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Editorial: Extreme climate events: Variability, mechanisms, and numerical simulations

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Editorial on the Research Topic
Extreme climate events: Variability, mechanisms, and numerical simulations

The IPCC AR6 reported that the frequency and intensity of extreme high temperature and heat wave events have increased significantly over most parts of the globe during the past few decades. The frequency and/or intensity of extreme precipitation have also increased over many land areas in central and South Asia, United States, northwest Australia, central and northern Europe, West and South Africa. In addition, some compound extreme events such as co-occurrent heatwaves and droughts are becoming more frequent. These extreme climate events are very likely to continue to increase as global warming intensifies in the future, thus increasing the threat the security of food and water for human communities.

Although scientists around the world have made great efforts to understand how and why the extreme climate events are changing, we are still facing several crucial challenges: What are the mechanisms for the change of regional extreme climate events under global warming? How to improve the predictability of extreme climate events at a regional scale? More importantly, what are the broad effects of extreme climate events on the ecosystem and environment? Answers to these questions would help society to know more clearly what actions should be taken to better predict the extreme climate events and to reduce the associated adverse impacts.

This Research Topic collects 16 papers focusing on the above scientific questions, and contributes to a better understanding of the variability, mechanisms, prediction, and impacts of extreme climate events. Below is a brief introduction of the 16 papers in this Research Topic.

Shin et al. investigated the synoptic features of a record-breaking heavy rainfall event during August 2018 in the Korean peninsula. They compared the synoptic environmental and frontal structures of the heavy rainfall events during August and the Changma period. The results indicate that these events have several common characteristics, including an expanded western Pacific subtropical high (WPSH) as well as strong low-level winds along the western or northwestern edge of the WPSH. Their study shows the importance of anomalous WPSH to the occurrence of heavy rainfall events in East Asia.

Wan et al. explored the impact of extreme weather events on the ground-level air pollution over eastern China and the association with the premature deaths. They suggest that the compound hot and dry extreme events could lead to a notable increase in the ground-level ozone concentration over eastern China. The extreme hot weather events may result in an increase in the ozone-related premature deaths. These results contribute to a better understanding of the influence of weather extremes on human health.

Wu et al. elucidated a strengthened relationship between summer rainfall over North China and Pacific Decadal Oscillation (PDO) since the mid-2000's. The results suggest that the negative phase of PDO brought more summer rainfall in North China *via* modulating the upper-level jet stream and the East Asia-Pacific teleconnection since the mid-2000's. Results of this study could help improve the understanding of the factors contributing to interdecadal variation of wet/dry condition over North China.

Yan et al. investigated the projected future change of the gross primary productivity (GPP) of the northern Asian ecosystem and the impact of extreme heat events. Their results suggest an overall increase of the GPP and extreme heat events over northern Asia in the future. The impact of extreme heat events on GPP exhibit spatiotemporal heterogeneity, indicating a complex relationship between the extreme events and the ecosystem GPP.

Huang et al. identified a decadal variation in the frequency of tropical cyclones (TCs) in the South China Sea. They found a seesaw interdecadal variation in the frequencies of two types of tropical cyclones around 1997, which are generated in the South China Sea and the western North Pacific. This seesaw variation of the two types of tropical cyclones is affected by the genesis positions of TCs and the large-scale environmental flow patterns. Their study contributes to a better understanding of the variability of tropical cyclones that influence East Asia.

Huang et al. analyzed two heavy rainfall events in northwestern China during the summer of 2012 and 2013. They suggest that the northwestward-moving plateau vortex plays an important role in the two heavy rainfall events, which affect the moist potential vorticity, moisture helicity, and convective clouds characteristics in association with heavy rainfall. This study indicates an important impact of plateau vortices originating from the Tibetan Plateau on the extreme weathers in East Asia.

Sun et al. explored the quasi-biweekly oscillation in the atmospheric circulation associated with the mei-yu onset period. They found that the quasi-biweekly oscillation in the geopotential height over the Ural Mountains and the Northwest Pacific has an important influence on the onset of mei-yu in the Yangtze-River valley. During recent years, extreme mei-yu events have occurred more frequently, causing flood and/or drought disasters. The results of this study may help to understand these extreme events.

Zhu et al. estimated the prediction skill of the CFSv2 for the extreme high temperature events (EHTE) in eastern China, which is relatively poor at present. They explored the influential factors of EHTE and constructed a physical-empirical model for predicting the EHTE in eastern China. The results indicate that this physical-empirical model may greatly improve the prediction of EHTE in eastern China. This study provides an approach for obtaining a better prediction of extreme high temperature events over China.

Lv et al. showed that during the past 35 years, there is no significant poleward migration of TC in the western North Pacific, but there is large interdecadal variation in the TC tracks over the western North Pacific. The interdecadal variation of TC tracks is mainly affected by the Interdecadal Pacific Oscillation.

Qianrong et al. investigated the atmospheric circulation anomalies associated with a heavy rainfall event in West China during August 2020. They found this event resulted from a combination of different factors, including westward extended and anomalously strong WPSH, eastward extended South Asian High, and an anomalous low over Mongolia. These results indicate that extreme rainfall in the interior region of Eurasia is associated with the interaction between low latitude factors and mid-to-high latitude factors.

Li et al. studied the characteristics of Madden-Julian Oscillation (MJO) activity under three super El Niño events. Anomalous propagation and intensity of the MJO are detected during the developing, maturation, and decaying stages of the super El Niño events, which are suggested to be related to the atmospheric circulation and moisture anomalies caused by these El Niño events. Their study contributes to a better understanding of the influence of extreme El Niño events.

Cheng et al. explored the atmospheric circulation anomalies associated with the record-breaking rainfall over South China during the "Dragon Boat Water" season in 2022. They found that this record-breaking rainfall was mainly caused by anomalous meridional atmospheric circulation, which accounts for about 86% of the actual rainfall anomaly. These results exhibit the importance of meridional water vapor transport to the extreme rainfall in East Asia.

Wolf et al. investigated the relationship among the extreme sea levels, extreme astronomical tide, and extreme storm surge along the Norwegian coast. They found the highest storm surges mostly coincided with moderate astronomical tides and *vice versa*. Their study shows the possibility to estimate extreme sea level return values based on a three-variable system.

Huo et al. studied the extreme mei-yu in the Yangtze-Huaihe River Valley during the summer of 2021. Their results suggest that the occurence of this extreme mei-yu event is due to the joint impacts of an anomalous quasi-stationary atmospheric wave train propagating northeastward from Hainan Island to northwestern Pacific, and an anomalous quasi-stationary atmospheric wave train propagating eastward in the mid-latitudes originating from the tropical Atlantic. This study contributes to a better understanding of the mechanisms of extreme mei-yu events.

Omondi and Lin. investigated the long-term trend and spatial-temporal variations of drought characteristics over equatorial East Africa in boreal spring during the last 120 years. The results exhibit a weak long-term drying trend and an increase in drought areal extent after the 1980s in equatorial East Africa, which suggest that the drought risks are increasing in equatorial East Africa under global warming.

Fan et al. explored the interdecadal variation of summer extreme high temperature days (EHTDs) in northern Eurasia and the underlying mechanisms. They found that the number of summer EHTDs in northern Eurasia notably increased after the mid-1990's, especially in the areas around Lake Baikal and the Caspian Sea. They suggest that anomalous Rossby wave activities induced by a warmer

state of North Atlantic plays an important role in this interdecadal increase of EHTDs. This study contributes to a better understanding of the interdecadal variation of heat waves in Northern Hemisphere.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

Author LZ was employed by CSIRO.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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