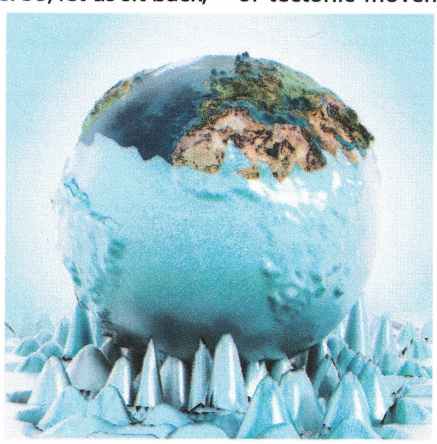
Climates: They Are A-Changin' (Part I in a series)

By Joseph Dunnigan

Climate change. It's a stand-alone phrase that can invoke some kind of emotion in most people whether it is anger, dismay, or, perhaps even, disbelief. But why are we now in such a predicament that almost every politician argues for or against policies that aim to deal with the effects of climate change? After all, doesn't the climate change anyway? Well, before I took my journey to learn more about the environment by joining the Sierra Club's LHG and studying climate change at Oregon State University, I too was mystified by the term *climate change*. And while I am still trying to understand it all, I am hoping that on this path of discovery that I entitled, 'Climates: They Are A-Changin' together we can uncover and understand the many facets related to climate change beginning with this article. So, let us sit back, take a breath and dive headfirst into this sometimes dividing, sometimes uniting, and very much current topic.



Now, If I may paraphrase a line from Lewis Carroll, "let us begin at the beginning," (well *sorta*) and briefly explore a period of Earth's climate change history before releasing the smoky layers of carbon and its connection to the climate change paradigm.

In the beginning ... there was climate change

According to the United Nations, "climate change is a long-term shift in temperature and weather patterns." The United Nations adds that these shifts can happen naturally. In fact, there are theories that suggest that the Earth, over its 4.5-billion-year history, has experienced many changes to its climate. Such occurrences have happened during the Neoproterozoic period, a point in time in which the Earth underwent cycles of glaciation (formation or covering of land by glaciers) and greenhouse events (the process of heat being trapped in the atmosphere by gases causing a rise in temperature) from about 1,000 to 580 million years ago (Hoffman and Schrag 2000; Pierrehumbert et al. 2011). But how did such an extreme climate change event occur?

According to Hoffman and Schrag, the continents atop their tectonic plates were clustered near the equator. Next, ice began to form at the southern or northern latitudes.

In fact, in that period the Earth was covered in so much ice that scientists called it the "Snowball Earth" (Pierrehumbert et al. 2011). According to scientists, this event is significant in that glaciation had been absent on Earth for almost a billion years. The origination of ice development is not well explained.

But a scholarly article by Retallack (2023) suggests that carbon sequestration due to increased microbiome and chemical weathering is to blame for reducing the atmosphere of its greenhouse gas which enabled cooling which then enabled the expansion of glaciers. What comes next is something out of a Hollywood movie.

Snow and ice have a high albedo (albedo is the ability to reflect light) and that as the ice sheets expanded, they reflected more sunlight, the more light that was reflected the colder the surface temperatures became, and the cooler the temperatures became the more the glaciers expanded (Hoffman and Schrag 2000; Li et al. 2011; Pierrehumbert et al. 2011). This is called ice-albedo feedback and could have created what has been termed as a runaway freeze (Hoffman and Schrag 2000). Luckily, a reversal did occur.

As we alluded to by the UN's definition of climate change, shifts can happen naturally, and one of the means of those shifts is when volcano activity occurs and spews out its carbon dioxide filled smoke (United Nations). During the Neoproterozoic period, volcano activity above and below the surface increased because of tectonic movement and with it an increase of greenhouse gases was emitted (Hoffman and Schrag 2000). What would have occurred next would have been a capture of the carbon via the formation of certain rocks, but this did not occur as the glaciers prevented the process from happening. What did happen was that the carbon and other greenhouse gases from the increase in volcanic activity accumulated in the atmosphere, then the Earth's surface temperature heated up, the glaciers melted, and the lower albedo of the exposed water and land reversed the feedback loop to create higher and higher temperatures.

During that "Snowball Earth" period life was on the verge of total collapse, luckily with the reversal an explosion of life occurred (Li et al. 2023). Perhaps without this drastic climate change event we would all not be here.

Conclusion

This is just one example of many in which climate change impacted the Earth. I chose to discuss it because I wanted to display a time in which carbon dioxide and greenhouse gases saved the day (so to speak) and spawned a new beginning to our little rock we call Earth. I by no means take this as an analogous to our current situation, in fact I believe the next step in our climate change journey would be to fast forward in time and relate the story about how we began to heat up the Earth's surface in a negative way. And so in the following articles I aim to discuss the dawn of the anthropogenic era, the carbon cycle, and how we as a people began to do so much damage to the Earth's natural processes that perhaps Hoffman and Schrag would have to amend their description of the "Snowball Earth period," and state that in no other time besides that of the post industrial era has Earth's climate been so disrupted. But alas, that's for another article. And so, our climate change journey begins ....

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Climates: They Are A-Changin' (Part II in a Series)

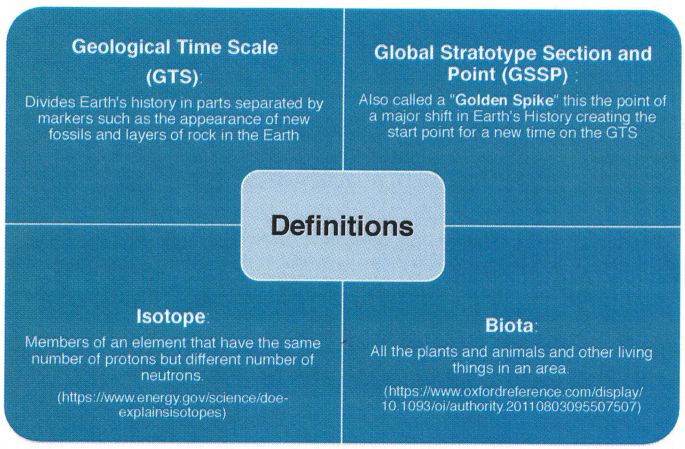
By Joseph Dunnigan

Introduction:

Last time we met, we had travelled back in time to an ancient Earth imprisoned in a sheet of ice. But with the help of primeval volcanic activity, greenhouse gases accumulated in the atmosphere and freed that "Snowball Earth" from its icy prison.[1,2] From that glacial retreat, life jumped back from the precipice of extinction and in the form of green algae began the journey through epochs of evolution.[2]

As flora and fauna evolved to fit into the ever-changing world, periods of glaciation and interglaciation occurred. Historically, major extinction events were caused by changes to the Earth's crust, climate, and sea level, as well as impacts from meteors.[3] Then at about 300,000 years ago, a new species arrived on the evolutionary timescale.[4] One whose big brain allowed it to adapt and overcome a myriad of abiotic and biotic struggles. These beings who would one day harness the technology of fire and never look back on their troglodyte ways were our *Homo sapiens* ancestors.

We are our ancestors' legacy. Far removed from the discovery of fire. We have begun the next great extinction event.[5,6] Caused not by Earth's natural changes or by a collision from an Armageddon-sized asteroid. No, this new phase of Earth's geological history is of our own making.



An Epoch by any other name...

In the last article, we learned about a period on the geological time scale called the Neoproterozoic. When Earth was covered in ice. Now we focus our attention on a smaller chapter of that temporal measurement. One that is still writing itself. One that may soon be renamed.

The Holocene is what our current epoch is officially called.[5,6] According to the Museum of Natural History, the Holocene began around 11,700 years ago and continues to this day.[7] The beginning of the epoch is at a point when the climate warmed after another period of glaciation.[7] The word "epoch" is a term used by scientists to divide up the earth's history on the geologic time scale.[8]

Each section of the geologic time scale is distinct. To create a unit of time on the geologic time scale, there are benchmarks that must be met.[6] According to Lewis and Maslin, the criteria to create a time on the geologic time scale requires that evidence, such as new fossils, must be found in rock, glacier ice, and other sediments. And that the evidence must be specific to the time and be globally marked.[6] With the use of specific markers such as fossils, the lowest portion of these layers begins the time unit. The next period's lowest portion ends the time unit and begins the new one.[6] Think of it like a multi-layered cake with different colors marking different layers of time stacked on top of one another. Each layer is separate but part of the same dessert, Earth (See Photo1 below). Now with this cake (Earth) the layers of each portion can take millions upon millions of years to form. Probably not a cake you'd want to eat, but a good one to live upon if you ask me!

Photo 1: Layered Cake - Stock Photo of Microsoft Word

Now, each layer of this earth is given a marker (the icing between the layers: Never mind the icing dripping down!) called the Global Stratotype Section and Point (GSSP) or "golden spike."[6] Often these "golden spikes" denote a major shift in Earth's history. Frequently evidenced by new fossils.[6] But here is where things get tricky.

According to Lewis and Maslin, the Holocene does show up in the fossil record albeit with some difficulty in identification. To make a better determination about the start of the Holocene, scientists turned to a shift in an isotope.[6]

Maybe it's here that you're thinking, "Great! Time is divided. And scientists use different things instead of fossils to determine the time scale of Earth's history. What does any of this matter anyhow?"

I would have to respond with, "Bingo!"

Juliet once professed, "What's in a name! that which we call a rose by any other name would smell as sweet..." [9] I would amend this statement to ask, "What's in an epoch! That which we call the Holocene by any other name would still be anthropogenic."

But it turns out that a group of scientists have been supporting a new name for this Holocene epoch. A name that would better reflect the *Homo sapiens'* influences on this planet. A name that would place us directly into the path of infamy!

Dawn of the Anthropocene:

Way back when in the year 2000, Paul J. Crutzen and Eugene F. Stoermer, wrote an essay called, 'The "Anthropocene."' In that essay, the authors argued that the current epoch was not adequately named and that a more accurate representation of this period would be to call it the "Anthropocene."

Anthropocene means "Recent age of Man." [5] The point of this was not as a testament to our achievements. Unfortunately, it was meant to reflect our devastating impact on this planet.[5] Sadly, this is supported by major extinctions, increases in atmo-

spheric greenhouse gases, and changes to the geochemical cycle.[5] And while the authors felt it was arbitrary to give an exact date to the start of the Anthropocene, they did suggest the industrial revolution as its beginning. Albeit with an openness to future suggestions by other researchers. Enter Lewis and Maslin to the scene of Geographical Time Scale.

Lewis and Maslin tried to pinpoint a start to the Anthropocene to legitimize it as an epoch like the Holocene. But a problem arose that was analogous to the issue of the Holocene, which was how to determine the start?

Lewis and Maslin used the requirements of the geologic time scale to suggest five possible beginnings to the Anthropocene. As they tested their hypotheses, they found that some of their suggestions failed the litmus. For example, the extinction of the Megafauna proved to be too spread in time and place to be a reliable marker of the beginning of the Anthropocene.[6] As Lewis and Maslin went through their list of suggestions for the start of the Anthropocene, they landed on two dates. These two dates were 1610 and 1964.

Why these two dates?

Lewis and Maslin did not arbitrarily reach the 1610 and 1964 dates. According to Lewis and Maslin, after the arrival of Europeans in the New World the result was the "largest human population replacement in over 13,000 years."[6] During this mixing of the Old and New Worlds, the exchange left an impression on both sides. Biota previously separated by oceans began to appear in the sediment record.[6] But it was the sudden drop in atmospheric CO_2 from 1492 to 1650 that led the authors to their conclusion that the 1610 date should be used as a marker for the beginning of the Anthropocene.

According to Lewis and Maslin, the genocide of millions of inhabitants in the Americas led to the regeneration of the land that had been used for farming as well as an abrupt reduction in the use of fire. Using ice cores to establish a specific date, the authors landed on 1610 as the marker for the beginning of the Anthropocene.

The 1964 date has a similar path for its establishment as the beginning of the Anthropocene. According to Lewis and Maslin, the "Great Acceleration," a period in which technology advanced exponentially, is a good timeline to be used as the beginning of the Anthropocene. It was during this period that nuclear testing occurred, plastics became a thing, and other chemicals began to be widely used.[6] During the early 1960s, nuclear testing decreased. But like the Holocene's marker, and the 1610 date for the Anthropocene, the 1964 date has a chemical attached to its reasoning.

According to Lewis and Maslin, 1964 is where global carbon-14 reaches its maximum in the strata or sedimentary record. Because of this sudden change in composition, the authors suggest, along with the appearance of plastics and other chemical evidence, that the year 1964 should be considered for the start of the Anthropocene.

Dating a new epoch is tricky. Trickier still is establishing an epoch that could replace a previous one. Especially one that is still happening, as is the case with the establishment of the Anthropocene. And unfortunately, politics does come into play. Using 1610 could imply colonialism and global trade of natural resources brought about the Anthropocene. While the 1964 date would imply a technology driven global threat.[6] But public perception aside, does it really matter to have a specific date?

Two dates to rule them all...

... so it seems.

But of course, this remains to be seen.

Unfortunately, I do not have a clear answer to the question of when the Anthropocene began. Nor do Lewis or Maslin or any other scientist, for now. Sure, there are many other hypotheses out there, but none have been ordained to make the Anthropocene official.

Officially, we live in the Holocene. But regardless of what name we call this time or by what date we decide to give as its start, one thing is certain, we humans have done something to this planet. We now seek to see if what we have done can be reversed.

The Saga Continues:

Defining the Anthropocene may give context to the climate change issues we now face. The very suggestion of a new epoch shows that humans have impacted the earth to such an extent that an entire new timeline in which we are the cause should be established. This is not meant as an award for our period here on earth but as a warning that we must change the path we are on. After all, epochs usually end when a new fossil record or global catastrophe occurs on the sedimentary time scale.

Climate change may have been the beginning of that catastrophe. To explore this subject further, our next article will delve into the rise of carbon by human actions and how it as an element has affected the systems on this planet.

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Climates: They Are A-Changin' (Part III in a Series)
Water Vapor and Carbon Dioxide

By Joseph Dunnigan

After the recent drought it may come as a surprise that the most abundant greenhouse gas in the atmosphere is water vapor. This begs the question, why is the discussion surrounding climate change always focused on CO_2? This article will explore the 'greenhouse' effect and how it keeps our Earth from freezing as well as why carbon dioxide is the focus of climate change discussions.

The "Greenhouse" Effect

John F Mitchell, a climate scientist, discussed in his article 'The "Greenhouse" Effect and Climate Change' how the Earth is kept warm. Here is a summary:
The atmosphere is what keeps the Earth warm. Earth emits radiation and in the absence of an atmosphere the radiation would not be captured. The planet would be substantially colder at around minus 18 degrees Celsius. Luckily, the atmosphere contains water vapor, carbon dioxide, and other gases such as methane and nitrous oxide. These gases, especially water vapor, absorb Earth's radiation, re-radiate it to Earth and space, creating a balance with solar radiation. This is what is called the "greenhouse effect."

Water Vapor and CO_2

Today, we often hear the phrase "greenhouse effect" as synonymous with climate change. Scientists found that most of the greenhouse gas concentration in the atmosphere is water vapor. If this is so, then why is carbon dioxide so often associated with climate change?

This is due mainly to the rise in greenhouse gas emissions. In an article by NASA, they discuss the relationship between water vapor and the rise in greenhouse gases causing a warmer climate. It goes a little like this:

- The increase in water vapor is a result of an increase in other greenhouse gases such as carbon dioxide.
- This increase in carbon dioxide and other greenhouse gases causes Earth's temperature to rise and with this rise in temperature is a rise in evaporation.
- As the air temperature increases it can hold more moisture (i.e. more water vapor).

Researchers state that this added moisture or water vapor prevents radiation from escaping causing a warmer atmosphere which continues the cycle.

Humans play a role

As discussed in the previous article of this series, the rise of carbon dioxide and other greenhouse gases is most associated with human activity. Specifically, the burning of fossil fuels and deforestation (Luo 2007). The IPCC and many news outlets have reported that 2023 was the hottest year on record. The World Meteorological Organization is set to report 2024 as the new record-breaking year.

Back to the *Climate* Future:

It has been reported that the future of climate and environmental protective legislation is in peril with the incoming administration. Now, it is more vital than ever to contact local politicians to express the need for alternative energy sources and to find ways to reduce carbon emissions. Because as has been expressed by countless news outlets, environmental activist groups, and the scientific community...

... Climates they are a changin'.

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