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Research Status and Prospect of Extreme High Temperature and Drought Events at Home and Abroad

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ABSTRACT

In recent years, the increasing frequency and intensity of extreme climate events worldwide have attracted widespread attention. Studies have shown that due to climate change caused by human activities, extreme climate events are becoming more common and severe. In China, studies on extreme temperature events have revealed that since the 21st century, extreme high-temperature events have increased significantly, while extreme low-temperature events have shown a decreasing trend. Therefore, geographers at home and abroad are more inclined to study extreme high-temperature and drought events. Such extreme climate changes not only affect the stability of the climate system but also pose challenges to social and economic development. Therefore, to effectively mitigate the impact of climate change on extreme climate events, countries around the world need to work together, strengthen international cooperation, and formulate and implement effective climate change policies and measures. Only through global cooperation can we better protect the global environment and ensure the sustainable development of humans and other organisms.

KEYWORDS

Extreme climate; Extreme high temperature and drought; High temperature; Drought.

1. INTRODUCTION

Extreme climate events refer to abnormal and extreme weather phenomena occurring in a certain region or period[1], such as extreme high temperature, extreme precipitation, drought, flood, etc[2]. With the intensification of global warming, the frequency and intensity of extreme climate events are on the rise, exerting severe impacts on human society, the ecological environment, and economic development[3]. Firstly, extreme high-temperature and drought weather pose significant challenges to food production, water resource management, and energy supply, which may lead to crop failure, water shortage, and tight power supply. Secondly, extreme rainfall and flood events may cause urban waterlogging, landslides, damage to infrastructure, and casualties, bringing great troubles to the lives of local residents

In recent years, frequent extreme climate events worldwide have attracted widespread attention. In 2018, Europe experienced continuous high temperatures, and severe forest fires broke out in many countries; in 2020, the western region of the United States suffered from continuous drought and high temperatures, resulting in severe water shortages and crop yield reduction; in 2021, the central region of China was hit by rare heavy rainfall, triggering severe flood disasters[3]. These events not only had a severe impact on the lives of local residents but also triggered global discussions on climate change.

Global warming is one of the main causes of the frequent occurrence of extreme climate events. It has led to changes in the atmosphere and ocean systems, increasing the probability and intensity of

extreme weather events. For example, global warming has caused a rise in the global average temperature, thereby increasing the frequency of extreme high-temperature events; at the same time, tropical cyclones and heavy rainfall weather may also become more intense due to the rise in sea surface temperature[4].

Facing the challenges of extreme climate events, the international community needs to take action. Firstly, countries around the world should work together to slow down the pace of global warming, reduce the rate of global average temperature rise by reducing greenhouse gas emissions and developing renewable energy. Secondly, countries need to strengthen their ability to adapt to climate change, including improving early warning systems, enhancing the construction of urban flood control and drainage facilities, and promoting the transformation of agricultural production methods, to reduce the losses caused by extreme climate events.

2. EXTREME HIGH TEMPERATURE AND DROUGHT

2.1. Global Research Progress on Extreme High Temperature and Drought

In the entire research on extreme climate, extreme high temperature and drought are the focus. Extreme high temperature and drought are among the more severe climate events under current global warming, which have a severe impact on human society, ecosystems, and economic development[5]. The following is the research progress on global "extreme high temperature and drought":

(1) Extreme high temperature:

a. In recent years, a number of extreme high-temperature events have occurred worldwide, such as the heatwave in Europe in 2018 and the extreme high temperature in North America in 2019[6]. Studies have shown that global warming is one of the main causes of the frequent occurrence of extreme high-temperature events[7]. For example, a study found that under the condition of unchanged meteorological conditions, global warming increased the occurrence probability of the 2018 heatwave event in Europe by 100 times[8-10].

b. In addition to global warming, human activities may also exacerbate the occurrence of extreme high-temperature events[11]. For instance, urbanization and land-use changes may lead to the "heat island effect" in urban areas, making the temperature in cities higher; industrial emissions and transportation may also cause a temperature rise in local areas[12].

(2) Extreme drought: Drought events are also increasing worldwide[13]. For example, drought events in eastern and southern Africa have become more frequent and severe in the past few decades[14]. Studies have shown that global warming is one of the main causes of the frequent occurrence of extreme drought events. For example, a study found that the drought events in Africa from 2011 to 2015 were related to global warming, which increased the occurrence probability of drought events in Africa by 50%[15].

(3) Besides global warming, human activities may also exacerbate the occurrence of extreme drought events. For example, excessive groundwater extraction may lead to the depletion of groundwater resources; large-scale agricultural irrigation may also cause water shortages.

(4) In general, addressing extreme high-temperature and drought events requires the adoption of a variety of measures. Firstly, countries around the world need to work together to slow down the pace of global warming, reduce the rate of global average temperature rise by reducing greenhouse gas emissions and developing renewable energy[16]. Secondly, countries need to strengthen their ability to adapt to climate change, including improving early warning systems, enhancing water resource management, and promoting the transformation of agricultural production methods, to reduce the losses caused by extreme climate events[17-18].

2.2. Domestic Research Progress on Extreme High Temperature and Drought

China is one of the regions with the highest frequency and intensity of extreme high-temperature and drought events in the world. In recent years, with the intensification of global warming, China has experienced a number of severe extreme high-temperature and drought events[19], such as the continuous drought in southern China from 2013 to 2014 and the continuous high temperature in northern China in 2019[20-21]. In response to these events, domestic scholars have carried out a large number of studies under the influence of international scholars, mainly involving the following aspects:

(1) Global warming and extreme high temperature and drought: Global warming is one of the main causes of the frequent occurrence of extreme high-temperature and drought events. By analyzing meteorological data and simulation results, Chinese scientists have found that the precipitation in China has shown a downward trend since the 1970s, while the temperature has shown an upward trend, and at the same time, the frequency and intensity of extreme climate events have also increased year by year[22-24]. Among them, the rate of temperature rise in northern China is faster than the global average, and the intensity and duration of high-temperature events are also increasing .

(2) Impact of extreme high temperature and drought on the ecological environment: Extreme high temperature and drought have caused severe impacts on China's ecological environment. For example, drought may lead to a drop in groundwater levels and the drying up of lakes, exacerbating water shortages; high temperature may accelerate the evaporation of soil moisture and plant transpiration, thereby leading to crop yield reduction and grassland degradation[25] . In addition, extreme high-temperature and drought events may also lead to the loss of ecosystem service functions, such as water conservation, soil conservation, and carbon sequestration[26].

(3) Impact of extreme high temperature and drought on social economy: Extreme high-temperature and drought events have caused severe impacts on China's social economy . For example, drought may lead to damage to agricultural production and a reduction in animal husbandry output, exacerbating food security and farmers' poverty; high temperature may lead to an increase in urban electricity consumption and energy consumption, exacerbating urban air pollution[27]. In addition, extreme high temperature and drought may also have a negative impact on transportation, tourism, industrial production, etc., and suppress economic growth.

(4) Measures to address extreme high temperature and drought: Facing the challenges of extreme high-temperature and drought events, China needs to take a variety of measures. Firstly, it is necessary to strengthen meteorological monitoring and early warning, and improve the ability of disaster prevention and mitigation ; secondly, it is necessary to strengthen the management and protection of water resources, promote the transformation of agricultural production methods , and optimize the urban water use structure, to reduce the losses caused by extreme high-temperature and drought events[28]. At the same time, it is also necessary to strengthen international cooperation to jointly address the challenges of climate change and extreme climate events.

To sum up, China has made certain progress in the research on extreme high temperature and drought, but it is still necessary to further explore the relationship between climate change and extreme climate events, the impact mechanism of high temperature and drought on the ecological environment and social economy, and the specific measures to address extreme high-temperature and drought events[29].

3. FUTURE RESEARCH ON EXTREME CLIMATE

With the intensification of global warming, the frequency and intensity of extreme climate events are increasing, posing a huge threat to people's lives, property, and social economy[30]. Therefore, future

research on extreme climate has become a hot topic. This part aims to summarize the focus of future research on extreme climate and point out the corresponding research methods and technologies[31].

3.1. Monitoring and Prediction of Extreme Climate Events

Improving the monitoring and early warning capabilities of extreme climate events is one of the focuses of future research. At present, commonly used monitoring methods include meteorological observation, satellite remote sensing, ground stations, and UAV technologies. In addition, it is also necessary to establish a prediction system based on climate models to improve the accurate prediction ability of extreme climate events.

3.2. Causes and Mechanisms of Extreme Climate Events

Exploring the causes and mechanisms of extreme climate events is one of the focuses of future research. Existing studies have shown that global warming is the main cause of the frequent occurrence of extreme climate events. In addition, atmospheric circulation, ocean circulation, and land processes are also closely related to extreme climate events.

3.3. Impact of Extreme Climate Events on the Ecological Environment

The impact of extreme climate events on the ecological environment is one of the focuses of future research. For example, drought may lead to a drop in groundwater levels and the drying up of lakes, exacerbating water shortages; high temperature may accelerate the evaporation of soil moisture and plant transpiration, thereby leading to crop yield reduction and grassland degradation. In addition, extreme climate events may also lead to the loss of ecosystem service functions, such as water conservation, soil conservation, and carbon sequestration.

3.4. Impact of Extreme Climate Events on Social Economy

The impact of extreme climate events on social economy is one of the focuses of future research. For example, drought may lead to damage to agricultural production and a reduction in animal husbandry output, exacerbating food security and farmers' poverty; high temperature may lead to an increase in urban electricity consumption and energy consumption, exacerbating urban air pollution. In addition, extreme climate events may also have a negative impact on transportation, tourism, industrial production, etc., and suppress economic growth.

3.5. Response Measures to Extreme Climate Events

Adopting effective response measures is one of the focuses of future research. In response to extreme climate events, it is necessary to strengthen meteorological monitoring and early warning, improve the ability of disaster prevention and mitigation; strengthen the management and protection of water resources, promote the transformation of agricultural production methods, and optimize the urban water use structure, to reduce the losses caused by extreme climate events. At the same time, it is also necessary to strengthen international cooperation to jointly address the challenges of climate change and extreme climate events.

To sum up, future research on extreme climate events needs to conduct in-depth discussions from the aspects of monitoring and prediction, causes and mechanisms, impacts on the ecological environment and social economy, and response measures, and conduct research in combination with existing technologies and methods.

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