Dean&Francis
ISSN 2959-6157

Analysis of the Complex Dynamics and Impacts of Global Climate Change

Yiwen Cui

Rosedale Global High School, L3R 6G2, Canada

*Corresponding author: chenjin15@xdf.cn

Abstract:

El Niño and Southern Oscillation (ENSO) is a complex climate phenomenon characterized by irregular changes in sea surface temperature and pressure in the equatorial Pacific Ocean. ENSO is a complex climate phenomenon characterized by irregular changes in sea surface temperature and pressure in the equatorial Pacific Ocean. These changes have a profound impact on global weather patterns, affecting temperature, precipitation, and extreme weather events. This article will deeply analyze the frequency, intensity, and regularity of El Niño, and explore its historical performance and changing trends. In addition, we will also evaluate the potential impacts of these phenomena on ecosystems, agricultural production, and human life, and help people better understand and respond to the challenges brought by El Niño. Through the study of these climate phenomena, it is hoped that a scientific basis can be provided for climate prediction and climate change adaptation measures, and practical suggestions can be provided to governments and relevant organizations in responding to climate change.

Keywords: ENSO; climate phenomenon; global weather.

1. Introduction

The El Niño-Southern Oscillation (ENSO) has a major impact on global climate through the El Niño (warming) and La Niña (cooling) events in the Pacific Ocean Understanding and mitigating ENSO is particularly important because of its impacts on water resource management, agriculture, and economic decline [1,2].

The incidence of ENSO has increased rapidly since it was first recognized by Peruvian fishermen in the 19th century; in the mid-20th century, research on ENSO highlighted its impact on the global climate and its potential impact on agriculture and other sectors. More advanced technology has enabled mankind to improve the accuracy of predictions.

The El Niño events of 1982-83, 1997-98 and 2015-16 have triggered many extreme weather events. Studying El Niño events can contribute to our understanding of global meteorology in general, especially those aspects that are of great importance to our lives.

The aim of this work is to analyze the frequency, intensity and patterns of El Niño events and assess their potential impact on climate change.

ISSN 2959-6157

2. The impact of El Nino phenomenon

During El Nino, the oceans release more heat, causing global temperatures to rise. It will make the tropics hotter, and it will also affect temperatures in the middle and high latitudes. During El Nino years, global average temperatures tend to be higher than normal [3,4].

El Nino can also increase the frequency and intensity of extreme heat. Many regions are likely to experience record-breaking heat, posing a serious threat to human health, agricultural production, and ecosystems. For example, high temperatures can affect the growth and yield of crops and can also trigger natural disasters such as forest fires [5].

El Nino often has an influence on marine creatures, lots of fish died from El Nino phenomenon, which directly lead to the decrease of the production of marine creatures, especially in some coastal developing country and become a handicap to the economy of these country.

El Nino have an impact to the atmospheric circulation and ocean temperature distribution. For example, some areas such as southern India, central and eastern South America and southern Chile, the western coast of North America, and East Africa will have more precipitation when El Nino occurs, while other areas like Australia, most of India, southern Africa, and Brazil may have less precipitation.

Firstly, El Nino results in higher global temperatures and changes in precipitation patterns, which increase the use of air conditioning and refrigeration equipment, thereby increasing electricity demand. For example, under the influence of the El Nino phenomenon, summer temperatures in northern China have broken through the historical extreme, resulting in an increase in the power load of the power grid, which in turn increases the demand for electricity [6,7]. In addition, El Nino also has a direct impact on the production of renewable energy sources such as hydropower, especially in those countries that rely on hydropower, such as Colombia, Brazil and Chile, where changes in precipitation can significantly affect power supply. So it is also has an impact on the production of energy. Additionally, El Nino also causes fluctuations in energy prices. Because El Nino affects agricultural production and energy supplies around the world, this can lead to higher energy and food prices. For example, the 2015 El Nino cycle triggered global food price volatility and energy disruptions, affecting global energy and food markets.

3. Overview of the disaster of strong El Nino events during 2015-2016

Strong El Nino phenomenon can bring a huge loss to human. And there is a case about the strong El Nino. The strong El Nino phenomenon in 2015 lasted for 20 months, it was the strongest phenomenon after 1951, which ranked only second to the phenomenon in1997 and 1998.

The heavy moisture carried from northern west Pacific Ocean and Indian Ocean in this strong El Nino phenomenon has generated a significant impact to global climate. In 2015, the average of global surface temperature was constantly increasing, and it has been the highest temperature average on record. In January 2016, the temperature in the Arctic reached to over 0°for the second time on record. Indonesia and the Philippines and other countries from southern east Asian suffered from the most ruinous drought in the last two decades, which frequent leaded to serious farm and forest fires. The temperature in India increased abnormally. Australia has been hit by a heatwave during the summer, which has sparked bushfire. This phenomenon also brought a severe drought to South Africa, Ethiopia and resulted in a serious reduction in food production in lots of African countries. A continuous drought appeared in Brazil. Many areas in Latin America had rainstorms and floods.

3.1 Case study: Economic loss to the Peruvian fishing industry caused by the strong El Nino in 2015-2016

Strong El Nino can also lead to a sharp decrease of the catch of anchovy (a sort of marine fish). Anchovy catching industry is always the mainstay industry in Peru. Both fishing volume and the production of fishmeal are among the top in the world. But during the strong El Nino in2015, Peru's National El Nino Research Management Board (ENFEN) reported that El Nino had already having an impact on the status of anchovy stocks. This strong El Nino events lead to a significant increasing of sea temperature and salinity, which prompted large numbers of anchovies swam deeper into the sea and made anchovy fishing more difficult. The mainly reason of that contains the abnormal rising of the sea temperature and the decreasing of oxygen content. The weakens of upwellings caused by strong El Nino also make an impact on the decrease of fishing volume in Peru. For these reasons, the strong El Nino phenomenon had a negative influence to the anchovy fishing industry in Peru, which also brought a financial crisis to Peru.

3.2 Comparison of El Nino period with non-El Nino years

The main distinction between El Nino years and ordinary years lies in the varying surface water temperatures in the central and eastern Pacific Ocean close to the equator,

along with the resulting climatic impacts.

Under normal circumstances, the monsoon current in the tropical Pacific extends from the Americas to Indonesia and Australia, keeping the surface of the Pacific warm. The prevailing updraft over Indonesia brings tropical rainfall to its surroundings. Under the action of trade winds, seawater flows from east to west. The surface warm current blows to the western Pacific and accumulates, resulting in a rise in sea surface temperature in the western Pacific. After the seawater in the central and eastern Pacific flows out, it is replenished by the upwelling of cold water from the lower layer, making the water temperature in this region lower than that of the surrounding areas and forming a sea temperature difference. This normal water flow and temperature distribution plays an important role in maintaining the earth's climate balance.

When El Niño occurs, the wind direction and ocean current are reversed. The surface heat flow of the Pacific flows in the opposite direction to the Americas. In this case, the water temperature in the central and eastern Pacific rises, while the water temperature in the western Pacific is relatively low. This breaks the normal sea surface temperature distribution pattern. This change will have an impact on the atmospheric circulation and cause changes in the airflow pattern in the equatorial Pacific. For example, the downdraft weakens or disappears, or even an updraft appears, which in turn affects the local rainfall pattern. Moreover, this change will lead to significant changes in the climate of many regions, resulting in abnormally increased precipitation in coastal areas of the Americas and abnormal drought in Southeast Asia.

4. The preventing of strong El Niño phenomenon

Although El Niño is a natural phenomenon of atmosphere and ocean that can't be prevented thoroughly, taking some measures can reduce its impact to a certain extent and play a similar preventive role.

Preventing and restoring natural ecosystems such as forests and wetlands helps to regulate the climate and water resources cycle. For example, large forests such as the Amazon rainforest can absorb and store a large amount of water, mitigating the climate fluctuations caused by El Niño to some extent. When the ecosystem is healthy and stable, it can better resist the impact of climate change and reduce ecosystem disorders caused by El Niño, such as species extinction, habitat destruction and other problems.

Ecological restoration projects, such as afforestation and wetland restoration, can increase the biodiversity and complexity of ecosystems. Rich biodiversity can make ecosystems more self-regulating and adaptive in the face of extreme weather conditions caused by El Nino. For example, diversified vegetation can better retain soil water and reduce soil erosion, thus ensuring the stability of agricultural production and ecological environment.

Adjust crop varieties and planting times according to the likely impact of El Nino. For example, increasing the proportion of drought-tolerant crops, such as sorghum and millet, in areas likely to experience drought; In areas likely to suffer from flooding, choose water-tolerant varieties or adjust planting cycles to avoid periods of high flooding. This would reduce the risk of widespread crop losses due to weather anomalies.

Promote efficient and water-saving irrigation technologies such as drip irrigation and sprinkler irrigation, which can improve the efficiency of water use and ensure the water supply required for crop growth in the case of drought caused by El Nino. At the same time, the use of precision agriculture technologies, such as precise fertilization and application according to soil fertility and climatic conditions, can improve the resistance of crops, so that they can better adapt to the adverse effects of climate change.

Construction of water conservancy facilities: Strengthen the construction and maintenance of water conservancy facilities such as reservoirs and DAMS. In areas where El Nino can cause flooding, strong and well-designed levees can protect people and farms from flooding. In areas likely to experience drought, large reservoirs can store enough water for agricultural irrigation, residential life and industrial production. For example, China's Three Gorges Water hub project has played an important role in regulating water distribution in the Yangtze River basin, helping to alleviate the water imbalance caused by climate anomalies such as El Nino.

Through the establishment of high-precision climate monitoring network and data analysis model, timely and accurately predict the occurrence and development of El Nino, as well as the possible impact of the region and degree. Early warning information is issued to the society in advance so that the government, enterprises, and residents have enough time to take countermeasures. For example, meteorological departments can use satellite remote sensing, ground observation stations and other means to monitor changes in key indicators such as ocean temperature and atmospheric circulation and issue El Nino-related disaster warnings weeks or even months in advance, so that farmers can harvest crops in advance and residents can prepare for disaster.

Improve agricultural insurance, property insurance and other related insurance mechanisms, so that individuals and enterprises can receive timely economic compensation when they suffer losses from El Nino-related disas-

ISSN 2959-6157

ters. This will help mitigate the impact of disasters on economic and social stability and promote post-disaster recovery and reconstruction. For example, in some agriculturally developed areas, the government encourages farmers to buy agricultural insurance. When El Nino leads to crop reduction or collapse, the insurance company will compensate according to the insurance contract, which guarantees the economic interests of farmers and maintains the sustainability of agricultural production.

5. Suggestion

Drought Management: In regions prone to drought during El Niño events, it's crucial to implement effective water management strategies. This can include water conservation measures, improving irrigation systems, and promoting the use of drought-resistant crops.

Early Warning Systems: Establishing and maintaining robust early warning systems can help communities prepare for and mitigate the impacts of El Niño. These systems can provide timely information on weather patterns, potential droughts, floods, and other extreme events, allowing for proactive measures to be taken.

Agricultural Adaptation: Farmers can adopt practices that enhance their resilience to El Niño-related droughts and floods. This may involve crop diversification, using drought-tolerant seed varieties, implementing efficient irrigation techniques, and practicing soil conservation measures.

Risk Reduction and Preparedness: Governments and communities should prioritize risk reduction and preparedness efforts. This includes developing contingency plans for food security, water supply, and emergency response in the event of El Niño-related disasters.

Infrastructure Improvement: Strengthening infrastructure, particularly in vulnerable areas, can help reduce the impacts of El Niño. This can involve improving drainage systems to manage flooding, reinforcing coastal defenses against storm surges, and enhancing water storage facilities to ensure adequate water supply during droughts.

Climate-Smart Livelihoods: Encouraging climate-smart livelihoods can help communities become more resilient to El Niño and other climate-related challenges. This may involve promoting sustainable agriculture practices, diversifying income sources, and investing in climate-resilient industries.

Public Awareness and Education: Raising public awareness about El Niño and its potential impacts is essential for effective coping strategies. Education campaigns can help communities understand the risks associated with El Niño and the actions they can take to protect themselves and their livelihoods.

6. Conclusion

El Niño has a very significant impact on global climate change and ocean movement, which also leads to many positive and negative influences on animal, plants and human beings. In this dissertation, we made a survey to the frequency of El Niño events that occurred in the recently strong El Niño events and research for some cases related to the influence of the strong El Niño events that occurred in 2015-2016 to fishing industry in Peru and the economic damage in many areas in this event. We also introduced the patterns of El Niño events, which helps to improve the awareness of El Nino phenomenon preventing. The importance of preventing strong El Niño phenomenon was also be mentioned, which can not only improve the conscious mind of human to prevent El Niño phenomenon but also facilitate the development of El Niño preventing and foresee the El Niño events in the future. Moreover, through this dissertation, people can know about the knowledge related to El Niño so that we can also have a clear mind of how we should do or shouldn't do when we meet with strong El Niño events.

References

[1] Shao Xie, Zhou Bing, 2016 Monitoring And Diagnosis Of The 2015/2016 Super El Nino Events. Meteorological Monthly,42(5):540-547.

[2] Yuan Yuan, Gao Hui, Jia Xiaolong, Et Al, 2016. Influences Of The 2014-2016 Super El Niño Event On Climate. Meteorological Monthly, 42(5): 532-539.

[3] Zhang Ping, Xu Feng, Tu Shifei, Et Al. Spatial And Temporal Characteristics Of The Ssta In The South China Sea From 1979 To 2017 And Its Correlation With The Walker Circulation Anomaly. Journal Of Marine Meteorology, 2019, 39(1): 15-25.

[4] Yuan Yuan, Zhou Ning-Fang, Li Chong-Yin. 2017. Correlation Between Haze In North China And Super El Niño Events. Chinese Journal Of Geophysics (In Chinese), 60(1): 11-21.

[5] Zhang X L, Ma Y X. Progresses Of El Niño And Southern Oscillation Research (In Chinese). Chin Sci Bull, 2024

[6] Zhang Xiaoxiao, Xue Feng, Dong Xiao, Et Al. 2022. Subseasonal Evolution Of The East Asian Summer Monsoon Simulated By Two Bcc Climate Models Participating In Cmip6 Climatic And Environmental Research (In Chinese), 27 (6): 729–746.

[7] Pu Yuli, Hong Qin, Feng Juan, El Nino The Impact Of The Event Development Period On The Summer Extreme Precipitation In Eastern China, 2024-04