The Influence and Causes of the Walker Circulation, and Measures to Mitigate its Hazards

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Abstract. In the context of the world's increasingly damaged ecological environment, rare natural disaster phenomena occur from time to time in seaside cities worldwide. Scientists later found that such irregular disasters are regular due to the instability of the Walker circulation, weakening to produce the El Niño phenomenon and strengthening to make the La Niña phenomenon. Based on this background, we not only have to think about the impact of various natural disasters generated by the Walker circulation on the ecology and economy of the world. This paper adds to the list of phenomena and effects of the Walker circulation that have not been systematically summarized over the years and expands on how to avoid large-scale disasters in the context of the Walker circulation, providing a more purposeful and distinctive organization of the research direction of the Walker circulation. This paper finds that both El Niño and La Niña caused by the Walker circulation have influenced the ecological and economic environment of the world. In the future, we can explore ways to smooth the Walker Circulation through research or to reduce the harm brought by the Walker Circulation to the world more purposefully and efficiently, to reduce its uncertainty, and to create an excellent and smooth background for the future of agriculture and commerce, so that the global community of interests can develop steadily.

Keywords: Walker circulation; ENSO; La Nina; environment; economic.

1. Introduction

The floods plagued Peru for years, the forest fires that burned in Australia, the cold wave that ravaged the United States, and so on. It is undeniably clear that the Walker circulation is an area that must recognize in ocean climate research and a place that cannot bypass many natural disasters. However, in terms of the direction of research on the Walker circulation, scientists have analyzed its intensity and the specific currents and seas, and the purpose of the study is mainly to make inferences or draw conclusions based on the data from their studies. Because of this, the current research on the Walker Current primarily focused on analyzing its circulation activity. And there needs to be more analysis and a comprehensive summary of its nature. Of course, due to the instability of the Walker circulation, scientists are suitable to start from the intensity and abnormal changes of the circulation. However, most of the papers are obscure due to the in-depth study of its activity characteristics, and a large amount of data pile up, thus making it impossible for many readers interested in the study of the Walker circulation to start from a large amount of data and accurately extract the valuable information applicable to them. Based on this, this paper establishes the idea of summarizing the Walker circulation as the main line, supplemented by the auxiliary idea of organizing its impacts and hazards and analogizing the mitigation practices for its disasters, to study the results of the Walker circulation's impact on the natural ecology and economic environment of the world.

In recent years, natural disasters caused by the instability of the Walker circulation have continued to be serious. Some severe disasters have even endangered people's lives and the development of society, based on which society's attention to it has been increasing. Considering its specific research results, there is currently a wealth of academic research on the analysis of Walker circulation data. International academic researchers have contributed to the world's understanding of the Walker circulation from different research perspectives. These studies have focused more on the data and technical aspects. A strong pillar provides for this study in this paper. At the same time, this paper combines examples, data, and analysis with the Walker circulation as the general background to write

this paper clearly and concisely. On this basis, this paper uses analogies for research and understanding, reflecting this paper's innovation at the theory application level.

This paper analyzes the two phenomena caused by the instability of the Walker circulation, analyzes the harmfulness of both, focuses on the impact of the Walker circulation on the world, and begins to study the results of the impact of the Walker circulation on the ecological and economic environment of the world. This paper provides a theoretical framework and logical starting point for further research on the Walker circulation phenomenon. At the same time, it makes up for the lack of systematic understanding of the Walker circulation phenomenon, expands the impact of the Walker circulation phenomenon on the world's ecological and economic environment, promotes the summary of related issues, and studies the impact of the Walker circulation on the world environment.

2. Phenomenon of Walker circulation

2.1. El Niño

2.1.1. Characterization of El Niño

El Niño-Southern Oscillation (ENSO) is a wind field, and sea surface temperature oscillation occurring in the equatorial eastern Pacific Ocean and is a low-latitude sea-air interaction phenomenon that manifests itself as the El Niño-La Niña transition in the ocean and the Southern Oscillation in the atmosphere. ENSO, which means “Holy Child” in Spanish, is a phenomenon that sometimes occurs around Christmas when the cold current flows through the coast of Peru, accompanied by sudden rainfall, migration of seabirds, and the appearance of large numbers of fish carcasses on the sea surface. The locals attribute this unusual irregularity to the formation of “ENSO”. Under normal conditions, a steady, easterly solid trade wind prevails on both sides of the Pacific equator, blowing warm surface waters away from the South American coast. However, when the trade winds weaken, the surface water temperature along the Pacific coast of South America increases, and the near-equatorial section of the Peruvian cold current degenerates into a warm current. A new El Niño event forms when the warming is more significant than 0.5°C and lasts for a few months to six months. The intra-seasonal variability of ENSO is on a time scale of 30-60 days. The annual variability is 2-7 years, usually referring to atmospheric variability, which also exists in tropical oceanic regions. Usually, it has a time scale of one year and generally influences by solar radiation. The most notable example is the monsoon [1, 2].

2.1.2. Hazards of El Niño

For the ecosystem, the occurrence of El Niño is undoubtedly a devastating disaster. El Niño can cause a massive die-off of local cold-water fish that do not adapt to the warm waters, leading to the death or migration of birds that depend on such fish as food. In addition, local anadromous migratory fish have difficulty adjusting to the warming growth environment for their juveniles and eggs, and their migration is severely affected; the number of fries rapidly reduces, the ecological balance of the area disrupts, and the normal development of this biosphere is seriously affected. In addition, the reduction of CO_2 is also a significant cause of causing the decrease of algae because the removal of CO_2 algae to carry out photosynthesis is less efficient, and the output of O_2 reduction so in this sea biosphere depends on oxygen survival of organisms gradually reduced. Finally, the ecological damage is caused by the frequent occurrence of catastrophic weather, such as droughts or forest fires in countries near the equator, including South Asia, Southeast Asia, Australia, and the Caribbean, due to the weakening of the updraft and the reduction of precipitation [3-5].

From the economic direction, the El Niño phenomenon closely relates to global climate change. It affects weather conditions and agricultural production on a large scale, with frequent pests and diseases. The regions associated with the phenomenon are Indonesia and Australia, where severe drought causes food crop production significantly to reduce, food prices are floating, and the sudden change in the growth environment of cash crops and low yields leads to a severe crisis in the market [6, 7]. Fig. 1 shows the drought caused by El Nino. According to statistics, the “El Niño” phenomenon

that occurred from 1982 to 1983 caused global climate anomalies and unprecedented natural disasters, resulting in a total loss of $8 billion. The El Niño phenomenon was also the driving force behind the 1998 mega-flood [1, 8].



Fig 1. Drought caused by El Nino [9].

2.2. La Niña

2.2.1. Characterization of La Niña

In Spanish, it is the translation of “little girl”. La Niña is the abnormal drop in water temperature in the eastern and central equatorial Pacific oceans. La Niña is the opposite of El Niño, so it is called "anti-El Niño," but its impact on climate is less potent than that of El Niño. The La Niña phenomenon is caused by the acceleration of the sea surface trade winds, prompting the emergence of offshore air currents in the eastern and central Pacific Ocean, resulting in the upturning of cold water from the deep seawater, thus lowering the sea surface temperature in the central and east equatorial Pacific Ocean. As a result, it generally reflects a cooling greater than 0.5°C lasting several months to six months [1]. However, due to the enhanced offshore winds and more vigorous upwelling on the eastern side of the ocean near the equator, the nutrients on the ocean surface increase, and the fishery instead increases its productivity.

2.2.2. Hazards of La Niña

Ecologically, it causes stronger than average trade winds, lower water temperatures, reduced cloudiness, higher pressure in the central and eastern equatorial Pacific, and the opposite in the western tropical Pacific. This results in frequent cold waves, high winds, floods, and other hazardous weather, including a significant increase in the frequency of sand and dust and the intensification of typhoons in areas close to the equator. It has resulted in flooding in the south and drought in the north, which prevents the biosphere from interacting correctly [10]. On the contrary, the economic economy, because of the butterfly effect caused by ecological problems, most crops and cash crops die in large numbers, the market is chaotic, and prices inflate, causing severe economic dislocation.

2.3. The relationship between El Niño and La Niña phenomena

Since the Walker circulation triggers both phenomena, the reason for the appearance of both phenomena is the instability of the Walker circulation. However, one is due to the weakening of the Walker circulation, the weakening of the trade winds near the equator, the decrease in water temperature in the west and the increase in water temperature in the east, and the formation of the El Niño cycle. On the other hand, a La Niña cycle formed because of the strengthening of the Walker circulation, the strengthening of the trade winds near the equator, the increase of water temperature in the west, and the decrease of water temperature in the east. However, it is undeniable that even

though La Niña is less than El Niño, the resulting impact is still devastating. The trade winds near the equator, and the monsoons near the areas where both phenomena occur will affect the strength of both to a greater or lesser extent. These two phenomena also influence by the ozone leaky energy effect caused by solar activity. Thus, the eclipse-El Niño coefficient theory has successfully inferred multiple El Niño and La Niña phenomena. It also proves that El Niño and La Niña are in a mutually meaningful and antagonistic relationship [8].

3. Causes affecting the Walker Circulation

3.1. Causes of the Walker Circulation

The tropical western Pacific Ocean (warm pool) has a low pressure and corresponds to an updraft. In contrast, in the tropical eastern Pacific Ocean (cold tongue water mass), there is a high pressure and corresponds to a downdraft; that is, the trade winds drive the warm equatorial current from east to west so that the water temperature in the eastern tropical Pacific Ocean is low. As a result, the water temperature in the west is high. The wind is westerly at the upper level and easterly at the surface, thus forming a closed circulation called the Walker circulation. As shown in Fig. 2, it is a thermal circulation, a latitudinal thermal circulation on the surface of the equatorial ocean due to the east-west difference in water temperature. In an average year, the eastern Pacific current near the equator sinks with little rain, and the western wind rises with more rain [11].

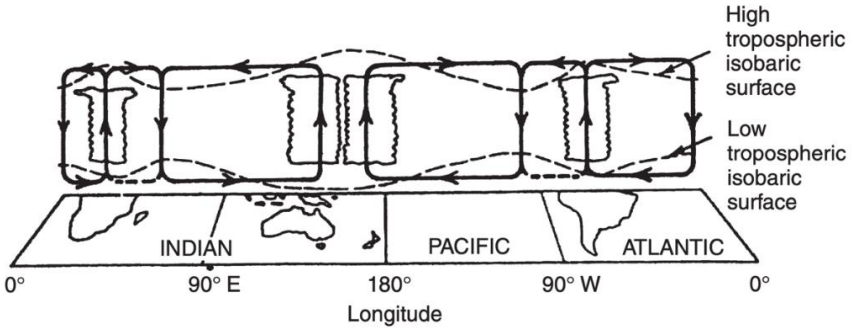


Fig 2. Schematic representation of the Walker circulation [11].

3.2. Influencing factors

We generally relate the Walker circulation to the Southern Oscillation (SO) as late as the Pacific seawater temperature, so the Walker circulation is associated with the monsoon and SST. And because updrafts and downdrafts generate the Walker circulation, so to influence of the Walker circulation also starts from the airflow, so the change of the strength of the western Pacific latitudinal circulation circle has an essential control on the evolution of the SST in the eastern equatorial Pacific, and the difference of the power of the west of Pacific latitudinal circulation circle is ahead of the change of the SST in the eastern tropical Pacific by 2-3 months, about one season [7]. From this, we can conclude that high winds and dust due to excessive logging or excessive or abnormal human interventions to change the climate may increase the impact on the airflow and cause a new round of El Niño or La Niña. Therefore, the influence of environmental changes on the Walker circulation is still significant.

4. Mitigation measures

4.1. Environmental management

4.1.1. Mitigation methods to deal with El Niño

According to the cause of the El Niño, the most fundamental way to mitigate the El Niño effect is to bring down the water temperature in the coastal area of the Pacific Ocean in South America so that

the Walker circulation, which initially moved eastward, can retreat and weaken the El Niño effect. Suppose you want to achieve the desired result. In that case, the simplest thing is to create seawater convection so that the upper and lower layers of seawater exchange and the lower layer of seawater turns over to the upper layer, making a drop in temperature. The formation of seawater convection first requires the appearance of compensating currents; then, researchers can create artificial compensating currents to weaken El Niño after predicting.

4.1.2. Mitigation methods to cope with La Niña

According to the cause of La Niña, the most fundamental reason for La Niña is the increase of SST, then the rise of SST is closely related to carbon dioxide emission. Therefore, we should reduce greenhouse gas emissions and comprehensively promote a green economy's development.

4.2. Human intervention

El Niño and La Niña now belong to the same climate disaster, and if people want to minimize the damage of both, then we need to make plans in the relevant institutions.

4.2.1. Strengthen monitoring and early warning

Always pay attention to the changing trend of meteorological departments, emergency departments, and water conservancy departments, make projection calculations according to the actual situation that happened in previous years, carefully study and judge the condition of relevant hardest hit areas, and start emergency response according to different situations. Promptly release relevant warning information so that all departments can respond to the call-in time, understand the latest case of the disaster and carry out tragedy.

4.2.2. Strengthen the government's efforts for disaster relief

First, it is necessary to increase the available dispatch and achieve a sufficient workforce, high efficiency, and high standard in performing relevant disaster relief tasks for scientific disaster relief. Classify each disaster situation into different levels and respond more systematically and comprehensively.

4.2.3. Make adequate backup work

In the agricultural economy and other related aspects that quickly hit hard, do timely stop-loss work to ensure the safety and stability of the market. Strengthen the support of the capital chain and timely coordination with the finance, supply, and marketing departments to ensure that people's lives are not affected. For ordinary families, it is necessary to popularize relevant knowledge in time to enhance their scientific prevention and safety knowledge of emergency disaster avoidance. Should set up a separate guidance department to ensure that disasters do not panic and are faced together in an orderly manner.

5. Conclusion

This paper has found that two phenomena caused by the instability of the Walker circulation have unavoidable catastrophic effects on the world's ecological environment. This paper has started by introducing these two phenomena to study their hazards in-depth and analyze the practices to mitigate the impact from different perspectives. It is imperative to protect the environment and to actively develop a plan to deal with the instability of the Walker circulation, which is unpredictable and increasingly severe, so minimizing the cost of damage is our primary goal. Therefore, we will conduct more modeling experiments and fieldwork in the future to add to the cause of Walker circulation research. This study fills the gap of a long period in which only data on the Walker circulation were available and provides scholars with a more concise understanding of the primary state of the Walker circulation in future research on this topic, leaving the material and foundation for the extension of subsequent research in this area.

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