

# The significance of comparing the rate of warming since the Industrial Revolution with the rate of paleoclimatic warming

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**Abstract.** The aim of this thesis is to explore the contrast between the rate of warming since the Industrial Revolution and the rate of paleoclimate warming, and the significance of this contrast. By comparing the rate of warming between these two periods, the impact of industrial activity on global climate change can be clearly seen. In addition, such a comparison can also help to gain a deeper understanding of the mechanism by which greenhouse gas emissions contribute to climate change and provide a scientific basis for the formulation of measures to reduce greenhouse gas emissions. At the same time, comparing the rate of warming since the Industrial Revolution with the rate of paleoclimate warming can also assess the severity of the current global warming, prompting people to take more active actions to address the challenges of climate change. Therefore, by examining the comparison between the rate of warming since the Industrial Revolution and the rate of paleoclimate warming, the impact of human activities on global climate change can be better understood and provide the scientific basis and urgency to slow down the process of climate change.

**Keywords:** warming, Industrial Revolution, paleoclimatic

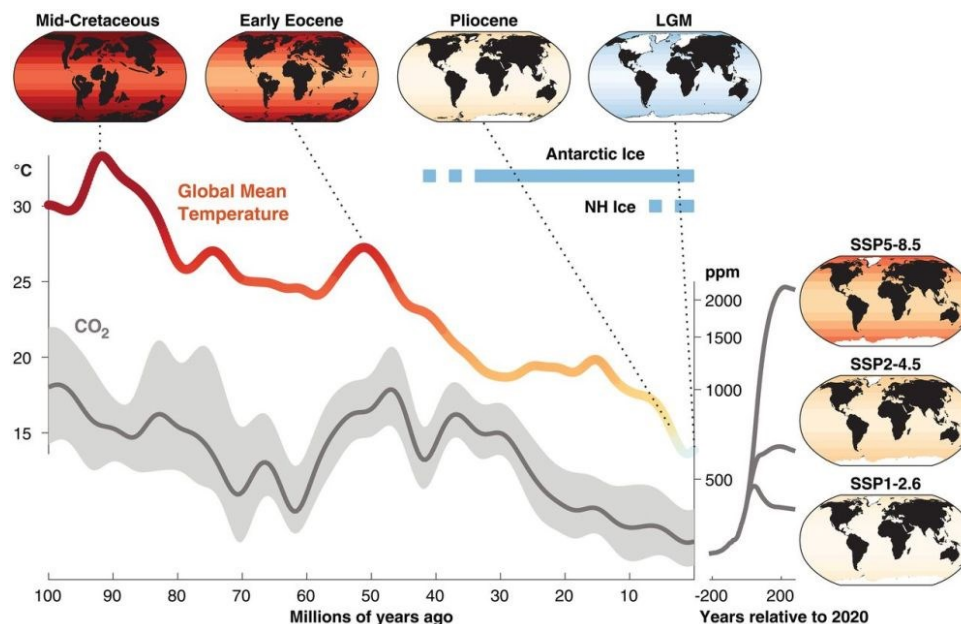
## 1. Introduction

Over the past few decades, global warming has gradually attracted attention. In particular, with the acceleration of human activities and industrialisation, global climate change has become a global problem. The rate of warming since the Industrial Revolution is much faster than the rate of ancient climate warming, and it reminds us that we need to take urgent action to deal with global warming. In addition, comparing the rate of warming since the Industrial Revolution with the rate of paleoclimate warming helps to assess the severity of the current global warming and motivates people to take more active actions to slow down the process of climate change. Therefore, comparing the rate of warming since the Industrial Revolution with the rate of paleoclimate warming is important for understanding the impact of human activities on global climate change and can provide a scientific basis for formulating measures to address climate change. In this regard, there is an urgent need to take action to reduce greenhouse gas emissions and protect the climate system of our planetary home.

## 2. Paleoclimate can provide an important scientific basis for understanding global warming

Paleoclimate records provide a detailed understanding of climate change over the past several million years, which is important for understanding the effects of current global warming and potential future climate change.

Through the study of the paleoclimate record, scientists are able to understand how the Earth's climate has changed in the past. For example, ice cores and marine sediment samples from the palaeoclimate record can provide detailed climate information, including temperature changes, precipitation, and ice cover. These data can be compared with modern climate observations to determine the magnitude and rate of recent climate change. The onset of increased GrIS melting closely followed the onset of industrial-era Arctic warming in the mid-1800s, but the magnitude of GrIS melting did not extend beyond natural variability until recently. Continued atmospheric warming will result in a rapid increase in GrIS runoff and sea level contributions due to the nonlinear response of surface melting to increased summer temperatures [1]. As another example, past climate states can reveal how the Earth's climate system operates when atmospheric CO<sub>2</sub> concentrations vary over a range (400-2000 ppm). Figure 1 shows the climate evolution history since 100 million years ago and projections for different scenarios for the next 200 years.



**Figure 1.** Climate evolution history since 100 million years ago and projections for different scenarios for the next 200 years [2]

Paleoclimate research can also provide insight into the mechanisms behind global warming. By studying the drivers behind past climate events, such as changes in solar radiation, greenhouse gas content in the atmosphere and the Earth's rotational orbital bias, scientists can better understand the causes of current global warming and possible future changes.

In summary, paleoclimate records provide scientists with an important scientific basis for understanding global warming. By studying past climate change and its effects on the environment and ecosystems, scientists can better predict and respond to the impacts of current and future global warming.

## 3. Paleoclimate versus temperature warming since the Industrial Revolution

In recent years, the warming has been significant, with the average temperature rise in 2011-2020 increasing by 1.09°C compared to the pre-industrial period (1850-1900), and 0.99°C warmer than the pre-industrial period in 2001-2020. It is evident that the climate is warming rapidly and that this warming is global. The rapid rate of warming is not limited to temperature indicators, with a global average rise

in sea level of about 20 cm (2018). The anthropogenic component of atmospheric CO<sub>2</sub> (atmospheric value subtracted from the pre-industrial revolution value of 280 ppm) has increased exponentially since the beginning of the industrial revolution (1800), with a doubling time of about 30 years [3].

Compared to AR5, the report's understanding of today's climate change goes back much further in time, with CO<sub>2</sub> concentration changes going back from above 800,000 year ago levels to above 2 million year ago levels, and mean surface temperatures going back from the warmest 30 years since 1400 to the warmest 50 years since 2000.

The rate of warming since the Industrial Revolution has been much faster than the rate of paleoclimate warming. By examining the historical climate record and modern climate data, we can see that global average temperatures have been on a rising trend since the Industrial Revolution. In contrast, ancient climate change occurred relatively slowly.

The rapid increase in the rate of warming since the Industrial Revolution is closely related to human activities. Human industrialisation has led to significant emissions of greenhouse gases (GHGs), in particular carbon dioxide (CO<sub>2</sub>). These greenhouse gases create a greenhouse effect in the atmosphere, causing the Earth's temperature to rise. Since the Industrial Revolution, human activities have led to a rapid increase in the concentration of greenhouse gases in the atmosphere, thereby increasing the rate of global warming.

The accelerated rate of warming since the Industrial Revolution has had a more pronounced impact on global climate change than ancient climate change. This is important for our understanding of climate change mechanisms. By comparing the rate of warming between these two periods, we can better understand the impact of greenhouse gas emissions on the climate system. This will help us to formulate measures to reduce greenhouse gas emissions in order to cope with global warming.

In addition, comparing the rate of warming since the Industrial Revolution with the rate of paleoclimate warming also helps to assess the severity of current global warming. Lifestyles and energy consumption patterns have changed dramatically since the Industrial Revolution, leading to significant greenhouse gas emissions. Global warming above 1.5°C could trigger multiple climate tipping points. Climate tipping points occur when a portion of the climate system changes to self-perpetuate beyond a warming threshold, leading to significant impacts on the Earth system [4]. Crossing the threshold would result in global mean temperatures much higher than during any interglacial in the last 10,000 years, and sea levels would be substantially higher than at any time in the Holocene [5]. The Antarctic ice sheet exhibits multiple temperature thresholds above which ice loss becomes irreversible, and once melted, the ice sheet will only regain its previous mass if the climate cools well below pre-industrial temperatures [6]. Massive loss of Antarctic ice can only be prevented by limiting greenhouse gas emissions to RCP 2.6 levels [7].

Global warming has serious implications for human social, economic and natural systems, such as rising sea levels, declining glaciers and increased extreme weather events. For example, anthropogenic forcing and perturbations may lead to a permanent El Niño phenomenon with potential global-scale impacts on ecosystems and consequent environmental and social phenomena. These El Niño-induced changes coincide with potential state shifts in terrestrial ecosystems across the globe, including potential greening of western North America, extinction of tropical rainforests in the Amazon, and further droughts in southeastern Africa and Australia [8].

By comparing the rate of warming since the Industrial Revolution with the rate of paleoclimate warming, we can better understand the urgency and magnitude of the current global warming, and thus motivate more aggressive action to slow the process of climate change.

#### **4. Conclusion**

As global warming intensifies, we urgently need to take action to reduce greenhouse gas emissions and protect the climate system of our home planet. This is a matter not only for our own survival and development, but also for the future of generations to come. If we continue to ignore the threat of climate change, its consequences will become increasingly serious, extreme weather events will become more frequent and severe, and human society and the natural environment will suffer great losses.

In order to address climate change, we need to adopt a series of measures, including reducing greenhouse gas emissions, enhancing energy transformation, improving energy efficiency and promoting sustainable development. Although the growth rate of global carbon dioxide emissions has slowed and many countries have strengthened their emission targets, the current mid-century net-zero target is insufficient to limit global warming to 1.5°C above pre-industrial temperatures[9]. The CO<sub>2</sub> emissions infrastructure will expand unless special efforts are made to develop alternatives [10]. Governments, enterprises, academics and all citizens should work together to achieve sustainable development of the economy and the environment by formulating and enforcing scientifically sound policies and regulations, promoting the development and application of clean energy, facilitating the transformation of the low-carbon economy, and strengthening environmental protection and ecological construction.

At the same time, there is a need to strengthen cooperation among countries around the globe, share experiences and technologies, formulate and implement more stringent climate change policies at the international level, and promote the process of global climate governance. Only through global cooperation can we better address the challenges posed by global warming, protect the Earth's climate system and achieve sustainable development for humankind.

In taking action, we should also focus on public participation and awareness-raising. Climate change education should be strengthened to enhance public awareness and understanding of climate change, stimulate public awareness and action on environmental protection, and form a synergy for the whole society to jointly address climate change.

In conclusion, the significance of comparing the rate of warming since the Industrial Revolution and the rate of paleoclimate warming is to remind us of the urgency of addressing the issue of global warming, to gain an in-depth understanding of the mechanism of climate change, to assess the severity of global warming, and to provide a scientific basis for formulating measures to address climate change. We need to take action to reduce greenhouse gas emissions, protect the climate system of our home planet and achieve sustainable development. Only through global cooperation and public participation can we effectively address the challenge of climate change and ensure the sustainable development of the planet.

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