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A Study on the Change of Monsoon Circulation under the Condition of Climate Warming

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ABSTRACT
With the development of science and technology in recent years, human carbon emissions are also gradually increasing. The influence of the greenhouse effect on human society is increasing day by day. The greenhouse effect has caused a series of changes in the climate and atmosphere. As a climate phenomenon that occurs every year, and in order to find out how the monsoon circulation is affected, the paper through a method of observing the impact of important natural disasters happened in recent years is trying to figure out how monsoon circulation will change in a warming climate. The result obtained in this paper is that the warming climate may affect the strength and lasting time of the monsoon, and the number of extreme weather events in recent years confirms this relationship.

Keywords: *Monsoon, Circulation, Warming, Climate change, Atmospheric*

1. INTRODUCTION

Monsoon climate is the main feature of climate in some countries. The climate warming causes many changes on earth's atmosphere climate, such as global warming, sea level rises, and some animal habitats being destroyed. Therefore, it is very important for us to learn their relationship. Because the Monsoon climate usually can bring some natural disasters every year, the disasters such as typhoons, tsunamis, and hurricanes can bring a big amount of costs to human society. Will the climate warming make these disasters more intense than before? So far, there is no definitive answer to this question. In recent years, most research on this topic has focused on future changes in precipitation in specific areas. However, in this article, I will focus on the relationship between the change of monsoon circulation and climate change and its impact on human society.

Is there any relationship between the Monsoon climate and the climate warming? How can climate warming affect monsoon circulation? This paper is trying to find some real cases happens in this world which may indicate that the climate warming can effect the monsoon circulation. This paper presents some ideas for preventing the damage caused by climate change. Besides, from learning this paper, we can also find there are some indirect relationship may exist between the climate warming and the monsoon circulation. I hope that through this research, people can understand more about the natural disasters caused by the monsoon circulation, and pay more attention to the relationship between climate changes and the monsoon cycle. and how people can avoid and reduce the impact of natural disasters brought on by the monsoon circulation.

2. DEFINITIONS

The monsoon is a type of atmospheric circulation. It is a wide range of winds between the land and the sea that change with seasonal regularity. It is a regional phenomenon, but it is controlled by the three-circle circulation on a larger scale. Due to seasonal changes, the three-circle circulation moves north-south and back across the globe, leading to the north-south passage of the pressure belt. With different combinations of conditions, the monsoon circulation in some areas is strengthened or weakened. Because of the different heat capacity between the land and the ocean. monsoon circulation occurs. In the summer, the land temperature is high, the atmosphere over the land expands and rises due to heat, forming a low-pressure zone, and the temperature on the ocean is lower, forming a high-pressure zone. In this way, there is a horizontal pressure gradient force between the ocean and the land, and the near surface wind will blow from the ocean to the land. The land usually heats up and cools down faster than the ocean.

Global warming is the rise of the earth's temperature. It is mainly caused by the excess carbon dioxide emitted

by modern society. It will bring several effects to earth environment and human society. For example: First, the glacial in polar regions would melt and causes the sea level to rise. Rising sea levels will cause severe damage to some coastal cities and countries such as Japan and Netherlands. Second, higher temperatures in low latitudes lead to lower grain production, which is unsuitable for most developing countries because they are mainly in the middle and low latitudes. Third, the rise of climate will destroy some animal's habitats, such as the polar bear. Thereby, the ecosystem will be destroyed.

3. CASE STUDIES

By the above definition, we can see no direct relationship, but how does wind form? We have to have temperature differences in the first place to have pressure differences. When we have pressure differences, we have wind, and climate warming affects the temperature differences. Climate warming may affect the strength of the monsoons, the timing and frequency of the monsoons.

In order to figure out the relationship between monsoon circulation and climate warming, the paper utilized cases to figure it out. There is a hypothesis, summer and winter winds may be stronger and longer-lasting in many mid-latitude countries.

3.1 Rainfall in Zhengzhou

The heavy rain happened in Zhengzhou, Henan, China, in July 2021.

In July 2021, the city of Zhengzhou in Henan province has been hit by torrential rain. It caused a massive amount of water on the ground, resulting in severe damage to society. According to the data, From 16:00 to 17:00 on July 20th in Zhengzhou, the rainfall in one hour reached 201.9 mm. From 20 o'clock on July 19th to 20 o'clock on July 20th, the single-day rainfall reached 552.5 mm. From 20 o'clock on July 17th to 20 o'clock on July 20th, the total rainfall in the three days was as high as 617.1 mm. The hourly and single-day precipitation have broken through the 60-year historical record since Zhengzhou was established in 1951. As shown in Figure 1, the amount of rainfall from July 19th to July 20th in Zhengzhou city. It is reported that the average annual rainfall in Zhengzhou is 640.8 mm, and the rainfall in these three days is equivalent to the total rainfall of the previous year. [1]

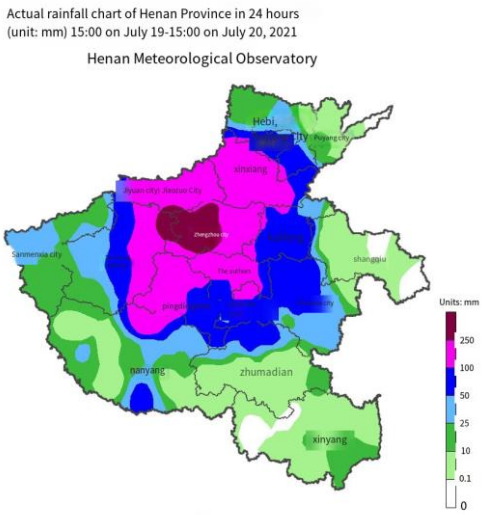

Figure 1. Precipitation map of Zhengzhou City on July 20, 2021

3.2 The impact of Super Typhoon Lekima in China

The feature of the Super Typhoon Lekima are the landing intensity is strong, the land stay time is long, the wind and rainfall intensity is large, the impact range is wide, and the impact of disasters is heavy etc.

The Super Typhoon Lekima in 2019 is the fifth most powerful super typhoon to make landfall in mainland China since 1949; It remained onshore in China for 44 hours, the sixth longest since 1949; And it has caused the first rainfall intensity in Shandong, China, and the second most rainfall intensity in Zhejiang, China. [5]

The Super Typhoon Lekima made landfall off the coast of Wenling City, Zhejiang Province, China, at 1:45 a.m. on August 10, with maximum winds of 16 (52 m/s) near the center and a minimum pressure of 930 hPa at the center. After that, at 20:50 on the 11th, it made a second landfall along the coast of Qingdao City, Shandong Province, China, with a maximum wind force of 9 (23 m/s) near the center and a minimum pressure of 980 hPa at the center. According to statistics, the super typhoon "Lekima" caused a total of 14.024 million people to be affected nationwide, the number of deaths due to the disaster was 66, the number of missing people was 4, and the emergency relocation and resettlement of 2.097 million people; at the same time, 15,000 houses collapsed,

133,000 rooms were damaged to varying degrees; the area of crops affected was 1137 thousand hectares, of which 93.5 thousand hectares were harvested; and the direct economic loss was 51.53 billion yuan. [4]

4. ANALYSIS

Both of the typhoon and the rainfall are caused by the monsoon circulation. By observing the typhoon and the rainfall from two cases above, we can find that the typhoon and rainfall from both cases are stronger than the usual.

Why is the rainfall so intense? Why does it keep so long? There are three main reasons as the hypothesis.

4.1 Relationship between monsoon circulation and warming temperature

For the heavy rain happened in Zhengzhou, Henan, China, in July 2021. There are 3 reasons may can explain why that happened.

First, the thermodynamic factors. Normally, the Chinese mainland is in the subtropical high-pressure zone in summer. However, the existence of the south Asian continent cuts off the subtropical high-pressure belt, so the center of the subtropical high-pressure belt is concentrated in the Pacific Ocean.As a result, in summer, sea breezes form from the Pacific Ocean to mainland China. The southeast monsoon carries a lot of water vapor, which is very easy to form precipitation.

Second, typhoon. Although typhoon “Firework” is a thousand kilometers away from China, it still controls the rainfall in Henan. China was also hit by typhoon Cempaka at the time. These two typhoons and cyclones worked together to make all the air from the Pacific Ocean blow towards the Chinese mainland.

Third, the terrain factor. Climate warming has intensified the subtropical high over the Pacific and the land temperature. That makes the pressure difference between the land and the ocean increase and makes the typhoon stronger than usual. Moreover, Zhengzhou is located under the Tai-hang Mountain. From the image below we can find China is high in the west and low in the east, a three-step distribution of terrain, because the height of the mountain affects how high water vapor climbs. The higher the altitude, the lower the temperature, when the water vapor rises to a certain height, the cold will form rain (orographic precipitation). Tai-hang Mountain is the junction of the two and three steps, so it affects the rainfall.

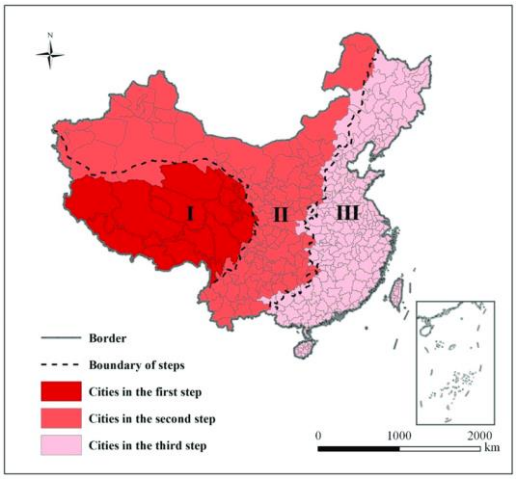

Figure 2. Topography map of China

Typhoon formation usually requires the formation of strong Cumulonimbus clouds on the surface of the sea, for the Super Typhoon Lekima happened in 2019, because of the temperature difference, the tropical low pressure receives more energy from the ocean, resulting in more intense typhoons.

4.2 Three ways to decrease damages

Therefore, what can we do for such a case we mentioned above? There are three ways that can decrease damage for such cases. First, we can strengthen the detection, research, and early warning of weather and climate extremes. People will have more time to prepare when the bad temperature comes. Second, we can improve education and publicity. Teaching everyone how to do when the bad temperature comes can save them under the bad temperature. Third, We can also advance prevention by releasing early warning information throughout the network. Because in nowadays, most of the population are using the internet. For example, After the extreme weather forecast in Zhengzhou came out, the positive response from all sectors of society, such as student suspensions and workers working from home, which greatly reduced casualties of people and property.

At the same time, there are 6 points that everyone should do for prevent the typhoon:

1. Listen to and watch typhoon warning information in a timely manner.

2. Fix outdoor items such as flower pot air conditioners before the typhoon comes, and do not put valuables such as home appliances under the windward window. Check the electrical safety of circuits, gas, fires, etc.

3. Do a good job of reserve work in time, prepare flashlights, drinking water food, candles, etc., in case of power outages and water outages.

4. During typhoons, try not to go out.

5. If you are in outside, do not use the buildings, billboards, TV towers, trees, etc. to avoid the rain.

6. Carefully close the windows at home. [6]

5. CONCLUSION

This paper studies the relationship between the monsoon circulation and the warming climate, and can draw the following conclusions. As we mentioned above, we could find some indirect relationships between the monsoon circulation and the warming temperature. The warming climate may affect the strength and lasting time of the monsoon, and the number of extreme weather events in recent years confirms this relationship. Heat, typhoons and topographic factors have contributed to heavy rains in Zhengzhou, in 2021, China, giving us a sense of the impact of climate change on monsoons. To stop global warming, it is not only up to our countries to achieve carbon peak and carbon neutrality, but also up to our individual efforts.

In addition, there are several deficiencies in this paper. First, the article lacks an explanation as to why Typhoon Lekima in 2019 is stronger than ever. The author will spend more time to working on my research next time. Besides, the content in this whole paper are all guesses, and there are no statements to prove that my guesses are right or wrong. Through this experience, the author believes there will be a better work in the future.

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