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The multiple causes of El Nino and its broad impacts on the global climate, ecology and economy

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Abstract:

This paper focuses on the El Nino phenomenon and makes a comprehensive analysis of its sources and consequences. The dynamic processes of the ocean, such as the shift of the thermocline in the equatorial Pacific Ocean, abnormal movement of ocean currents, and abnormal changes in atmospheric circulation, are among the many causes of El Nino. El Nino can cause multiple anomalies at the same time, with wide-ranging impacts on climate, ecosystems and human society. Extreme weather events such as storms and heavy rains are becoming more frequent in the tropics, causing climate anomalies to become more pronounced. It causes habitat destruction for Marine species and changes in the composition of several biomes. In terms of the economy, the El Nino climate anomaly leads to fluctuations in food production, affecting stability, and the increase in energy use caused by abnormal temperatures puts further pressure on the economies of different countries. Therefore, the study and prediction of El Nino phenomena is essential to establish effective coping mechanisms and mitigate its adverse effects on the environment and human culture.

Keywords: El Nino; global climate; ecology; economy

1. Introduction

In the context of the increasingly significant global climate change, the El Nino phenomenon, as an important climate phenomenon, is increasingly concern by the scientific community and the public. This El Nino phenomenon, a very influential natural weather in the Earth's climate system in the equatorial Pacific Ocean, its complex formation mechanism and wide impact have been the focus of the meteorological science community. As global climate change intensifies, a better understanding of the causes and possible consequences of El Nino is important to reduce disaster risk and improve response capacity.

The origin of El Nino involves complex interactions between the ocean and the atmosphere, as well as other factors such as Earth's rotation and volcanic activity. The appearance of El Nino will lead to a change of sea surface pressure and cause abnormal sea surface westerly winds, which are opposite to the original trade winds in the tropical Pacific, resulting in the weakening of the original trade winds and the weakening of the Peruvian Current, which makes the

warm water flow back from west to east, resulting in an abnormal increase in the surface water temperature in the central and eastern equatorial Pacific. At the same time, it affects the atmospheric circulation, making updrafts move strongly, and enhancing the rainfall caused by convective weather. This change will also cause global atmospheric circulation climate change [1]. The abnormal warming of the ocean will also exacerbate changes in the wind field, which in turn will react on the ocean, further affecting ocean currents and ocean temperatures. These changes in atmospheric circulation have led to more intense abnormal precipitation patterns, which in turn affect global climate change. Due to the interaction of ocean, atmosphere and other factors, the occurrence of the El Nino phenomenon is interwoven, but the related trigger mechanism and feedback mechanism of these factors still need to be explored and studied.

El Nino can have a variety of climatic, ecological and economic impacts. Due to the abnormal influence of precipitation and temperature patterns, will lead to abnormal rainfall in some areas, such as the west coast of South America, with heavy rain and floods, while Indonesia, the Philippines and other areas are dry and have less rain. At the same time, some areas have abnormal temperatures, such as experiencing unusually high temperatures or cold waves. In terms of the ecosystem, the El Nino phenomenon will destroy biological habitats, affect the ecological balance of the ocean and land, threaten the survival of species, change the original growth law and lead to natural disasters. In addition, El Nino can deal a major blow to the global economy. The decrease in fishery production and the unstable supply of agricultural products has led to floating prices, rising costs in related industries, and changes in energy market demand.

According to the complexity and importance of the El Nino phenomenon, this paper aims to comprehensively analyze the possible causes of the El Nino phenomenon and discuss its serious impact from the aspects of climate, ecology and economy. Through the in-depth analysis of the relevant data and the summary of the existing research results, we hope to provide effective scientific data for the prediction level of the El Nino phenomenon and further coping ability.

2. El Nino phenomenon and its triggering mechanism

The trigger for El Nino dates to the 1960s when meteorologists and oceanographers believed that El Nino was a large anomaly caused by an ocean-air interaction. El Nino is characterized by an abnormal rise in ocean temperatures in the eastern equatorial Pacific Ocean. Generally, the SST in this region is low. Due to the operation of the trade winds, the trade winds near the equator (mainly southeast and northeast trade winds) blow from east to west. This causes surface water from the eastern equatorial Pacific to be blown towards the western Equatorial Pacific, while deeper cold-water upturns to replenish the surface water [1]. As a result, the temperature of the surface water is lowered, and the sea surface temperature is kept at a lower level. When the trade wind changes, its force to push the surface water of the sea is weakened, the flow of the surface water is slowed down, and the upwelling of the bottom cold water is reduced, resulting in an increase in its surface temperature [2].

The weakening of trade winds will also affect atmospheric circulation patterns. In the Pacific region near the equator, the lower surface SST in the eastern Pacific leads to the phenomenon of atmospheric subsidence and the formation of high sea surface pressure, while the higher surface SST in the western Pacific leads to the rise of the atmosphere and the formation of low sea surface pressure. As the air flows from the high-pressure area to the low-pressure area, a closed circulation circle is formed, namely the Walker circulation [1]. As the trade winds weaken, the Walker circulation will adjust and weaken. Surface temperatures in the eastern Pacific are no longer cold, which has led to less atmospheric subsidence. At the same time, the surface temperature of the western Pacific region is relatively lower, and the updraft will be relatively reduced. This largely affects the vertical motion pattern of the Walker circulation. Causing anomalies in the distribution of heat in the atmosphere. This unusual change in atmospheric circulation causes changes in its evaporation conditions, increasing the amount of water vapor released into the atmosphere and further causing the atmosphere to behave abnormally. Resulting in abnormal moisture distribution and precipitation patterns in many areas. The increase in precipitation reduces the salinity of the sea surface, which in turn affects its density, resulting in a smaller density of the ocean. The low density of the seawater is not conducive to the upturning of the bottom water, thus aggravating the occurrence of the El Nino phenomenon [3].

At the same time, the Earth's rotation also has a certain influence on the occurrence of El Nino. The Coriolis force produced by the Earth's rotation has an important effect on the direction and strength of ocean currents. Although the speed of Earth's rotation changes slightly in the short term, in theory, any slowdown will have an impact on the Coriolis force and ocean currents. When the angular velocity of rotation slows down, the Coriolis force weakens. This will lead to a reduction in the strength of trade-wind-driven ocean currents in equatorial regions, such as the

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equatorial current. Under normal circumstances, these currents carry warm water from the eastern equatorial Pacific to the western equatorial Pacific, while lifting cold water from the bottom to the surface, thus maintaining the temperature balance of the ocean. However, a reduction in the strength of ocean currents would lead to a reduction in the exchange and circulation of this water. The upwelling of cold water in the eastern equatorial Pacific has decreased, which in turn has gradually increased the sea temperature in the region [4].

3. The relationship between El Nino phenomenon and global climate patterns and global economic fluctuations

3.1 Impacts on global climate

During El Nino, high sea surface temperatures in the eastern equatorial Pacific Ocean result in low sea surface pressure, forming an area of low pressure and attracting nearby water vapor to the region, and some regions geographically closer to the eastern equatorial Pacific Ocean, such as the west coast of South America, are more affected. The accumulation of large amounts of water vapor leads to unusually large amounts of rainfall and other extreme weather, such as floods and heavy rains [5]. At the same time, because El Nino alters atmospheric circulation patterns, the dry southeast trade winds that blow from land to sea are prone to weakening or reversing, bringing in moist air that further increases rainfall. On the contrary, the western equatorial Pacific region is affected by the shrinking of the cold-water area, and the rise of water vapor decreases, making it difficult to form effective rainfall [5]. This has led to drought and low rainfall in places such as Indonesia and the Philippines. Changes in atmospheric circulation patterns are also exacerbating drought conditions. The formation of high-pressure areas effectively inhibits the upward movement of air and reduces the chance of rainfall. The shift in wind direction also allows the wet winds that normally blow to the area to move to other areas. El Nino can also cause temperature anomalies in some regions [6]. Due to the over warming of the eastern equatorial Pacific Ocean, warm water releases excess heat into the atmosphere, causing a large amount of heat to affect other areas along the atmospheric circulation, resulting in abnormally high temperatures in those areas [6]. For example, during El Nino, the west coast of South America has a chance of mild winters because warm ocean air is transported to the region, causing its temperatures to be above average. The change in atmospheric circulation patterns also weakened the subtropical high, making it easier for polar cold air to travel south. When cold and warm air meets, it is easy to cause cold wave weather, resulting in some areas suffering from cold wave weather problems.

3.2 Impact on the ecological environment

During El Nino, SST increases in the eastern equatorial Pacific Ocean, which is unusually high and can affect Marine ecosystems because many Marine organisms have a specific range of adaptations to water temperature. For example, some cold-water fish, coral reefs and invertebrates may not be able to adapt to higher water temperatures and face forced migration or difficulty surviving. As a result, their original habitat is no longer suitable for survival, resulting in changes in the structure of the biome [7]. Ocean circulation patterns are also affected by El Nino. Maintaining the dispersal of Marine life and the flow of nutrients requires regular ocean circulation. Plankton development may be affected by changes in circulation that lead to a reduction in nutrients in a given area. Since plankton is the base of the Marine food chain, changes in its numbers can have an impact on organisms with higher trophic levels [8]. In addition, changes in rainfall patterns have the potential to disrupt ecosystems. For example, floods can severely damage wetland ecosystems along rivers, with impacts on aquatic life, amphibians and birds that depend on the wetlands. Drought reduces water resources, dries up soil and wilts plants. This poses a serious threat to terrestrial species, whose habitats can become uninhabitable due to drought and dependence on certain water sources and plants. At the same time, drought can also ignite forests, leading to an increase in the frequency and intensity of forest fires. Wildfires can burn large areas of forest and destroy the habitat of many wild animals. Many animals may be killed in the fires or forced to relocate in search of better living conditions. Forest fires affect the restoration and resettlement of forest ecosystems and also change the mix of plants and the structure of soil. This further caused habitat destruction [9].

3.3 Impact on the global economy

During El Nino, global weather patterns change, leading to extreme weather events such as droughts and floods in some regions, which have knock-on effects on agriculture, energy and fisheries. First, in agriculture, severe droughts can hit Australia and India during El Nino years, severely reducing yields of rice, wheat and other crops. In some parts of the Americas, floods and heavy rains can damage crops and reduce food production. Instability in food production leads to higher food costs and higher living costs for consumers. It also puts economic pressure on countries that import food. Changes in food produc-

tion caused by El Nino will directly affect the supply and demand relationship of the agricultural products market. When supply is reduced, agricultural prices will rise, and price fluctuations will have an impact on farmers' planting decisions and market expectations. In addition, the impact of El Nino on global temperatures can lead to changes in energy demand. Lower heating demand in warmer winters has led to lower energy prices for natural gas and coal. However, in some areas experiencing heat waves, the demand for refrigeration equipment such as air conditioners has increased, and the power supply has risen, resulting in a tight overall energy supply and higher prices. During El Nino, changes in ocean temperature and circulation affect the living environment and distribution of most fish. Some fish may migrate to other areas, resulting in fewer catches in areas where traditional fishing grounds are located. For example, Peru's anchovy fishing industry is often severely affected during El Nino years, with the growth and reproduction of anchovies greatly affected by their warm waters. The decline of fishery production will affect the income of fishermen and the development of related industries [10].

4. Conclusion

All in all, the causes of El Nino are multifaceted and complex, including ocean dynamics, inherent fluctuations in air circulation, human activities, and complex relationships within the Earth system. El Nino is caused by a complex interplay of factors, including changes in the trade winds, changes in the ocean thermocline, and small effects of the Earth's rotation. El Nino has broad and significant consequences, affecting everything from Marine ecosystems to terrestrial habitats, from climate change to the world economy. Climate change has led to altered precipitation patterns, unusually high temperatures and cold snaps, and has placed significant pressures on ecosystems, including reduced fisheries, increased forest fire danger, and damage to biodiversity. The global economy has affected the agriculture, energy, insurance and fisheries sectors to varying degrees. Declining fishery production, unstable agricultural production, and changes in energy demand all add uncertainties to the stable development of human society. For El Nino, we need to increase research and monitoring efforts to improve the timeliness and accuracy of forecasts. At the same time, the international community should work together to take practical remedial measures to mitigate the harmful effects of El Nino. We hope that measures such as rational planning of agricultural output, optimization of energy structure and strengthening ecological protection can better safeguard the ecological balance of the earth and the sustainable development of human society in the face of the El Nino phenomenon. Only then can we develop a more stable and peaceful way to coexist with nature.

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