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Analysis on the Effects of Ocean on Temperature

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Abstract: Nowadays, global climate change is one of the main concerns of modern society and an enormous issue for all humankind. Temperature is closely related to the greenhouse effect, so one of the major topics to be investigated in global climate is the factors affecting temperature rise. To estimate this change, it is typically crucial to forecast the temperature in the future. The Earth's average temperature is determined by a multi-step and complex process that uses statistical techniques and data from various sources. By collecting and summarizing data, this paper mainly focuses on analyzing the trends in sea surface temperature over the past few hundred years. Through recent studies and case analysis, this paper highlights that the ocean has become an indispensable part of mitigating climate warming and stabilizing temperature. The significance of studying the impact of the ocean on temperature lies in its role as a climate regulator, providing scientific basis for global climate change and guidance for regional adaptation efforts. Because of its enormous heat capacity and thermal inertia, the ocean is an important component of the climate system and plays a buffering and regulating role in atmospheric temperature.

Keywords: Climate change, greenhouse effect, the Earth’s average temperature, ocean

1. Introduction

Studies over the past decades have provided crucial information on global warming, which is now a considerable issue for all humankind. Nowadays, global warming is widely affecting human-natural systems on all continents. Global warming refers to the massive climate change caused by human activities that have affected the Earth's atmospheric environment. It is characterized by an increase in the Earth's surface temperature due to the absorption of solar radiation by greenhouse gases in the upper atmosphere.

Recent theoretical development has revealed that temperature is closely related to the greenhouse effect. However, limited open literature has reported what factors can affect the temperature to reduce the greenhouse effect. This article focuses on the factors affecting temperature rise. In the past several decades, one of the most popular ideas about global warming is that the ocean has played a vital role in stabilizing the rate of warming in the international areas caused by the increase in greenhouse gases, delaying the warming response to greenhouse gas increases [1]. For instance, oceanic climate is the most basic climate type on Earth, formed by the action of large bodies of water in the ocean. The overall characteristic is that it is less affected by the mainland and more affected by the ocean. Under oceanic climate conditions, the annual and daily temperature changes are relatively gentle, and the annual and daily temperature ranges are smaller than those of

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continental climate [2]. Global warming is a factor that threatens every country, and carbon emissions from the burning of fossil fuels are a significant cause of climate change [3].

Figure 1: The North Atlantic Warm Current [4]

The North Atlantic Warm Current (Figure 1) is the strongest warm current in the northern Atlantic and a continuation of the Gulf of Mexico Warm Current, known as the "warm engine" of the Earth's climate. This warm current has profound impacts on the global climate and ecosystems, particularly playing an important role in climate regulation in Europe and eastern North America. Russia has a port called Murmansk, which is located within the Arctic Circle but remains ice free all year round due to the influence of the North Atlantic Warm Current. It is the highest latitude ice free port in the world [4].

Through collecting and summarizing relevant data, this paper mainly analyzes the trends in sea surface temperature over the past few hundred years. The significance of studying the oceans for global warming is not only to understand how the oceans regulate the climate system of the Earth, but also to predict how people will use the oceans in the future to mitigate global warming, reduce the harm caused by the greenhouse effect, and assess the potential impact of these changes on human society and the natural environment.

2. Overview by three sets of figures

Representative Concentration Pathways (RCPs) are scenario models representing different greenhouse gas emission pathways to predict climate change impacts. RCP 2.6 is the most optimistic scenario if strong emission reduction measures can be taken globally. In this case, it is expected that by 2100, the global average temperature rise will be controlled at a relatively low level. RCP 4.5 is an intermediate scenario that assumes moderate policy interventions to reduce greenhouse gas emissions. Under this path, although the goal of deep emission reduction has not been achieved, the emissions growth will gradually slow down and tend to stabilize. In contrast, RCP 8.5 is the most pessimistic and extreme scenario, predicting that economic activity and technological development will lead to sustained growth in greenhouse gas emissions in the coming decades without effective mitigation measures. Its predicted result is that the Earth's surface temperature will significantly increase by the end of this century.

This paper firstly gives a brief overview of the history of temperature change tendency. In various projections (RCP 2.6, RCP 4.5, RCP 8.5), there are three images about future temperature tendencies.

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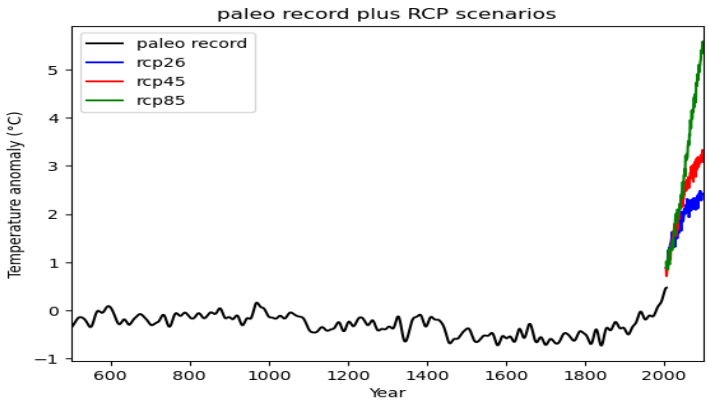

Figure 2: Hockey stick curve: Line plot of global-mean, annual-mean temperature anomaly as a function of time, for observations continued by RCP8.5 and RCP2.6 scenarios.

Firstly, the curve in Figure 2 that resembles a hockey stick is known as a hockey-stick curve due to its shape, showing a decline during the majority of the temperature record and an increase in the past century. This chart shows that during the more than nine hundred years before the mid-20th century, although temperature changes fluctuated greatly, they generally appeared as a slowly decreasing straight line segments. It was not until the last few decades that the temperature change line suddenly bent upwards. To be more specific, it is obvious that the fluctuation of the black curve from about the year 600 to the year 2000 is relatively stable, based on actual observations. At the turning point, there are the three curves with different colors, which respectively predict the scenarios (RCP 2.6, RCP 4.5, RCP 8.5). Since RCP has an effect on temperature, a higher RCP concentration will also result in a higher temperature.

In the RCP 8.5 scenario, the average temperatures will rise by about 5.8 degrees in 2100 [5]. This will lead to a rise in sea level, threatening the security of coastal cities and valley areas and even inundating coastal lowlands.

Secondly, the ecosystem will be destroyed. Climate warming may disrupt the ecological balance and affect the distribution and living conditions of wild animals and plants, resulting in the loss of biodiversity and the collapse of the ecosystem. At the same time, climate warming will also lead to changes in precipitation patterns, which will affect the water supply system. This changes will have a profound impact on both the natural environment and human society. So the control and mitigation of global warming is a major challenge that must be addressed both at present and in the future. Moreover, the researchers believe that if the current ocean climate disappears, the migration adaptation of many marine species may no longer be possible and will face extinction [6].

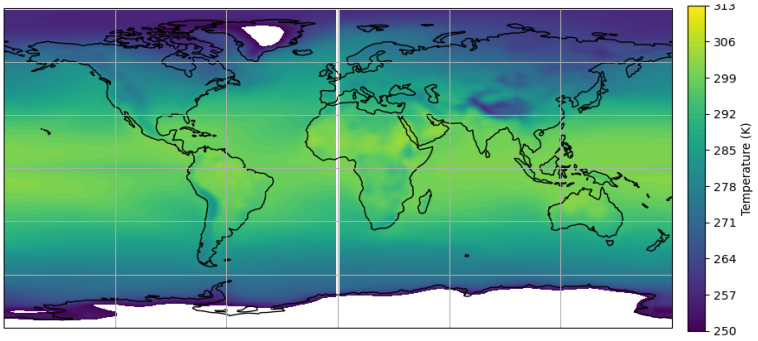

Figure 3: Temperature during 1st 5 years of RCP 8.5

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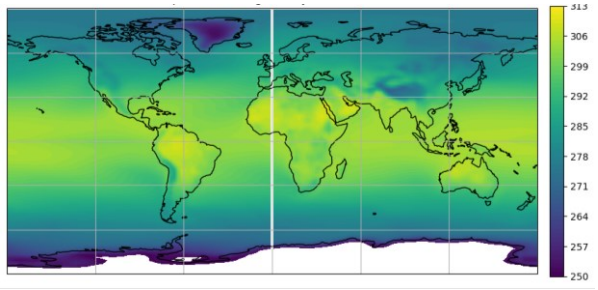

Figure 4: Temperature during last 5 years of RCP 8.5

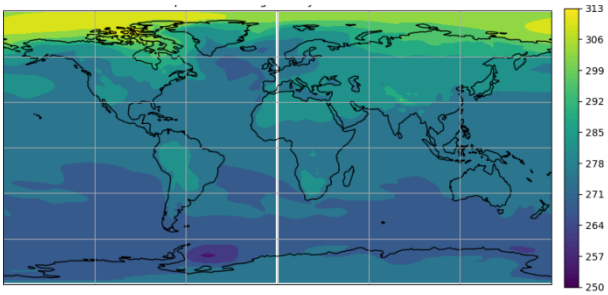

Figure 5: Temperature during last 5 years of RCP 8.5

Figure 3 to Figure 5 illustrate the historical changes in global temperature over the first and last five years of the 21st century in RCP 8.5 scenario. The color scale on the right side of the image indicates the relationship between Fahrenheit temperature and display color, with yellow indicating warmer areas and blue indicating colder regions. This dataset consists of three images, the first two of which compare the sea surface temperature in the first and last five years under ACP 8.5. Both of these images exhibit a phenomenon where the yellow distribution at the center spreads in a strip along the latitude line from the equator to both sides. In mid-to-high latitude regions, the color gradually changes from yellow to blue until reaching the poles, with blue and purple appearing in most areas. This indicates that the surface temperature of the ocean has been gradually decreasing from the equator to the poles, ranging from approximately 313 to 250 degrees Fahrenheit. Meanwhile, comparing the two images, it can be seen that there is a general warming trend, with areas that were previously blue shifting to yellow over time. From Figure 3, it can be concluded that the temperature rise in high-latitude regions is expected to be higher than that in low-latitude regions, especially in polar regions, a phenomenon known as “polar amplification” [2].

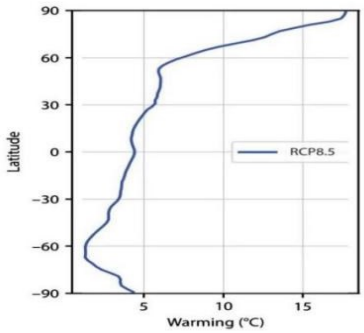

Figure 6: Polar amplification: the zonally-averaged warming vs latitude in the RCP 8.5 scenario

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Figure 6 shows that the regional average warming and latitude changes in the RCP 8.5 scenario are not significant in the Southern Hemisphere, while the magnitude and speed in the Northern Hemisphere gradually increase with latitude, reaching over 15 degrees Celsius in polar regions. As shown in Figure 6, this is a specific manifestation of polarity amplification. Polarity amplification usually refers to significant climatic change near polar regions in global climate forcing. Polar amplification is believed to mainly come from the positive feedback of ice and snow retreat [7]. This shows how climate change is affecting the temperatures of Arctic Ocean and its marginal seas. In recent years, Arctic sea ice has significantly decreased. At the same time, the warming rate of near-surface air in the region is almost twice that of the global average, a phenomenon known as Arctic amplification.

3. The information of polar amplification

Models participating in the Coupled Model Intercomparison Project and the updated Community Climate System Model document the polar amplification of climate change in the Northern Hemisphere. The Arctic's simulated polar warming ranges from 1.5 to 4.5 times the world mean warming, specifically. Although a large portion of the polar amplification is probably due to ice-albedo feedback, the degree of the feedback is dependent on a number of physical processes. Furthermore, polar amplification is typically larger in models with relatively limited Arctic ice cover in the control climate. Additionally, a comparison of model findings reveals a significant correlation between increased Arctic warming and increases in polar cloud cover and poleward ocean heat transport at high latitudes. This implies that polar amplification may be altered by these alterations in the environment. This effect leads to a rapid rise in temperatures in the Arctic region, accelerating the global water cycle and prolonging navigation times, which has an impact on international shipping and trade. At the same time, the melting of polar glaciers leads to rising sea levels, which threatens coastal security and ecosystems, forming a positive feedback mechanism and further exacerbating global climate change.

4. Conclusion

In summary, the above maps show the changes in ocean temperature in recent years and predict how ocean temperature will rise in the future. These figures showcase the impact of climate change on ocean temperature and the problems caused by low-temperature changes in recent centuries. The regulatory role of the ocean in the global climate system cannot be ignored. Human activities have profoundly changed the marine environment, contributing to accelerate ocean warming [8]. By analyzing recent research and case studies, this study finds that the ocean plays a leading role in mitigating climate change. The research results provide valuable scientific information for promoting the achievement of sustainable development goals. However, this study has limitations, especially in terms of the generalizability of its findings. The underlying mechanisms linking ocean temperature changes with the greenhouse effect require further clarification. More literature and research investigations are required. Future research needs to focus on specific ways that people can use the ocean to stabilize temperature changes, as well as a deeper understanding of the greenhouse effect, to mitigate the harm of global warming to humans and nature [9], better protect biodiversity, ensure the normal operation of marine and terrestrial ecosystems in terms of structure and function, protect biodiversity, regulate species migration, and stabilize the food chain. Future research will be able to explore more diverse factors and make good use of the ocean's mitigation of greenhouse effects, thus gaining a more comprehensive understanding of the complex issues of global warming related to global warming and the ocean’s role in climate regulation.

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