EnviroConvergeBlog 02: Comprehension of the precedents contained in the long-term geo-science history.

Introduction

Gaps and inconsistencies in the current mainstream environmental discussion have been identified in the preceding EnviroConvergeBlog 01. These gaps potentially affect the optimism or pessimism that adults and students may feel for the future of the environment over the next twenty years. This Blog (EnviroConvergeBlog 02) expands on the first of these environmental gaps.

Citation references, Paragraph and Section references are those contained in the PhD Thesis “Values and science in contemporary education: The study and impact of student orientation.” The Thesis document is available in the University of Newcastle repository, here: http://hdl.handle.net/1959.13/1501410 (and then by clicking on Attachment01).

Discussion

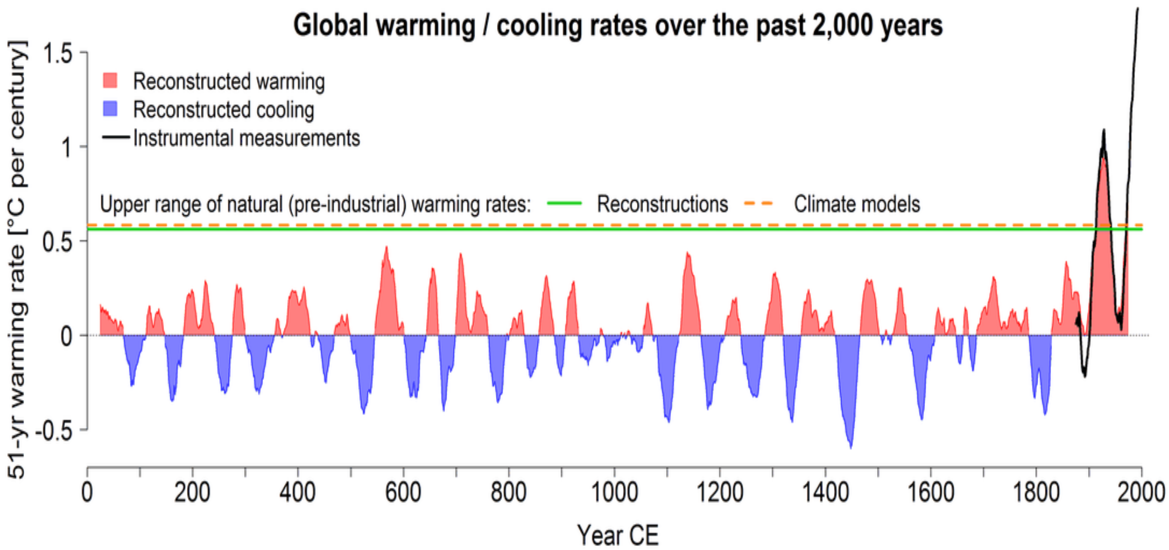
3.2.1.1 Environmental Gap 1. Comprehension of the precedents contained in the long-term geo-science history.

Maslow’s needs - Safety.

Sustainable Development Goal (SDG) - 13. Climate action.

The short-term global warming narrative

Climate researchers such as Mann (2012) use temperature proxy data to produce narratives covering the previous 2000 years. In this process, Mann relates that the warmest period on record was the second half of the 20th century, describing this phenomenon graphically as a hockey stick. This research is promoted as a wake-up call that humans are heating the planet, and that the Earth will suffer increasing impacts if action is not taken to reduce emissions. This is the conventional environmental narrative that humans are causing global temperature rise. This position is supported in the popular technical media by Ryan (2019), attributed to the University of Bern, when producing the following figure (Figure 3.4) “Global warming/cooling rates over the past 2,000 years.”



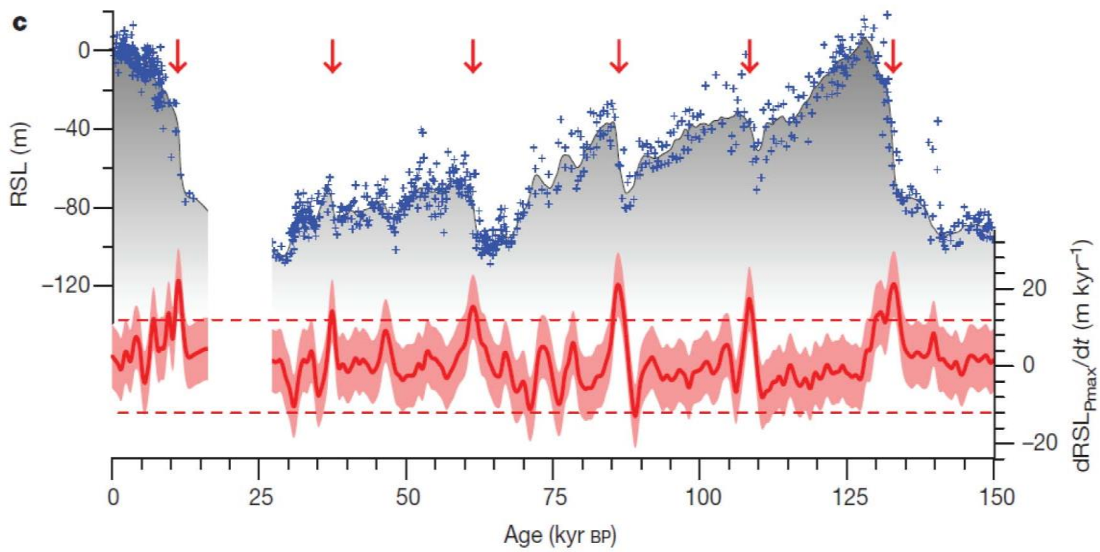
(Ryan, 2019, p. 1)

Figure 3. 1 Global warming/cooling rates over the past 2000 years

The above figure illustrates the abrupt increase in the rate of temperature warming during the last 100 years, attributing this to human causes. The hockey stick narrative is supplemented by investigations into the long-term past, far beyond the last 2000 years, as described in the following paragraphs.

Sea level changes in the previous glacial cycle

A detailed understanding of the relationships between climate and global ice volume provides a more informed understanding of current global warming. That is, global ice volume is negatively correlated with global temperature. Highly resolved and continuous sea level records are essential for quantifying ice-volume changes. Accordingly, Grant et al. (2012) have presented an independent dating of a continuous, high-resolution sea level record throughout the past 150,000 years, in Figure 3.5 below. This figure shows that rates of sea level rise reached at least 1.2 m (120 cm per century) during all major episodes of ice-volume reduction. From 1966 to 2009, sea levels have risen around the Australian coastline at an average of 1.6mm/year, which is approximately 7 cm over the past half-century. This is consistent with global averages (Siebentritt, 2016). That is, the current rate of sea level rise is not "unprecedented", as the historical rate of increase of sea levels (120 cm/century) was greater than the current rate of increase (14 cm/century). Another complication is that in Greenland, climate and ice-volume change are directly coupled, i.e., temperature rise results immediately in ice melting, whereas, in Antarctica, ice melt lags temperature rise by approximately 700 years. Most importantly, approximately 125,000 years before the present (BP), sea level was higher than current levels (Grant et al., 2012).



(Grant et al., 2012, p. 746)

Figure 3. 2 Sea level changes in the previous glacial cycle

Additional geological data provided by Pan, Murray-Wallace, Dosseto, and Bourman (2018) and by Nott (2016) reveal the following for the previous glacial period:

i. Historical global sea level above current (2018) levels: 4.80 +/- 1.0 m
ii. Temperature: Approximately 5.0 °C above the 2018 temperature.

The Intergovernmental Panel on Climate Change (IPCC) supports the notion that in the previous interglacial warming (IGW), global temperature and sea levels were higher than present, with the following extract:

> *….reconstructed levels during past warm climate periods: likely 5–10 m higher than today around 125,000 years BP, when global temperatures were very likely 0.5°C–1.5°C higher than 1850–1900; and very likely 5–25 m higher roughly 3*

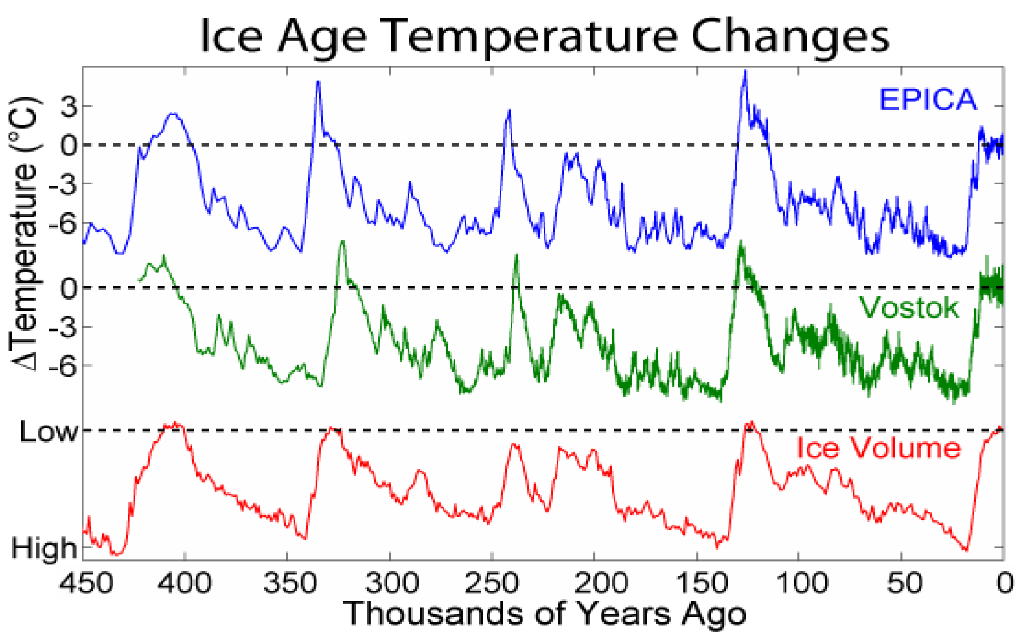
> *million years BP, when global temperatures were 2.5°C–4°C higher (medium confidence).*
>
> (IPCC, 2021, p. 21)

A provisional summary from a detailed view of the previous glacial cycle is that in the previous interglacial warming (IGW) period the sea levels were higher than current levels and therefore, by proxy conclusion, the temperature was warmer than currently. This situation existed in the previous interglacial period in the absence of any significant anthropogenic causes. The resultant questions are:

i. What were the causes of the higher sea level and temperatures?
ii. Are the past causes still valid for the current interglacial warm period?

Temperature and ice volume in the previous four glacial cycles

The temperature-ice volume relationship over the four previous glacial cycles is illustrated in Figure 3.6 below, attributed to Robert A. Rhode as described by Nott (2016). This relationship is compatible with that in Vimeux, Cuffey, and Jouzel (2002), and in Petit et al. (1999) as well as in Lüthi et al. (2008).



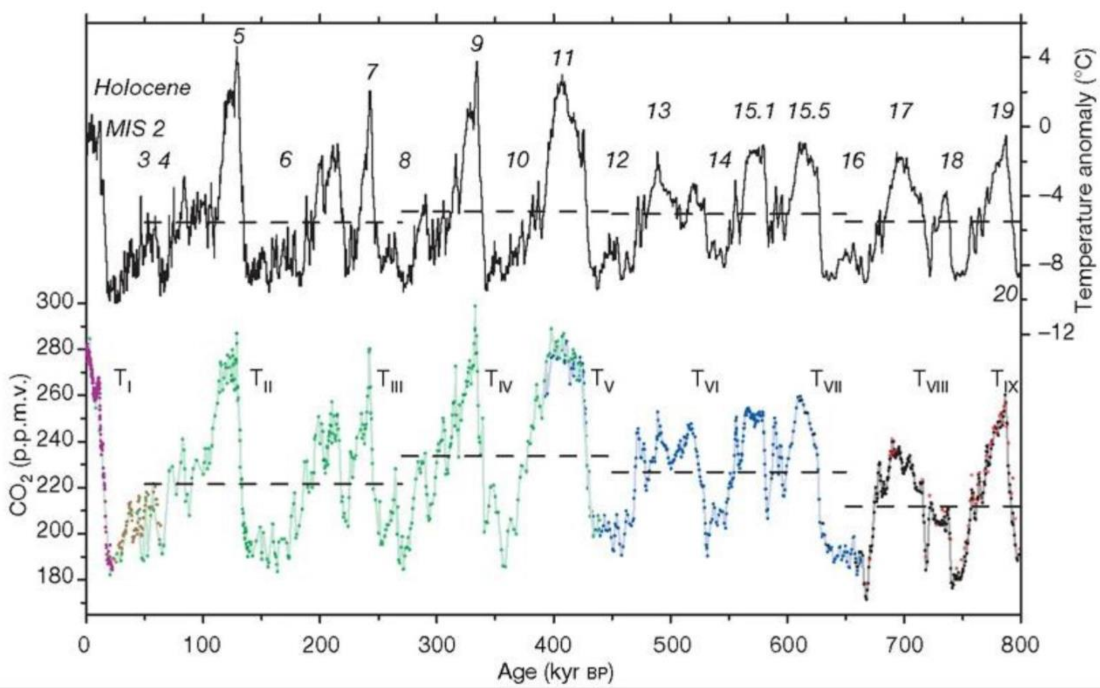
(Nott, 2016, p. 1)

Figure 3. 3 Ice Age Temperature Changes

From an inspection of Figure 3.6, it is evident that the relationship for the most recent glacial cycle (as described earlier) was maintained in a similar fashion for the duration of the four glacial cycles. The most pertinent aspect is that for all of the four glacial cycles, the temperatures were higher than current levels. This situation existed in the absence of any significant anthropogenic causes. The following Figure 3.7 supports the data in Figure 3.6.

CO_2 and temperature in the previous eight glacial cycles

The paleoclimate record as per the following Figure 3.7 shows CO_2 and temperature in the previous eight glacial cycles contained in Lüthi et al. (2008), with strong positive correlation between temperature and the concentration of atmospheric CO_2 during the glacial cycles of the past eight hundred thousand years.



(Lüthi et al., 2008, p. 380)

Figure 3. 4 CO_2 and temperature in the previous eight glacial cycles

A minor part of the correlation is due to the relationship between temperature and the solubility of CO_2 in the surface ocean, but the majority of the correlation is consistent with a feedback between CO_2 and climate. However, despite the existence of a positive correlation, it is exceedingly difficult to determine a causal relationship (NOAA, 2020). That is, it is not possible to determine with any degree of certainty, the answer to the question as to whether increasing levels of CO2 are exclusively responsible for increases in temperature. The following paragraphs regarding the topics of Earth's orbital variation, Sunspot activity and Climate model characteristics explore alternative possibilities of variations in global temperature.

Earth's Orbital Variations

The primary long-term determinants of cyclical sea level change in the history of planet Earth are the variations in the Earth's rotation and in the orbit around the Sun. The variations according to Muller and MacDonald (1997) are contained below in Table 3.2.

Table 3. 2 Variation in the Earth's axial rotation and its planetary orbit around the Sun

VARIATION	DESCRIPTION	PERIODICITY
Eccentricity (of orbit around the Sun).	Earth's approx. 365-day orbit around the Sun is not perfectly circular but is slightly elliptical. Earth is not a constant distance from the Sun.	400,000-year cycle. Insolation (solar radiation reaching Earth) changes as distance from Sun changes.
Inclination (of earth's orbit around the Sun)	The planets orbit the Sun in one flat plane (almost) with the plane of Jupiter's orbit being the (close approx.) reference plane. Changes in inclination brings Earth on a different path where there is interplanetary material, meteoroids and dust, which are accreted into Earth. Well-dated climate proxy records show the 100,000-year cycle only over the last million years. Prior to this transition, the 100-kyr period was either absent or very weak.	100,000-year cycle. The sudden onset of the 100-kyr peak about 1 million years before the present (BP) can also be dealt with by the accretion hypothesis. We are required, however, to assume that the dustiness of the solar system underwent a discontinuous change at about a million years. Calculated variation of eccentricity does not show any discontinuity (in the orbit of the Earth around the Sun) a million years BP.
Obliquity (of earth's rotation on its axis)	The tilt of the Earth's rotation on its axis results in the seasons. The maximum tilt varies between 22.1 and 24.5 degrees over a 41,000. Year cycle.	41,000-year cycle.
Precession	"Spinning top movement." Gyroscopic wobble. Zodiac.	23,000-year cycle. Some say 26,000 years e.g., Mayan calendar.

Sunspot Activity

Sunspot activities are the primary short-term influence on Earth's solar variations. Sunspots are temporary dark spots on the Sun's surface where magnetic field fluctuations impede convection, reducing temperature of the Sun's surface. Sunspots occur in pairs, with a life of between a few days to a few months (Easterbrook, 2016a). Differing assessments have been promulgated regarding the impact of the 11-year cycle of sunspot activity. According to Mann, Lean, and Mahl (2018) climate models with realistic sensitivities suggest that the Sun's variability accounts for less than half the Earth's surface warming in the industrial period, and that climate change model simulations are in good agreement with the pre-industrial empirical Sun-climate association. Additionally, climate variability may be associated with the 11-year irradiance cycle in ways implied by empirical associations, but these are not presently understood or accounted for in climate models (Mann et al., 2018). Contrastingly, Tikhonov and Vladimirtsev (2019) forecast the onset of global cooling in the middle of this current century, elaborating that cold climate similar to the period of Maunder low solar activity (1645-1715) can occur from 2020 to 2053. A similar prediction of Maunder-like cooling in the three decades post 2020 has been raised (Easterbrook, 2016b, p. 408). In clarification, Tikhonov and Vladimirtsev (2019) identified two main components of solar magnetic waves which circulate independently within the outer solar atmosphere and within the Sun's interior layers. They found that sunspots appear because of the interaction of these two components, and accordingly, they reconstructed solar activity in the period from 3000 years BP to 1200 years into the future to arrive at forecasts regarding the effect on the Earth's climate of the changing solar radiation (Zharkova, Shepherd, Popova, & Zharkov, 2015).

Climate model characteristics

Evans (2016) posited that the typical conventional basic climate model has two serious architectural errors and, in response, has developed an alternative model whose architecture rectifies the errors. By fitting the climate data to the alternative model, Evans (2016) found:

i. The equilibrium climate sensitivity was most likely less than 0.5°C
ii. The increase in CO_2 most likely caused less than 20% of the global warming from the 1970s
iii. The CO_2 response was less than one-third as strong as the solar response.
iv. The conventional model overestimates the potency of CO_2 because it applies the strong solar response instead of the weak CO_2 response to the CO_2 forcing (Evans, 2016).

In support of the discussion in the above paragraph, Gao, Booij, and Xu (2020) have recognised that climate change projections are usually subject to high uncertainty, making it difficult to identify robust adaptation strategies in the decision process. Therefore, it is of fundamental importance to characterise and quantify uncertainty associated with projections in climate change impact studies. Uncertainty in climate change projections mainly arises from three different sources as follows:

i. Scenario uncertainty. Scenario uncertainty is interpreted as responses to different assumptions of future greenhouse gas emissions, reflecting the limited knowledge of external factors such as anthropogenic activities and social development strategies that influence the climate system.

ii. Model uncertainty. Model uncertainty originates from different responses to different model structures under the same future emission scenario. This is primarily due to imperfect physical and numerical formulations representing the actual climate system.

iii. Internal climate variability. Internal climate variability is the natural unforced variability of the climate system representing dynamical processes intrinsic to the system and composite sub-systems (Gao et al., 2020).

An example of limitation of school curriculum

Extract from the Queensland Earth & environmental science general senior syllabus 2019 in the section SHE (Science as a Human Endeavour) and marked as not examinable:

> *Anthropogenic climate change — what's the evidence?: Analysis of gas concentrations in the atmosphere and ice cores indicates that greenhouse gas levels have increased as a result of emissions from human activities over the twentieth century. (QCAA, 2020b, p. 62)*

Discussion of the above extract: It is recommended that for education purposes, the timeframe of environmental activities be extended back further to 800,000 years, so that several cycles of glaciation and interglacial warming can be observed. Whilst there is no doubt that CO_2 levels have increased since the start of the Industrial Revolution, Figure 3.7 shows cycles of CO_2 levels in the 800,000 years prior to the Industrial Revolution. One possible cause of the cycles of CO_2 levels in the extended period prior to the Industrial Revolution was the Earth's orbital variations as detailed in Table 3.2

Conclusion regarding Environmental Gap 1

A view of the period to 800,000 years BP shows the four most recent interglacial warm periods (0 to 450,000 years BP) during which the temperatures exceeded present global temperatures, and the four immediately prior interglacial warm periods (450,000 to 800,000 years BP) during which the temperatures were below the present temperature (Grant et al., 2012); (Nott, 2016); (Lüthi et al., 2008).

The IPCC supports the position that 125,000 years BP, global temperatures and sea-levels were higher than today (IPCC, 2021, p. 21). The dearth of an authoritative scientific explanation of the long-term geological record complicates the formulation of a credible geo-science based quantitative model of the future. This scale and nature of this uncertainty and indecision may lead to scepticism or pessimism and thence to learned helplessness in our youth. However, the lack of certainty is not a reason for inaction, and this situation can be mitigated by the enhancement of the school curriculum by extending the education environmental discussion back 800,000 years as described in the previous paragraphs.

Conclusion

Recommended action regarding Environmental Gap 1 - Comprehension of past events through a geo-science lens does provide a guide to the possible achievement of broad agreement regarding proposed remedial environmental action going forward, as identified in the risk scenarios in Table 3.3. This scenario provides the environmental adversaries with a common cause. The common challenge is for both parties to establish joint contingency plans for adaption to the possible range of serious sea level increase. This challenge is further explored in the following "Environmental Gap 2". The recommended action is the enhancement of the school curriculum by extending the education environmental discussion back 800,000 years as described in the previous paragraphs. This action is further documented in Sections 7.2.5 and 7.5.1.

Addendum to Blog

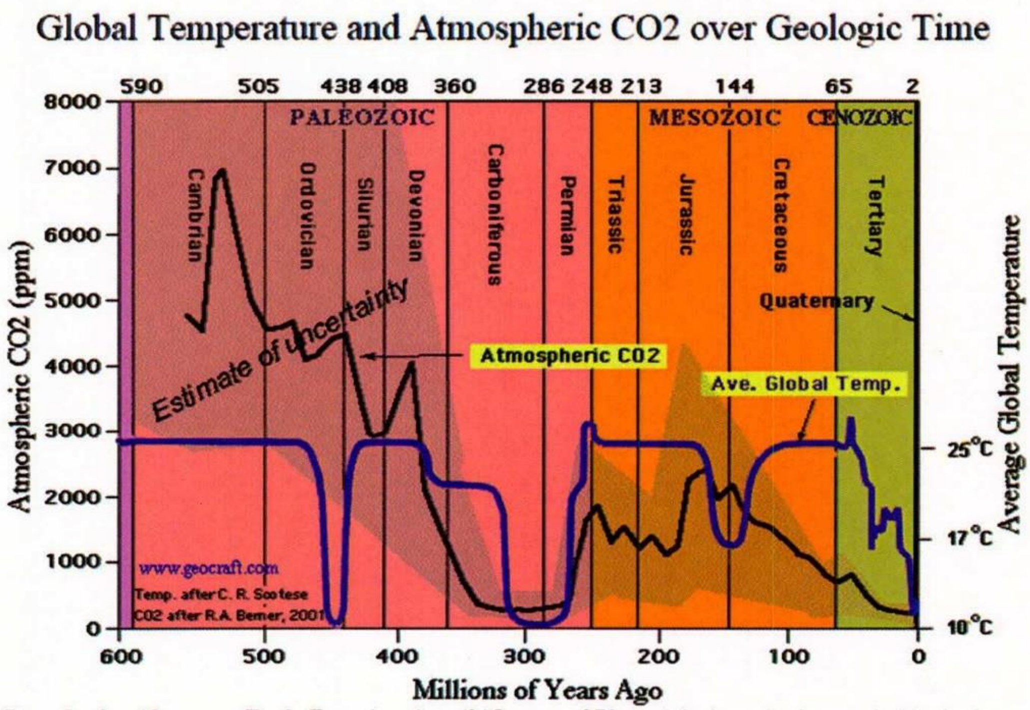


Figure 4: Co-plotted Phanerozoic temperature from Scotese and CO2 level from Berner shows that temperature does not depend on CO_2 level [6].

(Pangburn, 2015, p. 844)

Analysis and further Conclusion

The above figure shows that in the long-term past, the levels of Atmospheric CO_2 and Temperature were uncorrelated but significantly higher than today, except for the period 270 to 340 million years ago. These elevated CO_2 and Temperature levels were not caused by homo sapiens activity, as the species did not exist in this time period.

Pangburn, D. (2015). Influence of carbon dioxide on average global temperatures during the phanerozoic. *Energy & Environment*, 26(5), 841-845.

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