major variations in the earth's albedo and changes in the sea level are also bound to lag behind rises of the temperature. This is logical: Ice sheets can have a significant volume, and it takes some time for those to melt or grow.

The carbon dioxide content of the earth's atmosphere *was* an enhancing feedback on the basic cause of the ice age cycle, the intensity of the early summer Northern hemisphere sunshine. It is entirely plausible that without humanity causing its end, the 'little ice age' would have continued as a full transition to the next ice age. Instead of a return to a warmer climate followed around 1600. In the Anthropcene climate the carbon dioxide content of the earth's atmosphere ceased to be an enhancing factor on the ice age cycle and became a main primary driver of the earth's warming.

Whilst there are other ways in which humanity is damaging the earth and the oceans in particular, the focus of this article is on carbon dioxide emissions, the likely results of further increases in the carbon dioxide content of the atmosphere (if arising) and a possible partial repair of that damage.

Accordingly, this article surveys the likely changes in atmospheric and ocean circulation in an advanced greenhouse climate (if no adequate steps to contain the rising trend of the carbon dioxide content of the atmosphere are taken). For reasons to be summarised in more detail further down in this article in relation to the physical properties of water e.g. the water vapour curve (section: "global warming enhances precipitation and storms") rising temperatures drive a poleward

transport of water vapour through the atmosphere. That process is bound to cause a significant reduction in the salinity of the Arctic Ocean. As there is a several kilometres deep column of relatively saline water in that ocean area, a complete collapse of the Gulfstream is likely to take considerable time. Nevertheless a tipping point, where a significant additional increase in atmospheric carbon dioxide is likely to arise, could be much nearer. And that is likely to bring mobilization of methane hydrates in its wake.

2. The Accuracy of Climate Forecasts

Rahmsdorf, Foster and Cazenave [7] report that: "[…] the adjusted observed global temperature evolution closely follows the central IPCC projections."

The reference the *adjusted* global temperature evolution in this quote appears to refer to erratic unforeseen short term changes in the global temperature, such as those caused by the injection of volcanic dust in the stratosphere.

At first sight, there appears to be some tension between this finding of Rahmsdorf, Foster, Cazenave [7], and that of Cook [8]. The latter author informs us that: "It's immediately apparent the IPCC underestimated temperature rise with observations warmer than all projections."

However, this contradiction is more apparent than real. Cook does not refer to any other greenhouse gas than carbon dioxide, but closer inspection of his text reveals that IPCC consistently underestimated the carbon dioxide content of the atmosphere and its rising trend. In other words, IPCC forecasts have always consistently underestimated the earth's temperature, not because of any flaw in the models, but because emissions have been more than IPCC expected.

The atmospheric concentration of the greenhouse gas carbon dioxide is an important enhancing feedback on the ice age cycle [9], even whilst the primary cause is the Milankovitch astronomical cycle, i.e. the earth's albedo variation in response to the intensity of the Northern hemisphere *spring* sunlight. This is because land in the polar climate zone, e.g. Antarctica is in any case under permanent ice cover, whereas the much greater land mass in the Northern hemisphere sub-arctic climate zone is where the remaining snow cover will melt in June -or stay over until the next winter and accumulate as ice-. but the combustion of fossil fuels has turned the carbon dioxide content of the atmosphere from an enhancing feedback into a primary cause of climate change.

Although the enormous thermal mass of the oceans will cause a significant delay in any kind of climate change, it is nevertheless the case that we should, according to nature's normal course of action be heading towards the next ice age. Indeed, there was a, by medieval standards quite cold period, from about the 16th to the 19th century known as "the little ice age" Wikipedia [10]. During this period, to be precise, between 1600 and 1700 AD, the carbon dioxide content on Antarctica was only about 280 ppm [11]. The year of the lowest CO_2 concentration appears to be (according to Wikipedia [10]) 1521, possibly later, up to 1600. That confirms the role of carbon dioxide prior to the industrial revolution: an enhancing feedback on the change in temperature, rather than a primary cause.

3. Direct and Indirect Greenhouse Gas Effects

A satisfactory approximation of the relation between the carbon dioxide content of the atmosphere and its heat trapping effect is logarithmic [12]. This means that the direct increase in warming caused by an additional part per million CO_2 is a constant (of 5.35), *divided* by the (absolute)

CO_2 atmospheric concentration in parts per million. What does, however, radically change the overall effect of emissions is the *water vapour feedback* and its relation to atmospheric circulation. This is not because no similar relation might be applicable to water vapour, but because the amount of water vapour which the atmosphere can hold is strongly dependent on the temperature. Water vapour is a strong greenhouse gas: "Water vapor is known to be Earth's most abundant greenhouse gas [13]."

As water vapour has a weight of only about half that of dry air, this means air at sea level above the tropical ocean is much lighter than the dry air in the polar climate zone or high above the earth. The presence of a relatively light air/water-vapour mixture at ground/sea level inevitably causes storms at ground level around depressions which are columns of rising air.

4. Poleward Transport of Heat and the Return of Liquid Water

The evaporation of water in warm climate zones requires heat which results in cooling the warmer parts of the earth. Nevertheless, because these are the warmer parts of the earth, the air there is relatively warm and therefore also light, and capable of holding more water vapour than air in colder climate zones can.

This fact gives rise to air rising upward in the warmer parts of the earth, especially above the oceans, and flowing poleward. When the water vapour in that air cools in colder climate zones, the heat lost in evaporation is again released with precipitation, as *latent heat*, giving rise to poleward transport of that heat.

This poleward flow of latent heat is now approaching a tipping point where it could radically change ocean circulation to one which is quite different from what it has been throughout the Quaternary geological period. That return flow used to be a process known as *overturning*, i.e. the return flow of liquid water was along the bottom of the ocean. There are actually two overturning processes. I summarised those two overturning processes in Heesterman [14]; Heesterman [15] concentrates more on carbon capture and its limitations.

A brief summary/recapitulation of the two overturning processes is useful here. Broecker [16] generally refers to the sinking of cold water whilst Toggweiler and Key [17] appear to have added the detail that separation of sea water into freshwater ice and a more salty, brine-like remaining water during the winter causes (used to cause) this briny remaining wate to sink to the bottom. It is doubtful whether cold water on its own actually led to sinking of water. Colder parts of the oceans, and in particular the polar areas have a surplus of precipitation over evaporation. Toggweiler and Key correctly point out that it is the seasonal winter separation between the surface and ice, which causes the remaining brine to sink to the bottom. Open ended loss of salt in the polar parts of the oceans, appears to have been the case during the late Cretaceous, when the Arctic Ocean was a suitable habitat for crocodiles [18], but as yet the poleward flow of water vapour and its associated latent heat does not dominate over the horizontal movement of ocean water as driven by the earth's rotation.

On overturning IPCC [19] expresses the opinion: "The Atlantic Meridional Overturning Circulation is very likely to weaken over the 21st century for all emission scenarios. While there is high confidence in the 21st century decline, there is only low confidence in the magnitude of the trend. There is medium confidence that there will not be an abrupt collapse before 2100. If such a collapse were to occur, it would very likely cause abrupt shifts in regional weather patterns and water cycle,

such as a southward shift in the tropical rain belt, weakening of the African and Asian monsoons and strengthening of Southern Hemisphere monsoons, and drying in Europe."

Li et al. [20], mention that there has been a trend towards a *more stratified* ocean, and I commented in Heesterman (2021) [14] that the poleward transport of water in vapour form via the atmosphere is bound to enhance the stratification of the oceans in colder parts of the world. This is because fresh or brackish water is lighter than the greater mass of the ocean water. IPCC [19] although not specifically referring to Li et al agrees: "Increased stratification reduces the vertical exchange of heat, salinity, oxygen, carbon, and nutrients".

It is argued here that, whilst observations so far appear to indicate a trend, the process underlying this trend ends with a *tipping point*. Once the poleward flow of water in vapour form via the atmosphere has resulted in a substantial layer of relatively fresh water in the Arctic Ocean and the Southern Ocean around Antarctica, freezing out of freshwater ice can leave a remaining amount of liquid water which is still less salty than the deeper parts of the ocean. Once that happens, both the direct downward transport of carbon dioxide with sinking water in the polar climate zones, and the support of the growth of algae and their conversion of carbon dioxide into living tissue by upwelling of minerals in the warmer parts of the oceans is then reduced, and the carbon dioxide content of the atmosphere increases even more.

5. Global Warming Enhances Precipitation and Storms

The enhancement of precipitation by climate change i.e. global warming is also reported by McGrath of BBC news [21]. Note that there were *two* incidents of extremely heavy rain in Europe in the summer of 2021, in mid July and again in the third week of August. An explanation of this fact and of the relation with poleward transport of wate vapour via the atmosphere is useful here. Warmer air can hold more water vapour than colder air. The relation between the amount of water vapour in any given volume that can exist in the gas phase rather than condensing as liquid water of freeing out as snow is known as the water vapour curve. It relates the partial pressure of water vapour in the air to the to the temperature. To all practical purposes this relationship does not depend on the presence of other gases than water vapour.

The word "curve" in the string "water vapour curve" implies a non-linear relation. Each further degree of global warming causes more water to evaporate from the tropical ocean, and more per degree of additional warming at higher temperatures. Basic physis indicates a tipping point, even whilst IPCC modelling estimates a trend. That tipping point arises when the salinity of the top layer of the Arctic Ocean is, even *after* a couple of metres of freshwater ice has frozen out of it is less than the salinity of the great mass of deeper water [14]. Tipping points cannot be identified by statistical analysis of such information about climate change in the past as we have. As far as I know, no such tipping point generating condition has as yet occurred, at least not during the period for which we have information in the form of air bubbles trapped in ancient ice in Antarctica.

Nevertheless, the confirmation of the relative accuracy and lack of bias of the IPCC forecast of the temperature as reported by Rahmsdorf et al does not apply for sea level rise: IPCC forecasts of sea level rise were typically near the upper limit of the projected uncertainty range [7]. Indeed, on p.3 of this article a difference between 1.2 mm/year average sea level rise as model outcome and 1.8 mm/year as observation of the sea level is mentioned. Could it be that melting of ice *below* the

sea bottom in methane hydrates (not mentioned in the IPCC report) is already taking place at a significant scale?

If failure to take adequate steps to contain emissions were to cause a breakdown of the Gulfstream and its continuation the North Atlantic Drift, that would imply a significantly reduced ability of the oceans to absorb carbon dioxide via the thermohaline circulation. This is the case, not only because cold water absorbs any gas including carbon dioxide more readily than warm water, but also because a lack of upwelling in warmer ocean areas. Although the supply of minerals to the oceans is most noticeable in coastal areas with river runoff, once no salty brine like water sinks down in the polar areas no corresponding upwelling arise in the much larger open ocean areas arises, which therefore become more completely deprived of minerals. The resulting stop in such growth of algae implies a corresponding inability of the open ocean to absorb carbon dioxide, whilst it used to be the case that minerals upwelling from the deep were spread over large ocean areas by surface currents. I have no knowledge of specific data on this point, but the very fact that four fifth of the earth's surface is ocean, must mean that this is an issue of some relevance. It is possible to monitor the extent to which this happens.

There is also serious doubt whether containing emissions is a sufficient measure to avoid catastrophic climate change. "The need to reduce greenhouse gas (GHG) emissions—such as through investing in energy efficiency, deploying solar panels and reducing deforestation, among others—is critical. At the same time, the latest climate science indicates that such efforts will not be enough to keep temperature rise below 1.5-2 degrees C (2.7-3.6 degrees F), which would prevent the worst impacts of climate change [22]."

As to methane, it is argued here that the increase in release of this gas from the east Siberian shelf [23] is the result of increased river runoff due to the enhanced poleward flow of water vapour and latent heat via the atmosphere and increased surface warming of the Arctic Ocean as discussed in Heesterman (2021) [14]. Th potential ocean de-stratification is of course dependant on the presence of more saline water deeper in the Arctic Ocean.

If a high CO_2 content of the atmosphere persist and increases even more, the logical result is would be plenty of rain and river runoff in the Arctic Ocean area, rain Antarctica and in the adjoining North and South temperate climate zone areas. The major part of the surplus of brackish water in the arctic and temperate zones of the ocean is then likely to return to warmer parts of the oceans over the surface. As net evaporation in the warmer ocean areas will make the surface layer there more saline and therefore heavier, the net result might eventually be a reversal of overturning. Despite the net poleward flow of water in vapour form via the atmosphere, the equatorward return flow over the surface would be even bigger, because the higher surface salinity in the tropical climate zone would cause the water there to sink down.

I would comment that I consider the conclusion of IPCC [19]: "The Atlantic Meridional Overturning Circulation is *very likely* to weaken over the 21st century for all emission scenarios. While there is *high confidence* in the 21st century decline, there is only *low confidence* in the magnitude of the trend. There is *medium confidence* that there will not be an abrupt collapse before 2100." to be either out of date despite its recent publication, or the result of the fact that IPCC reports are vetted by governments representatives. That vetting can have resulted in overreliance on statistical evidence, a method wich cannot forecast a tipping point. I cannot imagine that the level of rainfall reported above will *not* result in a reduction in the salinity of the Arctic Ocean, which

causes (in absence of drastic remedial action) the driving mechanism of the Northern hemisphere thermohaline circulation to collapse.

After all, the mechanism which drives the Atlantic Meridional Overturning Circulation as summarised in this article and explained in more detail in Heesterman (2021) [14] is the high salinity of Arctic Ocean surface water which remains and sinks to the bottom, after freezing of freshwater ice separates seawater of more or less average salinity into freshwater ice and remaining more brine-like residual. Yes, there is a delay, because a column of several kilometres of extra saline water in the Arctic Ocean will keep the downward movement of water in the Arctic Ocean going. However, I remain convinced that Li et al. [20] are right and that unless something fairly drastic is done, the carbon dioxide content of the atmosphere will be rising faster than is generally realized.

6. COP 26: No Help for Low Income Producers of Fossil Fuels

In Heesterman and Heesterman (2009: 251) [24] we observed: "Undoubtedly a world government, properly accountable to an elected world parliament, would be a desirable form of global governance in the predicament confronting humanity."

Now this is not going to happen any time soon. Nevertheless, I had hoped that any carbon trading scheme coming out of COP26 would include a genuine carbon market with a significant part of the money paid by the purchasers of carbon emissions permit paid out as compensation to, in particular those low income countries that were and still are substantial producers of fossil fuels. It would also be desirable if international cooperation included technological help with the development of more sustainable technologies.

For example, Kalimantan, Indonesia now has a serious problem with flooding [25]. It is not necessary: Indonesia's many volcanoes provide the natural raw material basis for the production of synthetic carbohydrate fuels [15]. In addition, its geography, i.e. its core territory consists of a chain of islands, means that its capability to cost effectively produce synthetic fuels, would probably mean that Indonesia has an opportunity to provide sustainable and cost effective shipping for a large area of the coast of Eastern Eurasia and Australia.

7. Extreme Downpours and Sea Level Rise are There Already

If a high CO_2 content of the atmosphere persist and increases even more, the logical result is a reversal of overturning, with plenty of rain in the Arctic Ocean area and tepid nearly fresh water on the surface sinking to the bottom due to gravity rather than salinity, and a surplus of brackish water from there returning to warmer parts of the oceans. That would appear the reason why during the Cretaceous geological period, the Arctic Ocean was a suitable habitat for crocodiles [18]. Global warming may not advance that far, and let's hope less drastic changes in ocean currents can be avoided. Wat must, however, be pointed out is the fact that temperate zone rainfall is already happening at near catastrophic rates. "From the 12th to the 15th of July, heavy rainfall associated with cut-off low-pressure system "Bernd" led to severe flooding particularly in the German states North Rhine-Westphalia and Rhineland-Palatinate, as well as in Luxembourg, and along the river Meuse and some of its tributaries in Belgium and the Netherlands [26]."

Dozens of people were killed by these floods [27].

On Monday, 4th October 2021, 29 inches of rain fell in the commune of Rossiglione in Genoa, Liguria, Italy, in just 12 hours, causing floods and landslides [28]. "Police were gr in search of more

possible victims and drawing up lists of the missing in the US north-east on Friday, as the death toll rose to 49 across eight states in the region after the catastrophic flooding set off by the remnants of Hurricane Ida after it roared up from Gulf coast [29].” “Widespread surface melting and an extensive rainfall event along the southeast coast extending up to the Summit region of Greenland occurred on August 14 and 15, […][30].”

Sea level rise is threatening the very existence of the Marshall Islands as a country with its own territory: “Projected sea level rise would mean 40% of the buildings in the Marshall Islands’ capital of Majuro would be permanently flooded and entire islands would disappear, potentially costing the Pacific country its status as a nation, according to a devastating new report from the World Bank [31].”

Excessive rainfall also occurred in the UK: “The Met Office has warned of life-threatening flooding as it issued amber weather warnings for rain in northwest England and southwest Scotland. Cumbria is being lashed with "persistent and heavy rain", which is not likely to ease until Thursday night, the service said. Up to 300 mm is expected to fall in parts of the region, which typically sees an average of 160mm in October [32].”

8. Possible Remedies

(1) Combustion of biomethane under oxyfuel combustion with recycling carbon dioxide. This avoids the generation of nitrogen oxides, and greatly facilitates carbon capture [33].
(2) Breaking open the ice cover of the Arctic Ocean, in order to keep the Northern arm of the thermohaline circulation going. Because the amount of water vapour that air can hold without precipitating out is strongly temperature dependent, breaking the ice cove of the Arctic Ocean does not, in practice, reduce its salinity to any relevant amount, and does not therefore affect the thermohaline circulation [14].
(3) Capturing carbon dioxide from ambient air. Once there is sufficient renewable energy generating capacity, the energy running costs of this remedy in in practice avoided by operating this technology only during off peak hours, e.g. at night.

Author Contributions

The author did all the research work of this study.

Competing Interests

The author has declared that no competing interests exist.

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